ANSI/ASHRAE Standard 90.2-2007
(Supersedes ANSI/ASHRAE Standard 90.2-2004)
Includes ANSI/ASHRAE addenda listed in Appendix C

ASHRAE STANDARD

Energy-Efficient Design of Low-Rise Residential Buildings

See Appendix C for approval dates by the ASHRAE Standards Committee, the ASHRAE Board of Directors, and the American National Standards Institute.

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 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

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ANSI/ASHRAE Standard 90.2-2007
Energy-Efficient Design of Low-Rise Residential Buildings

NOTE

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FOREWORD

The original Standard 90.2 was published in 1993, and revised editions were published in 2001 and 2004. The ASHRAE Board of Directors voted in 1999 to place ASHRAE standards on continuous maintenance, permitting the standard to be updated several times each year through the publication of approved addenda to the standard. Starting with the 2001 edition, the standard is now published in its entirety every third year. This schedule was intended to allow 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. This procedure allows users to have some certainty about when new editions will be published.

This 2007 edition of the standard has several new features, which can be viewed in brief in Appendix C of this document or online at www.ashrae.org. The committee welcomes suggestions for improving the standard. Users of the standard are encouraged and invited to use the continuous maintenance procedure to suggest changes. A form, Submittal of Proposed Change, is included at the back of this standard. The committee will take formal action on every proposal received.

The Standing Standards Project Committee is continually considering changes and proposing addenda for public review. When addenda are approved, notices will be published on the ASHRAE Web site. Users are encouraged to sign up for the free ASHRAE Internet Listserv for this standard to receive notice of all public review drafts and published addenda and errata.

1. PURPOSE

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

2. SCOPE

2.1 This standard provides minimum energy-efficiency requirements for the design and construction of

a. new residential dwelling units and their systems and
b. where explicitly specified,
   1. new portions of residential dwelling units and their systems and
   2. new systems and equipment in existing dwelling units.

Note: There are no requirements in this standard that apply to new portions of residential dwelling units and their systems, nor to new systems and equipment in existing dwelling units.

For the purposes of this standard, "residential dwelling units" include single-family houses, multi-family structures (of three stories or fewer above grade), and modular houses. This standard does not include "transient" housing, such as hotels, motels, nursing homes, jails, and barracks, or manufactured housing.

2.2 This standard applies to the building envelope, heating equipment and systems, air-conditioning equipment and systems, domestic water-heating equipment and systems, and provisions for overall building design alternatives and trade-offs.

2.3 This standard does not apply to

a. specific procedures for the operation, maintenance, and use of residential buildings;
b. portable products such as appliances and heaters; and
c. residential electric service or lighting requirements.

2.4 This standard shall not be used to abridge any safety, health, or environmental requirements.

3. DEFINITIONS, ABBREVIATIONS, ACRONYMS, AND SYMBOLS

3.1 Purpose. The purpose of this section is to define all terms, abbreviations, acronyms, and symbols unique to this standard.

3.2 Scope. These terms, abbreviations, acronyms, and symbols are applicable to all sections of this standard. Definitions as contained in *ASHRAE Terminology of Heating, Ventilation, Air Conditioning, & Refrigeration* shall apply to all terms in this standard unless specifically listed here.

3.3 Definitions

air films: interior and exterior air surface film coefficients for winter design conditions.

area of all ceiling assemblies: interior surface area of such assemblies that enclose conditioned space.

area of all door assemblies: opaque area of such assemblies (including the frame) that enclose conditioned space. For doors where the daylight opening area is greater than or equal to 50% of the door area, the entire area of the door assembly is considered fenestration area.

area of all exterior walls (gross): exterior surface area of the following assemblies that enclose conditioned space: opaque wall assemblies, including between-floor spandrels and peripheral edges of flooring; fenestration assemblies, including all glazed surfaces and sash and framing elements; and door assemblies. Areas of vents, grilles, and pipes are excluded.

area of all fenestration assemblies: interior surface area of such assemblies including all glazed surfaces (such as windows, skylights, and sliding glass doors), sashes, curbing, or framing elements that enclose conditioned space. For doors where the daylight opening area is less than 50% of the door area, the fenestration area is the daylight opening area. For all other doors, the fenestration area is the door area.

area of all floor assemblies: interior surface area of such assemblies that enclose conditioned space.

area of all opaque wall assemblies: gross area of exterior walls measured on the exterior consisting of all opaque wall areas (including foundation walls, between-floor spandrels, peripheral edges of floors, etc.) that enclose conditioned space (including interstitial areas).

assembly: portion of an envelope component represented by an arrangement and connection of building construction materials with a specific thermal transmittance or thermal conductance.

conditioned space: an enclosed space within a building that is provided with mechanical heating and/or cooling energy.

envelope component: major section of the entire envelope, such as the opaque walls above grade, ceilings, slabs, floors, glazings, doors, or walls below grade.

fenestration: all light-transmitting assemblies in a building envelope, including the glazing material, sash, frame, and permanently affixed external or internal shading devices, where such component assemblies enclose conditioned space.

heat trap: a device or arrangement of the piping entering and leaving a water heater, constructed to counteract the convective forces of the heated water (thermosyphoning) during standby periods.

heated slab: concrete slab-on-grade floor containing wires, cables, pipes, or ducts that transfers heat to the conditioned space.

living unit: one or more rooms designed or used as living quarters providing complete, independent living facilities for one or more persons, including permanent provisions for living, sleeping, eating, cooking, and sanitation.

multi-family structure: building of three stories or fewer above grade containing three or more living units other than townhouses, including a manufactured building (modular).

prescriptive design: design of a living unit or building of the same size and occupancy type as the proposed design that complies with the prescriptive requirements of this standard. The prescriptive design includes specified assumptions concerning shape, orientation, HVAC, and other system design features. The prescriptive design is used to generate the compliance requirement for the annual energy cost method.

proposed design: design of the living unit or building to be constructed. The design takes into account all qualities, details, and characteristics of the building that significantly affect the use of energy, such as construction, geometry, orientation, exposure, materials, equipment, and renewable energy sources.

sash crack: sum of all perimeters of all ventilators, sashes, or doors based on overall dimensions of such parts expressed in feet (counting two adjacent lengths of perimeter as one).

service water heating: supply of hot water for purposes other than comfort heating.

shall: term used to indicate provisions that are mandatory if compliance with the standard is claimed.

single-family house: building containing one or two living units or a townhouse, including a modular house.

townhouse: a living unit in which one or more walls are partition, lot line, or common walls but not containing common floor and ceiling combinations.

unconditioned space: space within a building that is not conditioned space (see *conditioned space*).

vapor retarder: see *water vapor retarder.*

walls: those portions of the building envelope that are vertical or tilted at an angle of 30 degrees or less from the vertical plane.

- ***above-grade:*** all the exterior walls of any given story if 50% or more of the gross exterior wall area of the story is exposed to outside air.
- ***below-grade:*** all the exterior walls of any given story if more than 50% of the gross exterior wall area of the story is below grade.
- ***mass wall:*** a wall constructed of concrete, concrete masonry, insulating concrete form (ICF), masonry cavity, brick (other than brick veneer), earth (adobe, compressed earth block, rammed earth), and solid timber or logs.

water vapor retarder: material or construction that adequately impedes the transmission of water vapor under specified conditions. Water vapor retarders have a water vapor permeance of less than 1.0 perm when tested in accordance with ASTM E 96.

zone: a separately controlled heated or cooled space in a residential building.

3.4 Abbreviations, Acronyms, and Symbols

Symbol		Meaning
AAMA	=	American Architectural Manufacturers Association
A wall, roof, etc.	=	area of a specific building component
ACCA	=	Air Conditioning Contractors of America
ach	=	air changes per hour
AEC	=	annual energy cost
ANSI	=	American National Standards Institute
ARI	=	Air-Conditioning and Refrigeration Institute
ASTM	=	American Society for Testing and Materials
C	=	thermal conductance
CFR	=	Code of Federal Regulations
COP	=	coefficient of performance
CRRC	=	Cool Roof Rating Council
DOE	=	U.S. Department of Energy
EER	=	energy efficiency ratio
ELA	=	effective leakage area
HVAC	=	heating, ventilating, and air conditioning
IPLV	=	integrated part-load value
NA	=	not applicable
NCC	=	National Climate Center
NFPA	=	National Fire Protection Association
NFRC	=	National Fenestration Rating Council
NR	=	no requirement
R	=	thermal resistance
SHGC	=	solar heat gain coefficient
TMY	=	typical meteorological year
U	=	thermal transmittance
U_o	=	overall thermal transmittance
WYEC	=	weather year for energy calculation

4. COMPLIANCE

4.1 General. This standard provides different methods by which compliance can be determined for low-rise residential buildings—prescriptive or performance path methods (Sections 5, 6, and 7) or an annual energy cost method (Section 8).

5. BUILDING ENVELOPE REQUIREMENTS

5.1 Prescriptive Path

5.1.1 General. This section provides thermal performance requirements for the residential building envelope that separates conditioned spaces from either exterior conditions or unconditioned spaces.

5.1.1.1 Single-Family and Multi-Family Compliance. For the appropriate climate, the single-family house and multi-family structure envelope shall comply with:

a. the Prescriptive Path Method in accordance with Sections 5.2 through 5.11, or
b. the Envelope Performance Path Trade-Off Method in accordance with Section 5.12, or
c. in cases where a systems analysis method of building design is desired, the requirements of Section 8 of this standard.

5.1.1.2 Climate. The climate for the requirements in Sections 5 and 8 shall be determined based on Section 9.

5.2 Prescriptive Path Method. For one- and two-family dwellings and multi-family structures, the thermal resistance of the cavity insulation and the thermal resistance of the continuous insulation uninterrupted by framing, applied to the opaque building envelope components, shall be greater than or equal to the minimum R-values; the thermal transmittance of all assemblies shall be less than or equal to the maximum U-factors; and SHGC of all fenestration assemblies shall be less than or equal to the maximum SHGC criteria, shown in Table 5.2.

Exception: High albedo roofs in Section 5.6.

5.2.1 Thermal Transmittance. The design thermal transmittance (U) shall be the variable used to specify the requirements and demonstrate compliance for all doors and fenestration. All design U-factors are air-to-air, including interior and exterior air films. Calculation of design U-factors shall be done in accordance with the procedures in the *ASHRAE Handbook—Fundamentals* and account for thermal bridges and anomalies.

When more than one assembly is used in an envelope component, the design U-factor for that envelope component shall be calculated using Equation 5-1.

$$U = (U_1 \times A_1 + U_2 \times A_2 + \ldots + U_n \times A_n)/A \tag{5-1}$$

where

U = thermal transmittance of the envelope component, Btu/h·ft^2·°F

A = area of the envelope component, ft^2

U_{1-n} = thermal transmittance of the individual component assemblies, Btu/h·ft^2·°F

A_{1-n} = area of the individual component assemblies, ft^2

5.2.2 Thermal Conductance. The thermal conductance (C) of all below-grade envelope components shall be the variable used to set the requirements and demonstrate compliance. All C-factors are surface-to-surface, excluding air films and the adjacent ground. Calculation of C-factors shall be done in accordance with the procedures in the *ASHRAE Handbook—Fundamentals* and account for thermal bridges and anomalies.

When more than one assembly is used in an envelope component, the C-factor for that envelope component shall be calculated using Equation 5-2.

$$C = (C_1 \times A_1 + C_2 \times A_2 + \ldots + C_n \times A_n)/A \tag{5-2}$$

where

C = thermal conductance of the envelope component, Btu/h·ft^2·°F

A = area of the envelope component, ft^2

C_{1-n} = thermal conductance of the individual component assemblies, Btu/h·ft^2·°F

A_{1-n} = area of the individual component assemblies, ft^2

5.3 Walls Next to Unconditioned Spaces. Unconditioned spaces shall include unconditioned basements, unconditioned enclosed mechanical rooms, and unconditioned enclosed vestibules. Wood- and steel-framed walls adjacent to unconditioned spaces shall comply with the insulation values specified in the Table 5.2 category "Frame Adjacent to Unconditioned Spaces." Mass walls adjacent to unconditioned spaces shall comply with the "Above-Grade Mass, Exterior Insulation" insulation values specified in Table 5.2.

5.4 Mass Walls. Exterior insulation requirements shall apply when at least 50% of the required insulation R-value is on the exterior of, or integral to, the wall. Walls that do not meet this requirement for insulation placement shall meet the requirements for interior insulation. The interior insulation case shall apply when there are no exterior insulation requirements and wood or steel framing is used. When an added R-value of 3.4 or less is required, concrete block walls, in accordance with ASTM C90, with cores filled with material having a maximum thermal conductivity of 0.44 Btu·in./h·ft^2·°F, shall be permitted to be used.

5.5 Envelope Assemblies Containing Steel Framing

5.5.1 Steel Stud Walls. The thermal transmittance of frame walls that contain steel stud assemblies shall be calculated using a series path procedure that corrects for parallel paths, as presented in Equations 5-3 and 5-4.

$$U_i = 1/R_t \tag{5-3}$$

$$R_t = (R_i + R_e) \tag{5-4}$$

where

U_i = total thermal transmittance of the envelope assembly

R_t = total resistance of the envelope assembly

R_i = thermal resistance of the series elements (for i = 1 to n), excluding the parallel path element(s)

R_e = equivalent resistance of the element containing the parallel path, as shown in Equation 5-5

The value of R_e is

$$R_e = (\text{R-value of insulation}) \times Fc, \tag{5-5}$$

where

Fc = correction factor from Table 5.5.1.

5.5.2 Steel Framing in Ceiling/Roof. When the ceiling/roof assembly contains cold-formed steel truss framing, the U_R value to be used shall be determined by Equations 5-3, 5-4, or 5-5. These equations apply to cold-formed steel truss roof framing spaced at 24 in. (609 mm) on-center and where the penetrations through the cavity insulation do not exceed three penetrations for each 4 ft (1220 mm) length of the truss.

For constructions without foam between the drywall and bottom chord of the steel truss, use Equation 5-6.

Table 5.2 Prescriptive Envelope Criteria

Climate Zone	Ceilings				Walls										Floors					Doors	Fenestration			
	Attic Space		Without Attic Space (Cathedral or Flat Roof)		Above-Grade Frame				Frame Adjacent to Unconditioned Space	Above-Grade Mass Exterior Insulation	Above-Grade Mass Interior Insulation	Below-Grade Exterior Insulation[a]	Below-Grade Interior Insulation[a]	Unvented Crawlspace	Frame Over Exterior		Frame Over Unconditioned Space and Vented Crawlspace		Slab-on-Grade	Non-Wood	Vertical Glazed Assemblies		Skylights	
	Wood	Steel	Wood	Steel	Wood		Steel			Continuous Insulation	Interior Insulation	Continuous Insulation	Interior Insulation	Interior Insulation	Wood	Steel	Wood	Steel	Perimeter Insulation					
	Cavity	Cavity	Cavity	Cavity	Cavity	Cont. Ins.	Cavity	Cont. Ins.	Cavity						Cavity	Cavity	Cavity	Cavity						
No.	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R[b]	U	U	SHGC	U	SHGC[b]
1	30	30	13	19	13	0	15	0	0	0	0	0	0	0	15	22	13	15	NR	0.39	0.67	0.37	1.60	0.4
2	30	30	22	19	15	0	21	0	0	0	0	0	0	0	19	22	13	15	NR	0.39	0.67	0.37	1.05	0.4
3A,B	30	30	22	22	15	0	15	7.5	11	0	4	0	0	13	19	30	19	30	NR	0.39	0.47	0.40	0.90	0.4
3C	30	30	22	22	15	0	15	7.5	11	0	4	0	0	13	19	30	19	30	NR	0.39	0.47	0.40	0.90	NR
4	38	38	22	22	15	5	15	7.5	13	3	4	0	0	21	21	38	19	30	NR	0.39	0.35	NR	0.60	NR
5	43	43	26	30	21	0	21	10	13	3	4	5.4	11	30	25	38	25	38	NR	0.39	0.35	NR	0.60	NR
6	49	49	38	38	15	10	21	10	15	6	15	8.1	11	30	25	38	25	38	NR	0.39	0.35	NR	0.60	NR
7	49	49	38	38	21	10	21	10	15	6	15	10.8	11	30	38	38	30	38	NR	0.39	0.35	NR	0.60	NR
8	52	52	38	38	21	10	21	10	15	6	21	10.8	11	30	38	38	30	38	NR	0.39	0.35	NR	0.60	NR

[a] Either the below-grade exterior insulation or the below-grade interior insulation requirements must be met. Insulation must extend the full height of the wall.
[b] NR = No requirement.

TABLE 5.5.1 Wall Sections with Steel Studs Parallel Path Correction Factors, R_e

Nominal Stud Size[a]	Spacing of Studs, in.	Cavity Insulation R-Value	Correction Factor	Effective Framing/ Cavity R-Values
2 × 4	16 o.c.	R-11	0.50	R-5.5
		R-13	0.46	R-6.0
		R-15	0.43	R-6.4
2 × 4	24 o.c.	R-11	0.60	R-6.6
		R-13	0.55	R-7.2
		R-15	0.52	R-7.8
2 × 6	16 o.c.	R-19	0.37	R-7.1
		R-21	0.35	R-7.4
2 × 6	24 o.c.	R-19	0.45	R-8.6
		R-21	0.43	R-9.0
2 × 8	16 o.c.	R-25	0.31	R-7.8
2 × 8	24 o.c.	R-25	0.38	R-9.6

For SI: 1 in. = 25.4 mm.
o.c. = on-center.
[a]Applies to steel member studs up to a maximum uncoated thickness of 0.064 in. (64 mil) (16 gauge) (1.6 mm).

$$U_R = \frac{1}{0.864 \times R_{ins} + 0.330} \quad (5\text{-}6)$$

where

R_{ins} = R-value of the cavity insulation, h·ft^2·°F/Btu

For constructions with R-3 foam between the drywall and bottom chord of the steel truss, use Equation 5-7.

$$U_R = \frac{1}{0.864 \times R_{ins} + 4.994} \quad (5\text{-}7)$$

For constructions with R-5 foam between the drywall and bottom chord of the steel truss, use Equation 5-8.

$$U_R = \frac{1}{0.864 \times R_{ins} + 7.082} \quad (5\text{-}8)$$

Exceptions: When overall system tested U_R values for ceiling/roof assemblies from approved laboratories are available (when such data are acceptable to the building official).

When the roof/ceiling assembly contains conventional C-shaped cold-formed joist/rafter steel framing, the U_R value to be used shall be determined by using Equation 5-9.

$$U_R = \frac{1}{R_s + (R_{ins} \times F_{cor})} \quad (5\text{-}9)$$

where

R_s = total thermal resistance of the elements of ceiling/roof construction, in a series along the path of heat transfer, excluding the cavity insulation and the steel framing, h·ft^2·°F/Btu

R_{ins} = R-value of the cavity insulation, h·ft^2·°F/Btu

F_{cor} = correction factor listed in Table 5.5.2, dimensionless

Exception: When overall system tested U_R values for ceiling/roof assemblies from approved laboratories are available (when such data are acceptable to the building official).

5.5.3 Steel Framing in Floors Over Unconditioned Spaces. When the floor assembly contains cold-formed steel framing, the value of U_{fn} used shall be recalculated using a series of path procedures to correct for parallel path thermal bridging. The U_{fn} shall be determined as follows using Equation 5-10:

$$U_{fn} = \frac{1}{R_{fn} + (R_{ins} \times F_{cor})} \quad (5\text{-}10)$$

where

R_{fn} = total thermal resistance of the elements of floor construction, in series along the path of heat transfer, excluding the cavity insulation and the steel joist, h·ft^2·°F/Btu

R_{ins} = R-value of the cavity insulation, h·ft^2·°F/Btu

F_{cor} = correction factor listed in Table 5.5.3, dimensionless

Exception: When overall system-tested U_{fn} values for steel-framed floors from approved laboratories are available (when such data are acceptable to the code official).

5.6 High Albedo Roofs. For roofs in climate zones 1, 2, or 3, where the exterior surface has either of the following:

a. a minimum total solar reflectance of 0.65 when tested in accordance with ASTM C1549, E903, or E1918 and a minimum thermal emittance of 0.75 when tested in accordance with ASTM E408 or C1371, or
b. a minimum solar reflectance index (SRI) of 75 calculated in accordance with ASTM E1980 for medium wind speed conditions,

the R-value of the proposed ceiling shall comply with the values in Table 5.6.1 or the U-factor of the proposed ceiling shall comply with the values in Table 5.6.2. The values for

Table 5.5.2 Correction Factors (F_{cor}) for Ceiling/Roof Assemblies

Member Size[a]	Spacing of Framing Members, in.	Cavity Insulation R-Value			
		R-19	R-30	R-38	R-49
2 × 6	16 o.c.	0.70	0.81	0.85	0.88
2 × 8		0.35	0.65	0.72	0.78
2 × 10		0.35	0.27	0.62	0.70
2 × 12		0.35	0.27	0.51	0.62
2 × 6	24 o.c.	0.78	0.86	0.88	0.91
2 × 8		0.44	0.72	0.78	0.83
2 × 10		0.44	0.35	0.69	0.76
2 × 12		0.44	0.35	0.61	0.69

For SI: 1 in. = 25.4 mm.
[a]Applies to steel framing members up to a maximum thickness of 0.064 in.(16 gauge) (1.6 mm).

Table 5.5.3 Correction Factors (F_{cor}) for Steel Floor Assemblies

Member Size [a]	Spacing of Framing Members, in.	Cavity Insulation R-Value		
		R-19	R-30[b]	R-38[b]
2 × 6	16 o.c.	0.70	NA	NA
2 × 8		0.35	NA	NA
2 × 10		0.35	0.27	NA
2 × 12		0.35	0.27	0.24
2 × 6	24 o.c.	0.78	NA	NA
2 × 8		0.44	NA	NA
2 × 10		0.44	0.35	NA
2 × 12		0.44	0.35	0.32

For SI: 1 in. = 25.4 mm.
[a]Applies to steel framing members up to a maximum thickness of 0.064 in. (16 gauge) (1.6 mm).
[b]NA = not applicable

TABLE 5.6.1 High Albedo Roof—Ceiling Insulation (R-Values)

Zone	Ceilings with Attics		Ceilings w/o Attics	
	Wood R-Value	Steel R-Value	Wood R-Value	Steel R-Value
1	20	20	10	15
2	24	24	17	16
3	27	27	18	18

TABLE 5.6.2 High Albedo Roof—Ceiling Insulation (U-Factors)

Zone	Ceilings with Attics		Ceilings w/o Attics	
	Wood R-Value	Steel R-Value	Wood R-Value	Steel R-Value
1	0.054	0.057	0.082	0.109
2	0.045	0.048	0.053	0.109
3	0.040	0.042	0.049	0.096

solar reflectance and thermal emittance shall be determined by a laboratory accredited by a nationally recognized accreditation organization, such as the Cool Roof Rating Council CRRC-1 Product Rating Program, and shall be labeled and certified by the manufacturer.

5.7 Floors

5.7.1 Slab-on-Grade Floors. All R-values (°F·ft^2·h/Btu) refer only to the insulation, excluding the wall constructions and all other elements such as interior finish materials, the floor slab, exterior finish materials, air films, and the adjacent ground. Perimeter insulation shall begin at the top surface of the slab. The insulation length requirement may be satisfied by a combination of vertical and horizontal sections provided they are continuous. Perimeter insulation is not required of areas of very heavy termite infestation probability, as shown in Figure 5.6.

5.8 Doors. The requirements shall apply to all door assemblies that permit entry or exit from heated or mechanically cooled spaces or both.

5.8.1 Opaque Portion of Non-Wood Doors. The opaque portion of a non-wood door assembly shall not exceed the maximum U-factor shown in Table 5.2.

5.8.2 Opaque Portion of Wood Doors. The opaque portion of a wood door assembly shall not exceed a maximum U-factor of 0.40 Btu/h·ft^2·°F (5.678 W/m^2·K).

5.8.3 Glazed Portion of Any Door. The glazed portion of any door assembly shall not exceed a maximum U-factor as shown in the column entitled "fenestration" in Table 5.2.

5.9 Fenestration. The requirements shall apply to all operable or fixed glazed assemblies, including windows, skylights, and glass doors, and shall not exceed the maximum U-factors and SHGC values as shown in Table 5.2. The U-factor (*U*) of fenestration shall be determined in accordance with NFRC 100, and the SHGC of fenestration shall be determined in accordance with NFRC 200 by an accredited, independent laboratory, and the fenestration shall be labeled and certified by the manufacturer.

Exceptions:

a. Skylight area, including frames, less than or equal to 1% of the total floor space utilized for living, sleeping, eating, cooking, bathing, washing, and sanitation purposes is exempt from this requirement provided the skylight U-factor is less than 0.8.

b. Fenestration that can be thermally separated from the conditioned space (such as sunrooms, solariums, and greenhouses) shall be excluded from the prescriptive U-factor, SHGC, and area requirements provided it is separated by envelope components that meet this standard.

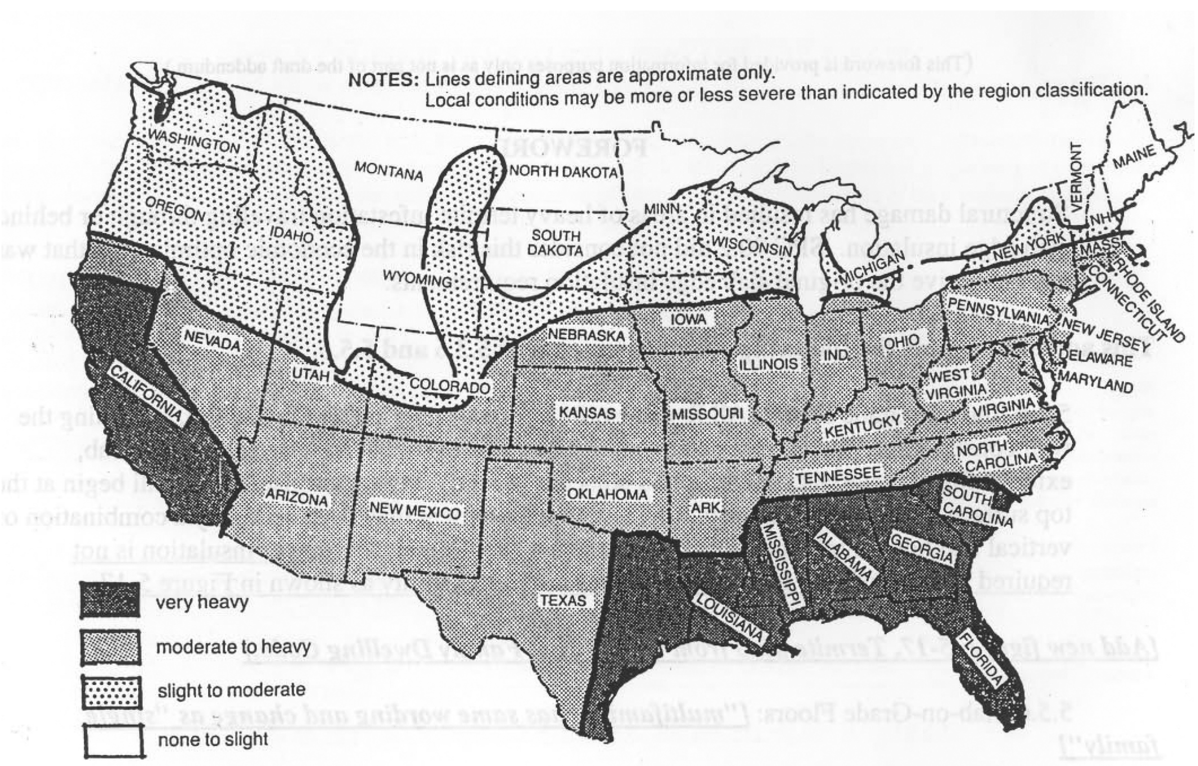

Figure 5.6 Termite infestation probability map.
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5.10 Air Leakage. The building envelope shall meet the provisions of Sections 5.10.1 through 5.10.4 or shall comply with *ANSI/ASHRAE Standard 119, Air Leakage Performance for Detached Single-Family Residential Buildings*.

5.10.1 Windows and Doors. Window and door assemblies shall comply with Table 5.10.1.

5.10.2 Access Openings. Access openings in the building envelope, other than sliding and swinging doors and windows, shall be sealed using weatherstripping and be provided with a latch or some other positive means of closure. The level of insulation provided with the access openings shall be equivalent to that of the building envelope assembly in which it is installed.

5.10.3 Foundations. Foundation walls, crawlspace walls, and other building envelope walls below grade shall have all cracks and the intersection of above-grade construction assemblies with below-grade construction materials sealed.

5.10.4 Joints and Penetrations. Joints and penetrations in the building envelope that are sources of air leakage shall be sealed with caulking, gasketing, weather stripping, or other materials compatible with the construction materials, location, and anticipated conditions.

5.11 Water Vapor Retarders and Moisture Barriers.

5.11.1 A durable continuous moisture barrier at least 6 mil thick shall be placed over exposed soils in crawlspaces and extend 1 ft (305 mm) up the crawlspace walls. Joints in the moisture barrier shall overlap a minimum of 1 ft (305 mm).

5.11.2 A moisture barrier shall be installed beneath a heated slab.

5.12 Envelope Performance Path Trade-Off Method. The building envelope complies with this standard if the proposed building satisfies the provisions of Section 5.2 and the envelope performance factor of the proposed building is less than or equal to the annual heating and cooling energy costs for the envelope of the prescriptive path building. The annual heating and cooling energy cost considers only the building envelope components. Heating, ventilating, and air-conditioning systems and equipment and service water heating shall be the same for both the proposed building and the prescriptive. The envelope performance factor shall be calculated using the procedures of Normative Appendix A.

6. HEATING, VENTILATING, AND AIR-CONDITIONING (HVAC) SYSTEMS AND EQUIPMENT

6.1 General. This section provides performance requirements for heating, ventilating, air-conditioning, and service water heating equipment for one- and two-family houses and multi-family structures.

6.2 Heating, Ventilating, and Air-Conditioning Systems and Equipment. This section shall regulate only equipment using single-phase electric power, air conditioners, and heat pumps with rated cooling capacities less than 65,000 Btu/h (19 kW), warm air furnaces with rated heating capacities less than 225,000 Btu/h (66 kW), boilers less than 300,000 Btu/h (88 kW) input, and heating-only heat pumps with rated heating capacities less than 65,000 Btu/h (19 kW).

6.3 Balancing. The air distribution system design, including outlet grilles, shall provide a means for balancing the air distribution system unless the design procedure provides a system intended to operate within ±10% of design air quantities.

6.4 Insulation for Ducts. All portions of the air distribution system installed in or on buildings for heating and cooling shall be R-8. When the mean outdoor dew-point temperature in any month exceeds 60°F (15°C), vapor retarders shall be installed on conditioned-air supply ducts. Vapor retarders shall have a water vapor permeance not exceeding 0.5 perm (0.003 μg/Pa·s·m^2) when tested in accordance with Procedure A in ASTM E96.

Insulation is not required when the ducts are within the conditioned space.

6.5 Insulation for Piping. HVAC system piping installed to serve buildings and within buildings shall be thermally insulated in accordance with Table 6.5.

6.6 Ventilation and Combustion Air

6.6.1 Ventilation Air. The building shall be designed to have the capability to provide the ventilation air specified in Table 6.6.1. Mechanical ventilation shall be calculated in accordance with Equation 6-1.

Table 5.10.1 Maximum Allowable Air Infiltration Rates,[a] Windows and Doors

Description	Air Infiltration Limit[b]	Reference Standard
Aluminum windows and sliding doors	0.37	AAMA/WDMA/CAS 101/I.S.2/A440
PVC windows and sliding doors	0.37	AAMA/WDMA/CAS 101/I.S.2/A440
Wood windows and sliding doors	0.34	AAMA/WDMA/CAS 101/I.S.2/A440
Wood doors	0.34	AAMA/WDMA/CAS 101/I.S.2/A440
Windows not covered above	0.34 cfm/ft of sash crack	
Fixed windows	0.34 cfm/ft^2 of window area	
Swinging doors	0.50 cfm/ft^2 of door area	

For SI Conversions: 1 cfm/ft = 66.89 m^3/h·m; 1 cfm/ft^2 = 18.29 m^3/h·m^2.
[a]Air infiltration as determined in accordance with ASTM E283 at a pressure differential of 1.57 lb/ft^2 (75 Pa).
[b]For windows the limit is cfm/ft of sash crack and for sliding doors the limit is cfm/ft^2 of door area.

Table 5.12 Performance Path Envelope Criteria

Climate Zone	Ceilings: Attic Space		Ceilings: Without Attic Space (Cathedral or Flat Roof)		Walls: Above-Grade Frame		Walls: Frame Adjacent to Unconditioned Space		Walls: Above-Grade Mass Exterior Insulation	Walls: Above-Grade Mass Interior Insulation	Walls: Below-Grade Exterior Insulation[a]	Walls: Below-Grade Interior Insulation[a]	Walls: Unvented Crawlspace	Floors: Frame Over Exterior		Floors: Frame Over Unconditioned Space and Vented Crawlspace		Floors: Slab-on-Grade (Perimeter Insulation	Doors: Non-Wood	Fenestration: Vertical Glazed Assemblies		Fenestration: Skylights	
	Wood	Steel	Wood	Steel	Wood	Steel	Wood	Steel						Wood	Steel	Wood	Steel						
No.	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	R	U	U	SHGC	U	SHGC[b]
1	0.036	0.038	0.063	0.084	0.089	0.118	0.274	0.442	0.261	0.261	0.633	0.630	0.412	0.060	0.089	0.066	0.090	0	0.39	0.67	0.37	1.60	0.4
2	0.036	0.038	0.041	0.084	0.083	0.090	0.274	0.442	0.261	0.261	0.633	0.630	0.412	0.051	0.089	0.066	0.090	0	0.39	0.67	0.37	1.05	0.4
3A,B	0.036	0.038	0.041	0.080	0.083	0.063	0.094	0.179	0.261	0.181	0.633	0.630	0.065	0.051	0.078	0.051	0.071	0	0.39	0.47	0.40	0.90	0.4
3C	0.036	0.038	0.041	0.080	0.083	0.063	0.094	0.179	0.261	0.181	0.633	0.630	0.065	0.051	0.078	0.051	0.071	0	0.39	0.47	0.40	0.90	NR
4	0.026	0.030	0.041	0.080	0.058	0.063	0.089	0.167	0.153	0.181	0.633	0.630	0.043	0.046	0.070	0.051	0.071	0	0.39	0.35	NR	0.60	NR
5	0.023	0.027	0.036	0.071	0.058	0.047	0.089	0.167	0.153	0.181	0.143	0.079	0.031	0.039	0.070	0.039	0.064	0	0.39	0.35	NR	0.60	NR
6	0.021	0.023	0.026	0.064	0.044	0.047	0.081	0.155	0.115	0.073	0.103	0.079	0.031	0.039	0.070	0.039	0.064	0	0.39	0.35	NR	0.60	NR
7	0.021	0.023	0.026	0.064	0.035	0.047	0.081	0.155	0.115	0.073	0.081	0.079	0.031	0.026	0.070	0.033	0.064	0	0.39	0.35	NR	0.60	NR
8	0.020	0.022	0.026	0.064	0.035	0.047	0.081	0.155	0.115	0.053	0.081	0.079	0.031	0.026	0.070	0.033	0.064	0	0.39	0.35	NR	0.60	NR

[a] Select the below-grade exterior insulation U-factor from Table 5.12 if the proposed design has exterior below-grade wall insulation. Select the below-grade interior insulation U-factor from Table 5.12 if the proposed design has interior below-grade wall insulation or no below-grade wall insulation.

[b] NR = No requirement.

Table 6.5 Minimum Pipe Insulation Thickness (in inches)[a,e]

Fluid Design Operating Temp. Range, °F	Insulation Conductivity		Nominal Pipe Diameter, in.				
	Conductivity, Btu·in./(h·ft²·°F)	Mean Rating Temp., °F	<1	1 to 1-1/4	1-1/2 to 3-1/2	4 to 6	Equal to or greater than 8
Heating Systems (Steam, Steam Condensate, and Hot Water)[b,c]							
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
Cooling Systems (Chilled Water, Brine, and Refrigerant)[d]							
40–55	0.22–0.28	100	0.5	0.5	1.0	1.0	1.0
Below 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 and/or additional insulation.

[e]For piping exposed to outdoor air, increase insulation thickness by 0.5 inch. The outdoor air is defined as any portion of insulation that is exposed to outdoor air. For example, attic spaces and crawlspaces are considered exposed to outdoor air.

Table 6.6.1 Ventilation Air

Category	Minimum Requirement	Conditions
Mechanical ventilation[a]	50 cfm outdoor air	When summer design infiltration rate calculated in accordance with reference standard A or B is less than 0.35 ach[b]
Kitchen exhaust	100 cfm intermittent	All conditions
Bath exhaust	50 cfm intermittent	All conditions

For SI: 1 cfm = 0.00047 m³/s.
[a]Calculate in accordance with Equation 6-1.
[b]Reference standards:
A. ACCA *Manual J*
B. ASHRAE GRP-158

$$\text{Mechanical Ventilation} = ((0.35 - \text{Summer}) \times \text{Volume}) / 60 \tag{6-1}$$

where

Mechanical Ventilation = required mechanical ventilation rate to supplement summer infiltration, cfm

Summer = summer design infiltration rate, ach

Volume = volume of conditioned space, ft³

6.6.2 Combustion Air. Combustion air for fossil fuel heating equipment shall be in accordance with the locally adopted code or with one of the following: natural gas and propane heating equipment, ANSI Z223.1/NFPA 54; oil heating equipment, NFPA 31; solid fuel burning equipment, NFPA 211.

6.7 Electric Heating Systems. Electric heating systems shall be installed in accordance with the following requirements.

6.7.1 Wall, Floor, or Ceiling Electric-Resistance Heating. When wall, floor, or ceiling electric-resistance heating units are used, the structure shall be zoned and heaters installed in each zone in accordance with the heat loss of that zone. Where living and sleeping zones are separate, the minimum number of zones shall be two. If two or more heaters are installed in any one room, they shall be controlled by one thermostat.

6.7.2 Electric Central Warm Air Heating. When electric central warm air heating is to be installed, an electric heat pump or an off-peak electric heating system with thermal storage shall be used.

Exceptions:

a. Electric resistance furnaces where the ducts are located inside the conditioned space and a minimum of two zones are provided where the living and sleeping zones are separate.
b. Packaged air-conditioning units with supplemental electric heat.

6.8 Bath Ceiling Units. Bath ceiling units providing any combination of heat, light, or ventilation shall be provided with controls permitting separate operation of the heating function.

6.9 HVAC Equipment, Rated Combinations. HVAC system equipment and system components shall be furnished with the input(s), the output(s), and the value of the appropriate performance descriptor of HVAC products in accordance with federal law or as specified in Table 6.9, as applicable. These shall be based on newly produced equipment or com-

Table 6.9 Minimum Requirements for Non-Federally Covered HVAC Equipment

Groundwater[a] source heat pump	Cooling mode	11.0 EER @ 70°F Ent. Water 11.5 EER @ 50°F Ent. Water	ARI-325
	Heating mode	3.4 COP @ 70°F Ent. Water 3.0 COP @ 50°F Ent. Water	ARI-325
Unitary A/C	Water-cooled split system	9.3 EER @ 85°F Ent. Water 8.3 IPLV @ 75°F Ent. Water	ARI 210/240
	Evaporatively cooled split system	9.3 EER @ 95°F Out. Amb. 8.5 IPLV @ 80°F Out. Amb.	ARI 210/240

[a]Performance for electrically powered equipment with capacity less than 65,000 Btu/h when rated in accordance with ARI Standard 325.

ponents. Manufacturers' recommended maintenance instructions shall be furnished with and attached to the equipment. The manufacturer of electric resistance heating equipment shall furnish full-load energy input over the range of voltages at which the equipment is intended to operate.

6.10 Controls

6.10.1 Temperature Control. Each system or each zone within a system shall be provided with at least one thermostat capable of being set from 55°F (13°C) to 85°F (29°C) and capable of operating the system's heating and cooling. The thermostat or control system, or both, shall have an adjustable deadband, the range of which includes a setting of 10°F (5.6°C) between heating and cooling when automatic changeover is provided. Wall-mounted temperature controls shall be mounted on an inside wall.

6.10.2 Ventilation Control. Each mechanical ventilation system (supply or exhaust or both) shall be equipped with a readily accessible switch or other means for shutoff. Manual or automatic dampers installed for the purpose of isolating outside air intakes and exhausts from the air distribution system shall be designed for tight shutoff.

6.10.3 Humidity Control

6.10.3.1 Heating. If additional energy-consuming equipment is provided for adding moisture to maintain specific selected relative humidities in spaces or zones, a humidistat shall be provided. This device shall be capable of being set to prevent energy from being used to produce relative humidity within the space above 30%.

6.10.3.2 Cooling. If additional energy-consuming equipment is provided for reducing humidity, it shall be equipped with controls capable of being set to prevent energy from being used to produce a relative humidity within the space below 50% during periods of human occupancy and below 60% during unoccupied periods.

6.10.3.3 Other Controls. When setback, zoned, humidity and cooling controls and equipment are provided, they shall be designed and installed in accordance with Section 6.10.

7. SERVICE WATER HEATING

7.1 Application. Residential-type water heaters, pool heaters, and unfired water heater storage tanks shall meet the minimum performance requirements specified by federal law. Unfired storage water heating equipment shall have a heat loss through the tank surface area of less than 6.5 Btu/h·ft^2.

7.2 Pump Operation. Circulating hot water systems shall be arranged so that the circulating pump(s) can be turned off (automatically or manually) when the hot water system is not in operation.

7.3 Central Water Heating Equipment. Service water heating equipment (central systems) that does not fall under the requirements for residential-type service water heating equipment addressed in Section 7.1 shall meet the applicable requirements for service water-heating equipment found in Standard 90.1.

7.4 Swimming Pools, Hot Tubs, and Spas

7.4.1 Pool Covers. Heated pools shall be equipped with a pool cover.

7.4.2 Covers. Outdoor pools deriving over 70% of the energy for heating (computed over an operating season) from nondepletable sources or from recovery of energy that would otherwise be wasted shall not be required to have pool covers.

7.4.3 Time Clock. Time clocks shall be installed so that the pump can be set to run in the off-peak electric demand period and can be set for the minimum time necessary to maintain the water in a clear and sanitary condition in keeping with applicable health standards.

7.4.3.1 Pump. Pumps used to operate solar pool heating systems are not required to have time clocks installed.

7.5 Heat Traps. Heat traps shall be installed on both the inlet and outlet of water heaters that have vertical pipe risers connected to the top of the heater unless the water heater is equipped with an integral heat trap or is part of a circulating system. The heat trap shall be installed as close as possible to the inlet and the outlet fitting. The heat trap may be an arrangement of piping and fittings, such as elbows, or a commercially available heat trap that prevents the thermosiphoning of the hot water during standby periods.

8. ANNUAL ENERGY COST METHOD

8.1 Purpose

8.1.1 Compliance. This section provides a compliance path for a proposed design based on calculated annual energy cost (AEC). The procedure consists of a comparison of the AEC of the proposed design with the AEC of a prescriptive design that meets the requirements of Sections 5, 6, and 7, and whose characteristics are defined in this section. If the AEC of the proposed design is less than or equal to the AEC of the prescriptive design, then the proposed design complies with the standard and need not comply with the specific requirements of Sections 5, 6, and 7. The intent is to allow flexibility in the design process while ensuring that the AEC of the proposed design is no more than is allowed under the prescriptive path.

Informative Note: This compliance path provides an opportunity to account for the benefits of innovative designs, materials, and equipment (such as active and passive solar heating and cooling, heat recovery, air-to-air heat exchangers, innovative foundation systems, advanced controls, high-efficiency equipment, radiant barriers, thermal mass, operable shading and insulation, and thermal storage) when they cannot be evaluated adequately under the prescriptive procedures.

This section also provides a procedure for estimating the AEC for building designs under standard conditions. In addition to providing compliance calculations, this procedure is intended to be used by designers for estimating energy costs of proposed designs. These estimates are based on reasonable assumptions for average conditions and may be used by designers, owners, financiers, and others in evaluating and comparing building designs. This procedure is intended to predict the AEC under average conditions. However, the AEC of any specified building may differ due to variations in construction, occupancy, operation, maintenance, and weather. Energy use for unusual equipment that is not included in the procedure (for example, swimming pools, hot tubs, saunas, engine block heaters, or well pumps) may also be a significant factor. Simplified calculation methods may be used to calculate the impact of certain design parameters; however, dynamic simulations using hourly weather data are recommended.

8.2 Scope. Annual energy cost compliance is applicable to energy use for space conditioning only. Energy for other uses, such as domestic hot water, cooking, lighting, and appliances, is included for total energy cost estimates but is not a variable between the proposed design and prescriptive design for compliance with this standard. Capital costs, replacement costs, maintenance costs, finance charges, and other construction or equipment costs are not included. Although space-conditioning, domestic hot water heating, and appliance energy costs are calculated together, no compliance trade-offs are allowed between them.

8.3 Mandatory Requirements. The proposed design and the AEC calculation shall comply with the requirements for calculations, testing, and rating specified in Sections 5, 6, and 7. The proposed design shall also comply with all other requirements of Sections 5, 6, and 7 if the effect of the requirements on the AEC of the prescriptive design is not fully and accurately included in the calculations performed in this section.

8.4 General

8.4.1 Professional Judgment. The modeling techniques and assumptions prescribed in this standard shall be used where specified. However, professional judgment is required where the standard does not prescribe specific modeling techniques and assumptions. Two rules shall be used when applying professional judgment. First, the proposed design and prescriptive design shall both be analyzed using the same techniques and assumptions except where differences in conservation features require a different approach. Second, simplifying assumptions that may reduce the energy use of the proposed design in relation to the prescriptive design shall not be used.

8.4.2 Assumption of Full Conditioning. All conditioned floor space in all buildings shall be assumed to be fully conditioned to maintain the specified thermostat setpoints during the entire year. Typical quantities of domestic hot water shall also be assumed to be supplied to all buildings. If equipment to supply full heating, cooling, and domestic hot water is not specified for the proposed design, equipment meeting the prescriptive requirements of this standard shall be assumed to operate for purposes of calculating the AEC.

8.5 Annual Energy Cost

8.5.1 Annual Energy Cost Definition. The AEC of a design shall be the total cost to supply energy for a single year during which the weather is typical of the long-term average conditions at the site. Energy prices during the typical year shall be those in effect at the time the calculations are done.

8.5.2 Annual Energy Cost Calculation. The AEC shall be the sum of the costs for each energy type consumed as calculated using Equation 8-1. The monthly energy costs (MECs) for an energy type shall be calculated using Equations 8-2, 8-3, and 8-4. The current rate or price quoted by the usual supplier and available at the site for the proposed design's type and size shall be used. The same rate schedule shall be used for the prescriptive and proposed designs unless a different rate is applicable to the proposed design because of energy conservation features. Where applicable, demand charges, rate blocks, and time-of-use rates shall be taken into account, and energy costs calculated accordingly. In buildings with multiple meters and multiple bills, the energy use shall be apportioned to each meter if this would affect the AEC. The energy consumed by space heating and cooling electric auxiliaries shall be included in the AEC.

$$AEC = \sum_{j=1}^{12} (MEC_{E,j} + MEC_{G,j} + MEC_{O,j}) \quad (8\text{-}1)$$

where

j = month of the year

$MEC_{E,j}$ = monthly energy cost for electricity, \$

$MEC_{G,j}$ = monthly energy cost for gas, \$

$MEC_{O,j}$ = monthly energy cost for other fuels, \$

The MEC for electricity is calculated using Equation 8-2:

$$MEC_{E,j} = [(O_E + DHW_E) \times Days_j + SH_{E,j} + SC_{E,j}] \times Rate_{E,j} \quad (8\text{-}2)$$

where

O_E = occupant electricity use from Equation 8-16, kWh/day

DHW_E = domestic hot water electricity use from Equation 8-12 or 8-14, kWh/day

$Days_j$ = days in the jth month

$SH_{E,j}$ = space-heating electricity use, kWh/month

$SC_{E,j}$ = space-cooling electricity use, kWh/month

$Rate_{E,j}$ = electric rate cost (including block effects), VkWh

The monthly energy cost for gas is calculated using Equation 8-3:

$$MEC_{G,j} = [(O_G + DHW_G) \times Days_j + SH_{G,j} + SC_{G,j}] \times Rate_{G,j} \tag{8-3}$$

where

O_G = occupant gas use from Equation 8-17, therms/day

DHW_G = domestic hot water gas use from Equation 8-13 or 8-15, therms/day

$SH_{G,j}$ = space-heating gas use, therms/month

$SC_{G,j}$ = space-cooling gas use, therms/month

$Rate_{G,j}$ = gas rate costs (including block effects), $/therm

The monthly energy cost for other fuels is calculated using Equation 8-4:

$$MEC_{O,j} = (DHW_O \times Days_j + SH_{O,j} + SC_{O,j}) \times Rate_{O,j} \tag{8-4}$$

where

DHW_o = domestic hot water use of other fuels, units/day

$SH_{O,j}$ = space heating use of other fuels, units/month

$SC_{O,j}$ = space cooling use of other fuels, units/month

$Rate_{O,j}$ = other fuels rate costs (including block effects), $/unit

8.6 Proposed Design. The analysis of the proposed design shall take into account all qualities, details, and characteristics of the design that significantly affect energy use and cost. These include construction, geometry, orientation, exposure, materials, equipment, and renewable energy sources. The characteristics and all significant energy conservation features shall be documented in the construction documents.

8.6.1 Annual Energy Cost of the Proposed Design. The AEC for the proposed design shall be one of the following:

a. the AEC for the proposed design, calculated for its combination of design, orientation, and site.
b. the highest AEC for the proposed design, simulated in each of the four cardinal orientations. Note that compliance via this method allows the proposed design to be built in any orientation.

8.6.2 Groups of Buildings. Averaging of groups of buildings shall not be allowed. Each building must comply on its own.

8.6.3 Buildings with Multiple Living Units. The AEC shall be calculated for the entire building if it has conditioned common spaces, such as corridors, recreation rooms, or laundries, or has central mechanical systems serving more than one living unit. If the building has no conditioned common spaces and no common mechanical systems, the AEC may be calculated either for the whole building or unit-by-unit.

8.6.3.1 Unit-by-Unit Calculations. For unit-by-unit calculations, an AEC is calculated separately for each proposed living unit plan according to one of the two approaches in Section 8.6.1. Top-floor, mid-floor, and bottom-floor units shall be considered separate living unit plans. Walls and other surfaces that separate living units from other living units shall be assumed to have no heat transfer.

8.6.3.2 Whole-Building Calculations. For whole-building calculations, a single AEC shall be determined by one of the following methods:

a. Calculate the AEC for the entire building as a single zone. Conditioned common spaces such as corridors and lobbies shall be included.
b. If each living unit meets the requirements of Sections 8.8.4.2(a), (b), and (c), the AEC may be calculated for the entire building as two zones by aggregating all of the living spaces of all units into one zone and all of the sleeping spaces into another. Sleeping spaces shall include bedrooms and associated bathrooms, dressing rooms, closets, and hallways. All other conditioned spaces shall be considered living spaces. Common spaces such as corridors and lobbies, if conditioned, shall be treated as living spaces.
c. Calculate the AEC for the entire building as the sum of the AECs of each living unit calculated separately. The AEC of conditioned common spaces shall be calculated and included in the building's total AEC.

8.6.4 Shading. When credit for passive solar-heating effects is being included in the analysis, the effect of the following types of shading shall be included in the analysis using an appropriate calculation tool selected from Section 8.8.5:

a. Self shading—shading by its own walls, roof, balconies, trellises, awnings, and other features or devices considered a part of the proposed design.
b. External shading—shading by existing, permanent landscape features such as trees, mountains, and other buildings.

8.7 Prescriptive Design. Calculations for the prescriptive design establish the AEC budget allowed for the proposed design. The geometry and orientation of the prescriptive design shall be as defined below. Envelope, HVAC, and domestic hot water systems shall meet the requirements of Sections 5, 6, and 7. Note that the prescriptive design is not intended to be a real physical structure and in many cases may be geometrically impossible.

8.7.1 Ducts. Ducts located in the prescriptive design shall be in the same location as the proposed design.

Exceptions: The distribution factor in the prescriptive design shall be assumed to be 0.85 for both heating and cooling when:

a. the ducts are installed in conditioned attic spaces, or
b. the ducts are installed in conditioned crawlspaces, or
c. the building official determines that the building design has been specifically altered to move the distribution system inside the conditioned space.

8.7.2 Floor Area. The conditioned floor area of the prescriptive design shall be equal to that of the proposed design.

8.7.3 Volume. The volume of the prescriptive design shall be equal to the volume of the proposed design.

8.7.4 Ceiling. The exposed ceiling area of the prescriptive design shall be equal to the exposed ceiling area of the proposed design. The exposed ceiling area of the prescriptive design shall be assumed to be a horizontal, unventilated, lightweight construction meeting the U-factor requirements for ceilings with attics.

8.7.5 Walls. The total exterior wall area of the prescriptive design shall be equal to the total exterior wall area of the proposed design. The area in the prescriptive design of each type of wall defined in Section 5 (for example, above-grade frame walls or above-grade concrete, masonry, or log walls with interior insulation) shall be equal to the area of that type of wall in the proposed design. One-fourth of the area of each wall type shall face each cardinal orientation.

8.7.6 Doors. The prescriptive design shall have one 40 ft^2 opaque, wood door facing north for each living unit in the proposed design.

8.7.7 Fenestration. The total vertical fenestration area of the prescriptive design shall be equal to the total fenestration area of the proposed design (including skylights). One-fourth of the fenestration area in the prescriptive design shall be located vertically on each orientation. The prescriptive design shall have no skylights.

8.7.8 Floors and Foundation Type. The prescriptive design shall have the same foundation type and floor constructions with the same fraction of each construction as the proposed design. The slab-on-grade perimeter shall be the same as in the proposed design. All floor conditions in the prescriptive design house shall be constructed and modeled in a manner consistent with that of the proposed design except that the prescriptive design shall meet the requirements of Section 5.

Select the below-grade exterior insulation U-factor from Table 5.12 if the proposed design has exterior below-grade wall insulation. Select the below-grade interior insulation U-factor from Table 5.12 if the proposed design has interior below-grade wall insulation or no below-grade wall insulation.

8.7.9 Shading. Walls and windows of the prescriptive design shall be considered to have no self or external shading, except any external shading modeled for the proposed design shall be modeled for the prescriptive design.

8.8 Calculation Procedure for Space Conditioning. The same calculation procedure shall be used for both the proposed design and prescriptive design except where noted. The calculation procedure shall account for the design parameters addressed in Sections 8.8.1 through 8.8.4 using the appropriate calculation tool selected from Section 8.8.5.

8.8.1 Internal Heat Gains. Internal heat gains from lights, people, and equipment shall be considered in calculating space-conditioning loads and energy consumption. The total internal gain shall be calculated by Equation 8-5. For single-zone calculations, the daily total sensible internal gains (Btu/day) shall be determined by Equation 8-6. For multiple-zone HVAC systems, the sensible internal gains shall be determined using Equation 8-6 for the living zone and Equation 8-7 for the sleeping zone. The daily total latent load for each zone shall be determined using Equation 8-8.

$$\text{Total Heat Gains} = \text{Sensible Heat Gains} + \text{Latent Heat Gains} \tag{8-5}$$

Single Zone or Living Zone:

$$\begin{gathered}\text{Sensible Heat Gains} = \\ (\text{Floor Area of Zone} \times 15\ \text{Btu/day} \cdot \text{ft}^2) \\ + (\text{Number of Living Units} \times 20{,}000\ \text{Btu/day})\end{gathered} \tag{8-6}$$

Sleeping Zone:

$$\begin{gathered}\text{Sensible Heat Gains} = \\ \text{Floor Area of Zone} \times 15\ \text{Btu/day} \cdot \text{ft}^2\end{gathered} \tag{8-7}$$

$$\begin{gathered}\text{Latent Heat Gains} = \\ 0.2 \times \text{Sensible Heat Gains}\end{gathered} \tag{8-8}$$

Internal heat gains shall be distributed over the day according to the profile in Table 8.8.1. The load for each hour is the daily total gain multiplied by the factor from the appropriate column.

Where multiple-zone space conditioning is modeled, the profile shown for Zone 2 shall be used for bedrooms and bathrooms; the profile shown for Zone 1 shall be used for all other conditioned rooms. Where single-zone space conditioning is modeled, the hourly profile for single-zone designs shall be used.

8.8.2 Internal Thermal Mass. Both the prescriptive design and proposed design shall have the same occupancy thermal mass (furniture and contents). The value shall be 8 lb/ft^2 of the conditioned floor area. This is based on 2 in. wood with a specific heat of 0.39 Btu/lb·°F and a conductivity of 1.0 Btu·in./(h·ft^2·°F). To account for structural mass (such as partition walls), a value of 5.0 lb/ft^2 of the conditioned floor area shall be used for the prescriptive design. This is based on the thermal

TABLE 8.8.1 Daily Internal Heat Gain Profile

Time of Day	Single Zone	Multiple Zones	
		Zone 1 Living	Zone 2 Sleeping
0000–0100	0.024	0.0161	0.0438
0100–0200	0.022	0.0148	0.0402
0200–0300	0.021	0.0114	0.0450
0300–0400	0.021	0.0113	0.0450
0400–0500	0.021	0.0121	0.0432
0500–0600	0.026	0.0146	0.0546
0600–0700	0.038	0.0277	0.0639
0700–0800	0.059	0.0530	0.0740
0800–0900	0.056	0.0633	0.0376
0900–1000	0.060	0.0686	0.0385
1000–1100	0.059	0.0638	0.0470
1100–1200	0.046	0.0500	0.0361
1200–1300	0.045	0.0484	0.0365
1300–1400	0.030	0.0315	0.0263
1400–1500	0.028	0.0294	0.0246
1500–1600	0.031	0.0341	0.0232
1600–1700	0.057	0.0619	0.0447
1700–1800	0.064	0.0718	0.0445
1800–1900	0.064	0.0724	0.0429
1900–2000	0.052	0.0596	0.0330
2000–2100	0.050	0.0549	0.0375
2100–2200	0.055	0.0620	0.0375
2200–2300	0.044	0.0438	0.0445
2300–0000	0.027	0.0235	0.0359

properties of l/2 in. gypsum board. The proposed design shall use the same value as the prescriptive design or a different structural mass assumption if detailed calculations are documented. Calculation methods that assume massless exterior walls and a combined interior thermal mass node shall use 3.5 Btu/°F per square foot of conditioned floor area total mass in the prescriptive design and in the proposed design unless additional structural thermal mass is documented in the proposed design.

8.8.3 Envelope

8.8.3.1 Exterior Absorptivity. Since colors are subject to change over the life of the building, the exterior absorptivity of all exterior walls shall be 0.5 regardless of color, and the exterior absorptivity of roofs shall be 0.2 regardless of color. If unconditioned spaces such as garages are not modeled, walls between them and conditioned space shall be treated as exterior walls with an absorptivity of zero.

Note: For low absorptivity roofs, the prescriptive design is permitted to employ the values in Section 5.6.

8.8.3.2 Window Internal Shading. Fenestration shall be assumed to be internally shaded for both the prescriptive and the proposed design cooling load calculations. Such shading shall be assumed to reduce the fenestration shading coefficient by 30% of its value without internal shading but shall have no effect on window U-factor. Credit shall be taken for higher performance shading and insulation systems in the proposed design that demonstrate significantly higher performance. All operable shading and drapes shall be closed when the air conditioner is running (1) to meet a cooling load and (2) at night, but they should be open during the rest of the day.

8.8.3.3 Natural Ventilation. Both the proposed design and the prescriptive design shall utilize occupant-managed natural ventilation to maintain the indoor comfort whenever the outdoor air condition allows the indoor cooling setpoint temperature to be maintained at a relative humidity of 70% or less. Natural ventilation strategies shall be used to reduce indoor temperature below the cooling setpoint when this is advantageous. Both the proposed design and the prescriptive design shall use the same control strategy for natural ventilation. The free vent area for the prescriptive design shall be 10% of the glazing area uniformly distributed. To account for screens, other obstructions, and occupant behavior, the maximum free vent area in the proposed design shall be 50% of the maximum clear opening or vent area reported by the manufacturer.

8.8.3.4 Infiltration. One of the three methods of calculating infiltration effects listed below shall be used. For the first two methods, infiltration rates for both the proposed design and prescriptive design are identical and the prescriptive infiltration requirements of Section 5.9 shall be met in the proposed design.

8.8.3.4.1 Both the proposed design and prescriptive design shall be assumed to have a constant air change rate of 0.5 ach.

8.8.3.4.2 Infiltration shall be calculated for both the proposed design and prescriptive design based on the effective leakage area (ELA) and site conditions for the proposed design plus an allowance for occupancy. The ELA shall be determined using methods described in the *ASHRAE Handbook—Fundamentals,* Standard 119, using a standard pressure of 4 Pa, or from standard test methods such as ASTM E283. The determination of the energy loss from infiltration shall be based upon the hourly calculation of specific infiltration as described in the *ASHRAE Handbook—Fundamentals,* Standard 119, or an equivalent method. A constant of 0.15 ach shall be added to the calculated leakage to account for occupancy-caused infiltration through door openings, exhaust fans, etc.

8.8.3.4.3 The infiltration of the proposed design shall be calculated according to Section 8.8.3.4.2 based on an assumed ELA at 4 Pa plus an allowance of 0.15 ach for occupancy effects. The infiltration rate in the prescriptive design shall be a constant 0.5 ach. Every building shall be measured after completion using ASTM E779 or an equivalent to verify that the actual ELA is less than or equal to that assumed in the calculation. Compliance is not achieved until this test is successfully completed.

8.8.4 HVAC Systems and Equipment

8.8.4.1 General. The annual energy cost of the proposed design shall be calculated using the HVAC equipment specified. The same fuel source shall be used in the proposed design and the prescriptive design. Equipment of the same DOE product class shall be used in the proposed design and prescriptive design except for the following:

a. For an electric central warm air system without thermal storage, the prescriptive design shall have an air-source heat pump.

b. For any electric heating system without thermal storage in climates greater than 2000 heating degree-days (base 65°F), the prescriptive design shall have an air-source heat pump.

The mechanical systems in the prescriptive design shall meet the minimum requirements specified in Section 6. If the system specified in the design is not directly categorized in Section 6, then the system from Section 6 that uses the same fuel type and that is most similar to the design shall be selected. If a design uses more than one fuel type for one purpose, such as a combination of electricity and gas for space heating, the prescriptive design shall utilize the same fuel sources for that purpose in the same proportions as the proposed design. In no case shall the energy cost comparison between prescriptive design and proposed design include changes from one fuel type to another for the same purpose, except where the proposed design utilizes renewable sources not included in the prescriptive design.

8.8.4.2 Zoning. The prescriptive design shall have one thermal zone. If electric resistance is modeled in the prescriptive design as specified in Section 6.7, then one of two options shall be used for modeling the proposed design. The first option is to model the proposed design as a single thermal zone. The second option is to model two thermal zones—a living zone and a sleeping zone—in each living unit when calculating the AEC of the proposed design if the following three conditions are met:

1. Each zone has its own thermostat that controls the supply of heating and cooling to the zone.
2. The total nonclosable opening area between adjacent zones in a living unit is less than 40 ft^2, and all remaining zonal boundary areas shall be separated by permanent walls or operable doors (or both) that are capable of restricting free air movement in the closed position.
3. For forced-air systems, conditioned air flows into, through, and out of a zone only when a zone requires conditioning. No measurable amount of air shall be discharged into any zone through damper leakage or as a bypass for system control. Each zone has its own return register located in the zone, but return dampers are not required.

8.8.4.3 Mechanical Ventilation. If the proposed design has a mechanical outdoor air ventilation system, the prescriptive design shall have a similar system meeting the prescriptive requirements and supplying the same air quantity.

8.8.4.4 Equipment Efficiency. Calculation of energy consumption shall be based on the data collected in the DOE-mandated test procedure for the equipment specified. The efficiency descriptor used to set minimum efficiency requirements in Section 6 shall be used to calculate energy consumption based on loads for methods in which a single efficiency is required. The same method of calculation shall be used in both the proposed design and the prescriptive design.

Informative Note: The use of more sophisticated calculations, which take any combination of ambient temperature, part load, sizing, or other effects into account, is encouraged.

8.8.4.5 Distribution Losses. The effects of distribution losses on the AEC of the proposed design shall be included for all central systems that use ducts that run partly or completely through unconditioned spaces. Equation 8-9 shall be used to adjust the efficiency of equipment to account for distribution losses:

$$\begin{gathered}\text{Adjusted Efficiency} = \\ \text{Equipment Efficiency} \times \text{Distribution Factor}\end{gathered} \tag{8-9}$$

The distribution factors from Table 8.8.4.5(1) shall be used with Equation 8-9. For systems with equipment and ducts located entirely within conditioned space or with less than 8 linear feet of ducts located in unconditioned space, the distribution factor shall be 1.0. If a basement with insulated walls contains ducts, the distribution factor shall be 1.0 provided all other ducts are within conditioned space or less than 8 linear feet are located in unconditioned space and all assemblies in the basement envelope meet the prescriptive requirements in Section 5. If equipment, ducts, or both are located on the roof or the exterior of the building, the distribution factor shall be 0.75 for heating and 0.80 for cooling. If a system has ducts located in more than one type of situation, the lowest applicable distribution factor shall be used. If ducts are located in the garage, the distribution factors for attics shall be used.

8.8.4.6 Equipment Capacity and Redundant Equipment. For calculation methods where equipment capacity does not affect energy consumption, the capacity of the equipment in the proposed design shall be ignored. Otherwise, actual equipment capacities and types shall be used in calculations unless the actual capacity is not adequate to meet the calculated load. In that case, for the purpose of calculating the AEC, the equipment capacity shall be increased to meet the load. If more than one type of equipment is assigned to the load, the capacity of the one with the highest energy cost shall be increased. For example, if a heat pump system with resistance backup heat is too small to meet the heating load, the resistance heater capacity shall be increased. The proposed design and the prescriptive design shall have equipment sized in a consistent manner, but not necessarily the same capacity, if, for example, the design loads are different. However, heat pump compressors for the prescriptive-design AEC calculation shall be sized to meet the smaller of the heating load or 125% of the cooling load at the respective design conditions.

Redundant equipment, emergency equipment, or both need not be included if it is controlled such that it will not operate under normal conditions.

TABLE 8.8.4.5(1) Distribution Factors

Duct Insulation °F·ft²·h/Btu	Duct Location					
	Attic		Crawlspace under Insulated Floor		Basement under Insulated Floor or Crawlspace with Insulated Walls	
	Heating	Cooling	Heating	Cooling	Heating	Cooling
One-Story Buildings:						
R-2	0.78	0.74	0.78	0.84	0.81	0.85
R-4	0.82	0.81	0.82	0.86	0.85	0.87
R-6	0.84	0.83	0.84	0.87	0.86	0.88
Two- and Three-Story Buildings:						
R-2	0.85	0.83	0.85	0.89	0.87	0.90
R-4	0.88	0.87	0.88	0.91	0.90	0.91
R-6	0.90	0.89	0.90	0.91	0.91	0.92

TABLE 8.8.4.5(2) Thermostat Settings (°F)

Time of Day	Single Zone		Multiple Zone			
			Zone 1 Living		Zone 2 Sleeping	
	Heat	Cool	Heat	Cool	Heat	Cool
0600–0900	68	78	68	78	68	78
0900–1700	68	78	68	78	60	85
1700–2300	68	78	68	78	68	78
2300–0600	60	78	60	85	60	78

8.8.4.7 Thermostat Setpoints. In calculating the AEC for both the prescriptive design and the proposed design, all conditioned spaces shall be maintained at the specified thermostat setpoints at all times except for minor deviations at thermostat setup and setback and when outdoor conditions exceed normal design conditions. If the specified equipment in the proposed design is too small to meet the load, its capacity shall be increased in the calculations. If equipment to meet a load is not included in the design, such equipment shall be assumed in the calculations and its energy cost included. In no case shall the AEC of the proposed design be reduced by not conditioning its spaces.

For central space-conditioning systems without zonal control, the entire conditioned floor area shall be one thermostatically controlled zone. The thermostat settings shall be those listed for a single zone in Table 8.8.4.5(2). For multiple-zone designs, the multizone thermostat settings in Table 8.8.4.5(2) shall be used. Zone 1 represents all conditioned spaces other than Zone 2 (bedrooms and bathrooms). The effect of heat transfer between zones including nonclosable openings shall be included in the calculation.

8.8.5 The Calculation Tool. The same calculation tool shall be used to calculate the AEC of both the prescriptive design and proposed design. The calculation tool shall be appropriate for the design parameters that are being analyzed. The calculation tool shall estimate the AEC impact of each energy conservation feature of the proposed design that deviates from the prescriptive design.

Hand calculation analyses shall include a written documentation of the assumptions made. Computer analysis shall be performed using programs that utilize scientifically justifiable techniques and procedures for modeling building loads, systems, and equipment. Computer program documentation shall state what methods are used and which conservation methods are accurately modeled.

Energy consumption for occupant energy uses shall be calculated according to Equations 8-16 and 8-17. The energy consumption for these end-uses shall be added to those calculated for heating and cooling for both the prescriptive design and proposed design before annual energy costs are calculated.

One of the calculation methods addressed in Sections 8.8.5.1 through 8.8.5.4 shall be used.

8.8.5.1 Simplified Calculation Methods. Annual heating and cooling energy shall be calculated using variable-base degree-days, as found in the *ASHRAE Handbook—Fundamentals*. Passive solar effects shall be calculated using the solar load ratio method as specified in *ASHRAE-Passive-Solar Heating Analysis*. These methods are applicable for calculations for the following conservation measures in climates with less than 8000 cooling degree-hours base 74°F (CDH74):

a. envelope and glazing U-factor and area,
b. equipment efficiency, and
c. passive solar effects.

8.8.5.2 Bin Calculation Method. Calculation techniques for this method are specified in simplified energy calculations in the *ASHRAE Handbook—Fundamentals* and *ASHRAE Simplified Energy Analysis Using the Modified BIN Method*. This procedure is applicable for the following measures in any climate:

a. envelope and glazing U-factor and areas,
b. equipment efficiency, and
c. evaporative and ventilative cooling.

8.8.5.3 Correlation Methods. Heating and cooling energies are calculated through correlation to a database generated for representative configurations using detailed hourly transient analysis. The database results are then translated into simplified algorithms that can be presented as tables, nomographs, or microcomputer programs. Correlation methods are allowed if it is shown that the construction variables to be analyzed are adequately quantified by the simulation program used to generate the database and that the results are reliably re-created by the simplified algorithms. Correlation methods shall not be used for analysis of weather or construction variables not covered by or outside the range of the database. The methodology used to generate the database, the correlation techniques, and their comparison to the basic data shall be well documented.

8.8.5.4 Transient Analysis Using Hourly Weather Data. This method uses calculation techniques as specified in the *ASHRAE Handbook—Fundamentals*. The method uses transfer functions, finite differences, or other methods to calculate the transient responses of the building to hourly weather data for a typical year. ASHRAE WYEC or NNC TMY weather data sets or the equivalent shall be used. If weather data for an entire year are not used, the weather data used must represent the full range of climatic variation for the full year in the chosen location. Documentation shall include the building location and weather station used in the analysis. Documentation shall also include adjustments made to compensate for microclimatic differences between the building site and the weather station.

8.9 Calculation Procedures for Domestic Hot Water Heating

8.9.1 General. Domestic hot water shall be assumed to be supplied to all living units. Both the proposed design and the prescriptive design shall use the domestic water heating system designed for the proposed application.

8.9.2 Domestic Hot Water Load. The total domestic hot water load used to calculate the annual energy consumption shall be the same for the prescriptive design and the proposed design. It shall be determined using Equation 8-10.

$$DHWL = AGPD \times 8.28 \times (135 - T_{inlet}) \tag{8-10}$$

where

$DHWL$ = domestic hot water load of the building, Btu/day

$AGPD$ = average gallons per day of hot water consumption, determined using the procedure described in Section 8.9.3

T_{inlet} = inlet mean water temperature, which shall be assumed to be equal to the average annual outdoor dry-bulb air temperature for the climate zone from Table 8.9.2 or 40°F, whichever is higher

8.9.3 Determine Average Gallons Per Day. The average gallons per day of hot water consumption for living units to be used in calculating hot water energy consumption shall be estimated with Equation 8-11.

$$AGPD = [CW + SPA + B](NP) \tag{8-11}$$

where

$AGPD$ = average gallons per day of hot water consumption

CW = 2.0 gal/day per person if a clothes washer is present in living unit, otherwise zero

SPA = 1.25 gal/day per person additional hot water use if a "spa-tub" is present in living unit, otherwise zero

B = 13.2 gal/day per person

NP = number of people in living unit; if exact information is unknown, estimate as follows:

(1.0)(NSR) for single-family detached and manufactured (mobile) homes with one to four sleeping rooms, plus (0.5)(NSR) for each sleeping room beyond four, or

(1.25)(NSR) for multifamily buildings with one to four sleeping rooms per dwelling unit, plus (0.5)(NSR) for each sleeping room beyond four

where NSR = number of sleeping rooms

Notes:

1. Equation 8-11 is based on the assumption that each living unit has its own individual water heater and cooking and bathing facilities and that water heating costs are paid for directly by the living unit's occupants, i.e., not included in rent.
2. For the purposes of Equation 8-11, the value for the number of sleeping rooms (NSR) has to be a number greater than zero per living unit.
3. Equation 8-11 is intended for use in estimating average energy consumption only. It is not appropriate for, nor intended for use for, system sizing purposes.

8.9.4 Energy Consumption. The daily average electric energy consumption of federally covered residential electric water heaters shall be determined by Equation 8-12. For federally covered commercial electric water heating equipment, Equation 8-14 shall be used. The daily gas consumption of

Table 8.9.2 Average Annual Outdoor Dry-Bulb Temperature by Climate Zone

Climate Zone	Average Annual Outdoor Dry-Bulb Temperature, °F
1	78
2	69
3 A,B	62
3 C	60
4	55
5	49
6	44
7	38
8	24

federally covered residential gas water heaters shall be determined by Equation 8-13. For federally covered commercial gas water heating equipment, Equation 8-15 shall be used. The daily energy use of domestic water heaters using the other fuels (such as fuel oil) shall be determined using appropriate conversion factors.

$$DHW_E = (DHWL/0.98 + Heaters \times (41,000/EF - 41,837))/3413 \quad (8\text{-}12)$$

$$DHW_G = (DHWL/E_r + Heaters \times (41,000/EF - 41,000/E_r))/100,000 \quad (8\text{-}13)$$

$$DHW_E = (DHWL + 24 \times Standby)/3413 \quad (8\text{-}14)$$

$$DHW_G = (DHWL + 24 \times Standby)/((1.0 - Flue) \times 100,000) \quad (8\text{-}15)$$

where

DHW_E = domestic hot water electricity use, kWh/day
DHW_G = domestic hot water gas use, therms/day
Heaters = number of water heaters in the proposed design
EF = energy factor
E_r = recovery efficiency (if E is not known, use 0.76)
Standby = total hourly standby loss from all water heaters, Btu/h
Flue = flue losses (fraction)

8.9.5 Hourly Domestic Hot Water Fraction. Where hourly hot water load is required, it shall be distributed over the day according to the profile in Table 8.9.5. The hourly hot water load is DHWL multiplied by the factor for the hour.

8.10 Occupant Energy Use. Occupant energy consumption for uses other than heating, cooling, and domestic hot water shall be calculated according to Equation 8-16 for electricity and Equation 8-17 for natural gas. Consumption of other fuels shall be calculated using the appropriate conversion factors. If hourly values are required, occupant energy use shall be apportioned using the hourly profile for single zones in Table 8.8.1.

TABLE 8.9.5 Daily Domestic Hot Water Load Profile

Time of Day	Factor
0000–0100	0.0085
0100–0200	0.0085
0200–0300	0.0085
0300–0400	0.0085
0400–0500	0.0085
0500–0600	0.0100
0600–0700	0.0750
0700–0800	0.0750
0800–0900	0.0650
0900–1000	0.0650
1000–1100	0.0650
1100–1200	0.0460
1200–1300	0.0460
1300–1400	0.0370
1400–1500	0.0370
1500–1600	0.0370
1600–1700	0.0370
1700–1800	0.0630
1800–1900	0.0630
1900–2000	0.0630
2000–2100	0.0630
2100–2200	0.0510
2200–2300	0.0510
2300–0000	0.0085

Note: These hourly values include a large diversity factor and shall not be used to calculate peak loads for equipment sizing.

Occupant Electricity Consumption:

$$O_E = A_F \times 0.0045 + R_E \times (0.9589 + A_F \times 0.001) + D_E \times (3.068 + A_F \times 0.001) \quad (8\text{-}16)$$

Occupant Natural Gas Consumption:

$$O_G = R_G \times (0.0685 + A_F \times 0.000034) + D_G \times (0.1047 + A_F \times 0.000034) \quad (8\text{-}17)$$

where

A_F = conditioned floor area of building, ft^2
O_E = occupant electricity use, kWh/day
R_E = number of electric range tops
D_E = number of electric dryers
O_G = occupant gas use, therms/day
R_G = number of gas range tops
D_G = number of gas dryers

9. CLIMATIC DATA

9.1 Scope. The climatic data contained in this section shall apply to Sections 5, 6, 7, and 8 for a given geographic location.

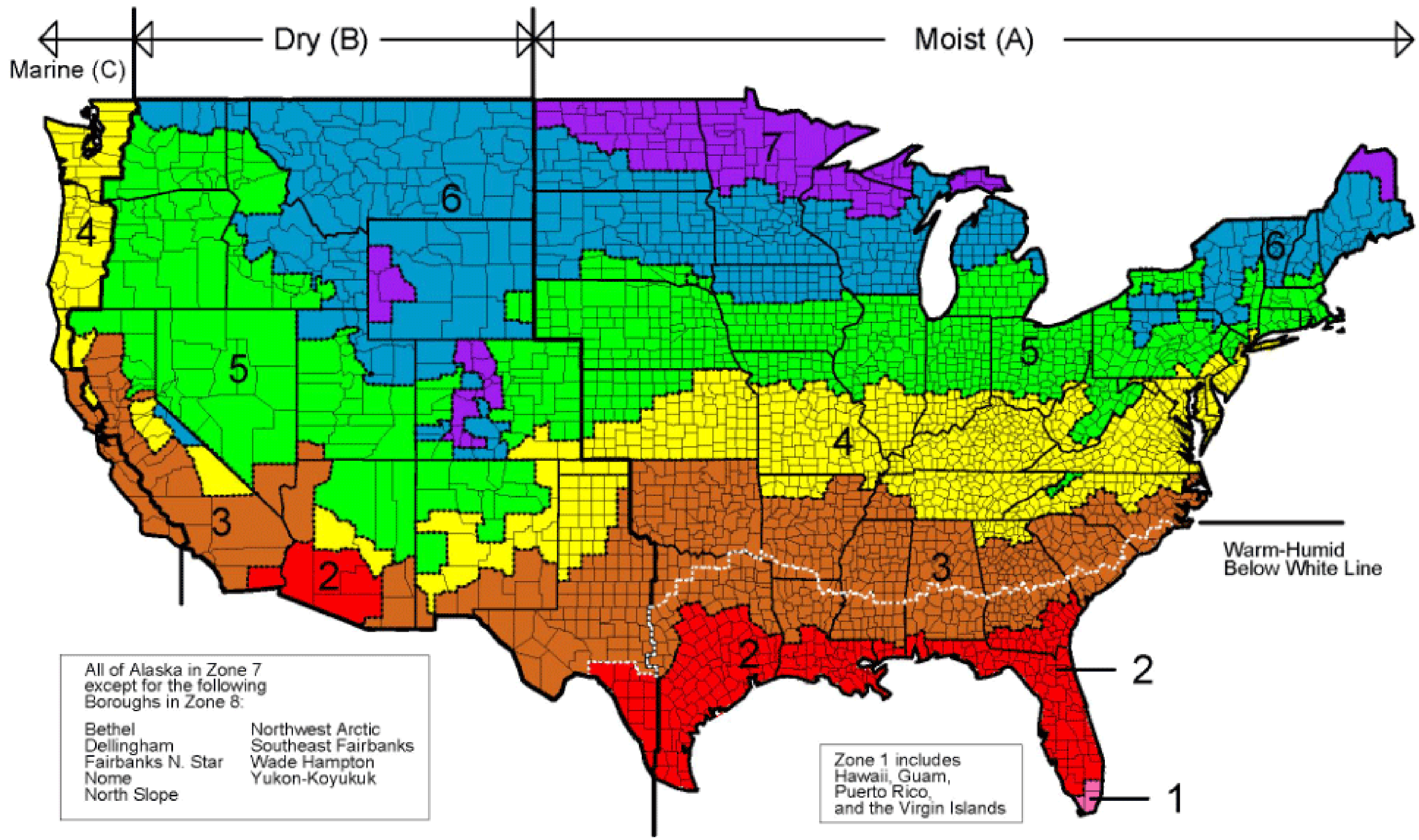

Figure 9.1 Climate zones for United States locations.

TABLE 9.1 Climate Zones—United States

State / County	Zone
Alabama (AL)	
Zone 3A,B Except	
Baldwin	2
Mobile	2
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 Fair-banks (CA)	8
Wade Hampton (CA)	8
Yukon-Koyukuk (CA)	8
Arizona (AZ)	
Zone 3A,B Except	
La Paz	2
Maricopa	2
Pima	2
Pinal	2
Yuma	2
Gila	4
Yavapai	4
Apache	5
Coconino	5
Navajo	5
Arkansas (AR)	
Zone 3A,B Except	
Baxter	4
Benton	4
Boone	4
Carroll	4
Fulton	4
Izard	4
Madison	4
Marion	4
Newton	4
Searcy	4
Stone	4
Washington	4
California (CA)	
Zone 3A,B Except	
Imperial	2
Alameda	3C
Marin	3C
Mendocino	3C
Monterey	3C
Napa	3C
San Benito	3C
San Francisco	3C
San Luis Obispo	3C
San Mateo	3C
Santa Barbara	3C
Santa Clara	3C
Santa Cruz	3C
Sonoma	3C
Ventura	3C
Amador	4
Calaveras	4
Del Norte	4
El Dorado	4
Humboldt	4
Inyo	4
Lake	4
Mariposa	4
Trinity	4
Tuolumne	4
Lassen	5
Modoc	5
Nevada	5
Plumas	5
Sierra	5
Siskiyou	5
Alpine	6
Mono	6
Colorado (CO)	
Zone 5 Except	
Baca	4
Las Animas	4
Otero	4
Alamosa	6
Archuleta	6
Chaffee	6
Conejos	6
Costilla	6
Custer	6
Dolores	6
Eagle	6
Moffat	6
Ouray	6
Rio Blanco	6
Saguache	6
San Miguel	6
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 5	
Delaware (DE)	
Zone 4	
District of Columbia (DC)	
Zone 4	
Florida (FL)	
Zone 2 Except	
Broward	1
Miami-Dade	1
Monroe	1
Georgia (GA)	
Zone 3A,B Except	
Appling	2
Atkinson	2
Bacon	2
Baker	2
Berrien	2
Brantley	2
Brooks	2
Bryan	2
Camden	2
Charlton	2
Chatham	2
Clinch	2
Colquitt	2
Cook	2
Decatur	2
Echols	2
Effingham	2
Evans	2
Glynn	2
Grady	2
Jeff Davis	2
Lanier	2
Liberty	2
Long	2
Lowndes	2
McIntosh	2
Miller	2
Mitchell	2
Pierce	2
Seminole	2
Tattnall	2
Thomas	2
Toombs	2
Ware	2
Wayne	2
Banks	4
Catoosa	4
Chattooga	4
Dade	4
Dawson	4
Fannin	4
Floyd	4
Franklin	4
Gilmer	4
Gordon	4
Habersham	4
Hall	4
Lumpkin	4
Murray	4
Pickens	4

State	County	Zone
	Rabun	4
	Stephens	4
	Towns	4
	Union	4
	Walker	4
	White	4
	Whitfield	4
Hawaii (HI)		
	Zone 1	
Idaho (ID)		
	Zone 6 Except	
	Ada	5
	Benewah	5
	Canyon	5
	Cassia	5
	Clearwater	5
	Elmore	5
	Gem	5
	Gooding	5
	Idaho	5
	Jerome	5
	Kootenai	5
	Latah	5
	Lewis	5
	Lincoln	5
	Minidoka	5
	Nez Perce	5
	Owyhee	5
	Payette	5
	Power	5
	Shoshone	5
	Twin Falls	5
	Washington	5
Illinois (IL)		
	Zone 5 Except	
	Alexander	4
	Bond	4
	Christian	4
	Clay	4
	Clinton	4
	Crawford	4
	Edwards	4
	Effingham	4
	Fayette	4
	Franklin	4
	Gallatin	4
	Hamilton	4
	Hardin	4
	Jackson	4
	Jasper	4
	Jefferson	4
	Johnson	4
	Lawrence	4
	Macoupin	4
	Madison	4
	Monroe	4
	Montgomery	4
	Perry	4
	Pope	4
	Pulaski	4
	Randolph	4
	Richland	4
	Saline	4
	Shelby	4
	St. Clair	4
	Union	4
	Wabash	4
	Washington	4
	Wayne	4
	White	4
	Williamson	4
Indiana (IN)		
	Zone 5 Except	
	Brown	4
	Clark	4
	Crawford	4
	Daviess	4
	Dearborn	4
	Dubois	4
	Floyd	4
	Gibson	4
	Greene	4
	Harrison	4
	Jackson	4
	Jefferson	4
	Jennings	4
	Knox	4
	Lawrence	4
	Martin	4
	Monroe	4
	Ohio	4
	Orange	4
	Perry	4
	Pike	4
	Posey	4
	Ripley	4
	Scott	4
	Spencer	4
	Sullivan	4
	Switzerland	4
	Vanderburgh	4
	Warrick	4
	Washington	4
Iowa (IA)		
	Zone 5 Except	
	Allamakee	6
	Black Hawk	6
	Bremer	6
	Buchanan	6
	Buena Vista	6
	Butler	6
	Calhoun	6
	Cerro Gordo	6
	Cherokee	6
	Chickasaw	6
	Clay	6
	Clayton	6
	Delaware	6
	Dickinson	6
	Emmet	6
	Fayette	6
	Floyd	6
	Franklin	6
	Grundy	6
	Hamilton	6
	Hancock	6
	Hardin	6
	Howard	6
	Humboldt	6
	Ida	6
	Kossuth	6
	Lyon	6
	Mitchell	6
	O'Brien	6
	Osceola	6
	Palo Alto	6
	Plymouth	6
	Pocahontas	6
	Sac	6
	Sioux	6
	Webster	6
	Winnebago	6
	Winneshiek	6
	Worth	6
	Wright	6
Kansas (KS)		
	Zone 4 Except	
	Cheyenne	5
	Cloud	5
	Decatur	5
	Ellis	5
	Gove	5
	Graham	5
	Greeley	5
	Hamilton	5
	Jewell	5
	Lane	5
	Logan	5
	Mitchell	5
	Ness	5
	Norton	5
	Osborne	5
	Phillips	5
	Rawlins	5
	Republic	5
	Rooks	5
	Scott	5
	Sheridan	5
	Sherman	5
	Smith	5
	Thomas	5
	Trego	5

TABLE 9.1 Climate Zones—United States *(continued)*

State County	Zone
Wallace	5
Wichita	5
Kentucky (KY)	
Zone 4	
Louisiana (LA)	
Zone 2 Except	
Bienville	3A,B
Bossier	3A,B
Caddo	3A,B
Caldwell	3A,B
Catahoula	3A,B
Claiborne	3A,B
Concordia	3A,B
De Soto	3A,B
East Carroll	3A,B
Franklin	3A,B
Grant	3A,B
Jackson	3A,B
La Salle	3A,B
Lincoln	3A,B
Madison	3A,B
Morehouse	3A,B
Natchitoches	3A,B
Ouachita	3A,B
Red River	3A,B
Richland	3A,B
Sabine	3A,B
Tensas	3A,B
Union	3A,B
Vernon	3A,B
Webster	3A,B
West Carroll	3A,B
Winn	3A,B
Maine (ME)	
Zone 6 Except	
Aroostook	7
Maryland (MD)	
Zone 4 Except	
Garrett	5
Massachusetts (MA)	
Zone 5	
Michigan (MI)	
Zone 5 Except	
Alcona	6
Alger	6
Alpena	6
Antrim	6
Arenac	6
Benzie	6
Charlevoix	6
Cheboygan	6
Clare	6
Crawford	6
Delta	6
Dickinson	6
Emmet	6
Gladwin	6
Grand Traverse	6
Huron	6
Iosco	6
Isabella	6
Kalkaska	6
Lake	6
Leelanau	6
Manistee	6
Marquette	6
Mason	6
Mecosta	6
Menominee	6
Missaukee	6
Montmorency	6
Newaygo	6
Oceana	6
Ogemaw	6
Osceola	6
Oscoda	6
Otsego	6
Presque Isle	6
Roscommon	6
Sanilac	6
Wexford	6
Baraga	7
Chippewa	7
Gogebic	7
Houghton	7
Iron	7
Keweenaw	7
Luce	7
Mackinac	7
Ontonagon	7
Schoolcraft	7
Minnesota (MN)	
Zone 6 Except	
Aitkin	7
Becker	7
Beltrami	7
Carlton	7
Cass	7
Clay	7
Clearwater	7
Cook	7
Crow Wing	7
Grant	7
Hubbard	7
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,B Except	
Hancock	2
Harrison	2
Jackson	2
Pearl River	2
Stone	2
Missouri (MO)	
Zone 4 Except	
Adair	5
Andrew	5
Atchison	5
Buchanan	5
Caldwell	5
Chariton	5
Clark	5
Clinton	5
Daviess	5
Gentry	5
Grundy	5
Harrison	5
Holt	5
Knox	5
Lewis	5
Linn	5
Livingston	5
Macon	5
Marion	5
Mercer	5
Nodaway	5
Pike	5
Putnam	5
Ralls	5
Schuyler	5
Scotland	5
Shelby	5
Sullivan	5
Worth	5
Montana (MT)	
Zone 6	
Nebraska (NE)	
Zone 5	
Nevada (NV)	
Zone 5 Except	
Clark	3A,B
New Hampshire (NH)	
Zone 6 Except	
Cheshire	5
Hillsborough	5

TABLE 9.1 Climate Zones—United States *(continued)*

State / County	Zone
Rockingham	5
Strafford	5
New Jersey (NJ)	
Zone 4 Except	
Bergen	5
Hunterdon	5
Mercer	5
Morris	5
Passaic	5
Somerset	5
Sussex	5
Warren	5
New Mexico (NM)	
Zone 5 Except	
Chaves	3A,B
Dona Ana	3A,B
Eddy	3A,B
Hidalgo	3A,B
Lea	3A,B
Luna	3A,B
Otero	3A,B
Bernalillo	4
Curry	4
DeBaca	4
Grant	4
Guadalupe	4
Lincoln	4
Quay	4
Roosevelt	4
Sierra	4
Socorro	4
Union	4
Valencia	4
New York (NY)	
Zone 5 Except	
Bronx	4
Kings	4
Nassau	4
New York	4
Queens	4
Richmond	4
Suffolk	4
Westchester	4
Allegany	6
Broome	6
Cattaraugus	6
Chenango	6
Clinton	6
Delaware	6
Essex	6
Franklin	6
Fulton	6
Hamilton	6
Herkimer	6
Jefferson	6
Lewis	6
Madison	6
Montgomery	6
Oneida	6
Otsego	6
Schoharie	6
Schuyler	6
St. Lawrence	6
Steuben	6
Sullivan	6
Tompkins	6
Ulster	6
Warren	6
Wyoming	6
North Carolina (NC)	
Zone 4 Except	
Anson	3A,B
Beaufort	3A,B
Bladen	3A,B
Brunswick	3A,B
Cabarrus	3A,B
Camden	3A,B
Carteret	3A,B
Chowan	3A,B
Columbus	3A,B
Craven	3A,B
Cumberland	3A,B
Currituck	3A,B
Dare	3A,B
Davidson	3A,B
Duplin	3A,B
Edgecombe	3A,B
Gaston	3A,B
Greene	3A,B
Hoke	3A,B
Hyde	3A,B
Johnston	3A,B
Jones	3A,B
Lenoir	3A,B
Martin	3A,B
Mecklenburg	3A,B
Montgomery	3A,B
Moore	3A,B
New Hanover	3A,B
Onslow	3A,B
Pamlico	3A,B
Pasquotank	3A,B
Pender	3A,B
Perquimans	3A,B
Pitt	3A,B
Randolph	3A,B
Richmond	3A,B
Robeson	3A,B
Rowan	3A,B
Sampson	3A,B
Scotland	3A,B
Stanly	3A,B
Tyrrell	3A,B
Union	3A,B
Washington	3A,B
Wayne	3A,B
Wilson	3A,B
Alleghany	5
Ashe	5
Avery	5
Mitchell	5
Watauga	5
Yancey	5
North Dakota (ND)	
Zone 7 Except	
Adams	6
Billings	6
Bowman	6
Burleigh	6
Dickey	6
Dunn	6
Emmons	6
Golden Valley	6
Grant	6
Hettinger	6
LaMoure	6
Logan	6
McIntosh	6
McKenzie	6
Mercer	6
Morton	6
Oliver	6
Ransom	6
Richland	6
Sargent	6
Sioux	6
Slope	6
Stark	6
Ohio (OH)	
Zone 5 Except	
Adams	4
Brown	4
Clermont	4
Gallia	4
Hamilton	4
Lawrence	4
Pike	4
Scioto	4
Washington	4
Oklahoma (OK)	
Zone 3A,B Except	
Beaver	4
Cimarron	4
Texas	4
Oregon (OR)	
Zone 4 Except	
Baker	5
Crook	5

TABLE 9.1 Climate Zones—United States *(continued)*

State / County	Zone
Deschutes	5
Gilliam	5
Grant	5
Harney	5
Hood River	5
Jefferson	5
Klamath	5
Lake	5
Malheur	5
Morrow	5
Sherman	5
Umatilla	5
Union	5
Wallowa	5
Wasco	5
Wheeler	5
Pennsylvania (PA)	
Zone 5 Except	
Bucks	4
Chester	4
Delaware	4
Montgomery	4
Philadelphia	4
York	4
Cameron	6
Clearfield	6
Elk	6
McKean	6
Potter	6
Susquehanna	6
Tioga	6
Wayne	6
Rhode Island (RI)	
Zone 5	
South Carolina (SC)	
Zone 3A,B	
South Dakota (SD)	
Zone 6 Except	
Bennett	5
Bon Homme	5
Charles Mix	5
Clay	5
Douglas	5
Gregory	5
Hutchinson	5
Jackson	5
Mellette	5
Todd	5
Tripp	5
Union	5
Yankton	5
Tennessee (TN)	
Zone 4 Except	
Chester	3A,B
Crockett	3A,B
Dyer	3A,B
Fayette	3A,B
Hardeman	3A,B
Hardin	3A,B
Haywood	3A,B
Henderson	3A,B
Lake	3A,B
Lauderdale	3A,B
Madison	3A,B
McNairy	3A,B
Shelby	3A,B
Tipton	3A,B
Texas (TX)	
Zone 3A,B Except	
Anderson	2
Angelina	2
Aransas	2
Atascosa	2
Austin	2
Bandera	2
Bastrop	2
Bee	2
Bell	2
Bexar	2
Bosque	2
Brazoria	2
Brazos	2
Brooks	2
Burleson	2
Caldwell	2
Calhoun	2
Cameron	2
Chambers	2
Cherokee	2
Colorado	2
Comal	2
Coryell	2
DeWitt	2
Dimmit	2
Duval	2
Edwards	2
Falls	2
Fayette	2
Fort Bend	2
Freestone	2
Frio	2
Galveston	2
Goliad	2
Gonzales	2
Grimes	2
Guadalupe	2
Hardin	2
Harris	2
Hays	2
Hidalgo	2
Hill	2
Houston	2
Jackson	2
Jasper	2
Jefferson	2
Jim Hogg	2
Jim Wells	2
Karnes	2
Kenedy	2
Kinney	2
Kleberg	2
La Salle	2
Lavaca	2
Lee	2
Leon	2
Liberty	2
Limestone	2
Live Oak	2
Madison	2
Matagorda	2
Maverick	2
McLennan	2
McMullen	2
Medina	2
Milam	2
Montgomery	2
Newton	2
Nueces	2
Orange	2
Polk	2
Real	2
Refugio	2
Robertson	2
San Jacinto	2
San Patricio	2
Starr	2
Travis	2
Trinity	2
Tyler	2
Uvalde	2
Val Verde	2
Victoria	2
Walker	2
Waller	2
Washington	2
Webb	2
Wharton	2
Willacy	2
Williamson	2
Wilson	2
Zapata	2
Zavala	2
Armstrong	4
Bailey	4
Briscoe	4
Carson	4
Castro	4
Cochran	4
Dallam	4
Deaf Smith	4
Donley	4
Floyd	4
Gray	4
Hale	4
Hansford	4
Hartley	4

TABLE 9.1 Climate Zones—United States *(continued)*

State / County	Zone
Hockley	4
Hutchinson	4
Lamb	4
Lipscomb	4
Moore	4
Ochiltree	4
Oldham	4
Parmer	4
Potter	4
Randall	4
Roberts	4
Sherman	4
Swisher	4
Yoakum	4
Utah (UT)	
Zone 5 Except	
Washington	3A,B
Box Elder	6
Cache	6
Carbon	6
Daggett	6
Duchesne	6
Morgan	6
Rich	6
Summit	6
Uintah	6
Wasatch	6
Vermont (VT)	
Zone 6	
Virginia (VA)	
Zone 4	
Washington (WA)	
Zone 5 Except	
Clallam	4
Clark	4
Cowlitz	4
Grays Harbor	4
Island	4
Jefferson	4
King	4
Kitsap	4
Lewis	4
Mason	4
Pacific	4
Pierce	4
San Juan	4
Skagit	4
Snohomish	4
Thurston	4
Wahkiakum	4
Whatcom	4
Ferry	6
Okanogan	6
Pend Oreille	6
Stevens	6
West Virginia (WV)	
Zone 5 Except	
Berkeley	4
Boone	4
Braxton	4
Cabell	4
Calhoun	4
Clay	4
Gilmer	4
Jackson	4
Jefferson	4
Kanawha	4
Lincoln	4
Logan	4
Mason	4
McDowell	4
Mercer	4
Mingo	4
Monroe	4
Morgan	4
Pleasants	4
Putnam	4
Ritchie	4
Roane	4
Tyler	4
Wayne	4
Wirt	4
Wood	4
Wyoming	4
Wisconsin (WI)	
Zone 6 Except	
Ashland	7
Bayfield	7
Burnett	7
Douglas	7
Florence	7
Forest	7
Iron	7
Langlade	7
Lincoln	7
Oneida	7
Price	7
Sawyer	7
Taylor	7
Vilas	7
Washburn	7
Wyoming (WY)	
Zone 6 Except	
Goshen	5
Platte	5
Lincoln	7
Sublette	7
Teton	7
Pacific Rim (PR)	
Zone 1 Except	
Barranquitas 2 SSW	2
Cayey 1 E	2
Pacific Islands (PI)	
Zone 1 Except	
Midway Sand Island	2
Virgin Islands (VI)	
Zone 1	

TABLE 9.2 Canadian Climate 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
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

Province / City	Zone
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
Sept-Iles A	7
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 9.3 International Climate Zones

Country / City	Province/Region	Zone
Argentina		
Buenos Aires/Ezeiza		3 A,B
Cordoba		3 A,B
Tucuman/Pozo		2
Australia		
Adelaide	SA	3 C
Alice Springs	NT	2
Brisbane	QL	2
Darwin Airport	NT	1
Perth/Guildford	WA	3 A,B
Sydney/K Smith	NSW	3 A,B
Azores		
Lajes	Terceira	3 A,B
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		3 C
Punta Arenas/Chabunco		6
Santiago/Pedahuel		3 C
China		
Anqing	Anhui	3 A,B
Bengbu		3 A,B
Fuyang		3 A,B
Hefei/Luogang		3 A,B
Huang Shan (Mtns)		5
Huoshan		3 A,B
Changting	Fujian	3 A,B
Fuding		3 A,B
Fuzhou		2
Jiuxian Shan		4
Longyan		2
Nanping		2
Pingtan		2
Pucheng		3 A,B
Shaowu		3 A,B
Xiamen		2
Yong'An		2
Dunhuang	Gansu	5
Hezuo		7
Huajialing		7
Jiuquan/Suzhou		6
Lanzhou		5
Mazong Shan (Mount)		7
Minqin		5
Pingliang		5
Ruo'ergai		7
Tianshui		4
Wudu		3 C
Wushaoling (Pass)		7
Xifengzhen		5
Yumenzhen		6
Zhangye		6
Fogang	Guangdong	2
Gaoyao		2
Guangzhou/Baiyun		2
Heyuan		2
Lian Xian		2
Lianping		2
Meixian		2
Shangchuan Island		2
Shantou		2
Shanwei		2
Shaoguan		2
Shenzhen		2
Xinyi		2
Yangjiang		2
Zhangjiang		1

TABLE 9.3 International Climate Zones *(continued)*

Country / City	Province/Region	Zone
Beihai	Guangxi	2
Bose		2
Guilin		2
Guiping		2
Hechi/Jnchengjiang		2
Lingling		3 A,B
Liuzhou		2
Longzhou		2
Mengshan		2
Nanning/Wuxu		2
Napo		2
Qinzhou		2
Wuzhou		2
Bijie	Guizhou	4
Dushan		3 A,B
Guiyang		3 A,B
Luodian		2
Rongjiang/Guzhou		2
Sansui		3 A,B
Sinan		3 A,B
Weining		4
Xingren		3 A,B
Zunyi		3 A,B
Danxian/Nada	Hainan	1
Dongfang/Basuo		1
Haikou		1
Qionghai/Jiaji		1
Sanhu Island		1
Xisha Island		1
Yaxian/Sanya		1
Baoding	Hebei	4
Chengde		5
Fengning/Dagezhen		6
Huailai/Shacheng		5
Leting		5
Qinglong		5
Shijiazhuang		4
Tangshan		5
Weichang/Zhuizishan		6
Xingtai		3 A,B
Yu Xian		6
Zhangjiakou		5
Aihui	Heilongjiang	7
Anda		7
Baoqing		7
Fujin		7
Hailun		7
Harbin		7
Hulin		7
Huma		8
Jixi		7
Keshan		7
Mudanjiang		7
Qiqihar		7
Shangzhi		7
Suifenhe		7
Sunwu		7
Tailai		7
Tonghe		7
Yichun		7
Anyang/Zhangde	Henan	3 A,B
Boxian		3 A,B
Gushi		3 A,B
Lushi		4
Nanyang		3 A,B
Xihua		3 A,B
Xinyang		3 A,B
Zhengzhou		3 A,B
Zhumadian		3 A,B
Fangxian	Hubei	4
Guanghua		3 A,B
Jiangling/Jingzhou		3 A,B
Macheng		3 A,B
Wuhan/Nanhu		3 A,B
Yichang		3 A,B
Zaoyang		3 A,B
Zhongxiang		3 A,B
Changde	Hunan	3 A,B
Chenzhou		3 A,B
Nanyue		4
Sangzhi		3 A,B
Shaoyang		3 A,B
Tongdao/Shuangjiang		3 A,B
Wugang		3 A,B

TABLE 9.3 International Climate Zones *(continued)*

Country / City	Province/Region	Zone
Yuanling		3 A,B
Yueyang		3 A,B
Zhijiang		3 A,B
Abag Qi/Xin Hot	Inner Mongolia	7
Arxan		8
Bailing-Miao		7
Bayan Mod		6
Bugt		7
Bugt		6
Chifeng/Ulanhad		6
Dongsheng		6
Duolun/Dolonnur		7
Ejin Qi		6
Erenhot		7
Guaizihu		5
Hailar		8
Hails		6
Haliut		6
Hohhot		6
Huade		7
Jartai		5
Jarud Qi/Lubei		6
Jining		7
Jurh		7
Lindong/Bairin Zuoq		6
Linhe		6
Linxi		7
Mandal		6
Naran Bulag		7
Nenjiang		7
Otog Qi/Ulan		6
Tongliao		6
Tulihe		8
Uliastai		7
Xi Ujimqin Qi		7
Xilin Hot/Abagnar		7
Xin Barag Youqi		7
Dongtai	Jiangsu	3 A,B
Ganyu/Dayishan		4
Liyang		3 A,B
Lusi		3 A,B
Qingjiang		3 A,B
Shenyang/Hede		4
Xuzhou		3 A,B
Ganzhou	Jiangxi	2
Guangchang		2
Ji'An		2
Jingdezhen		3 A,B
Lu Shan (Mountain)		4
Nanchang		3 A,B
Nancheng		3 A,B
Xiushui		3 A,B
Xunwu		2
Yichun		3 A,B
Changbai	Jilin	7
Changchun		6
Changling		6
Dunhua		7
Huadian		7
Ji'An		6
Linjiang		6
Qian Gorlos		7
Yanji		6
Chaoyang	Liaoning	5
Dalian/Dairen/Luda		5
Dandong		5
Haiyang Island		5
Jinzhou		5
Kuandian		6
Qingyuan		6
Shenyang/Dongta		6
Siping		6
Yingkou		6
Zhangwu		6
Beijing/Peking	Municipalities	4
Cangzhou		3 A,B
Shanghai		3 A,B
Shanghai/Hongqiao		3 A,B
Tianjin/Tientsin		4
Yanchi	Ningxia	5
Yinchuan		5
Zhongning		5
Daqaidam	Qinghai	7
Darlag		7

TABLE 9.3 International Climate Zones *(continued)*

Country / City	Province/Region	Zone
Delingha		7
Dulan/Qagan Us		7
Gangca/Shaliuhe		7
Golmud		6
Henan		7
Lenghu		7
Madoi/Huangheyan		8
Qumarleb		8
Tongde		7
Tuotuohe/Tanggulash		8
Wudaoliang		8
Xining		6
Yushu		7
Zadoi		7
Ankang/Xing'an	Shaanxi	3 A,B
Baoji		4
Hanzhong		4
Hua Shan (Mount)		6
Tongchuan		5
Xi'An		4
Yan An		5
Yulin		5
Chengshantou (Cape)	Shandong	4
Dezhou		3 A,B
Haiyang		4
Heze/Caozhou		3 A,B
Huimin		4
Jinan/Sinan		3 A,B
Linyi		4
Longkou		4
Quingdao/Singtao		4
Rizhao		4
Tai Shan (Mtns)		6
Weifang		4
Xinxian		4
Yanzhou		4
Yiyuan/Nanma		4
Datong	Shanxi	6
Hequ		6
Jiexiu		5
Lishi		5
Taiyuan/Wusu/Wusu		5
Wutai Shan (Mtn)		8
Yangcheng		4
Yuanping		5
Yuncheng		3 A,B
Yushe		5
Barkam	Sichuan	5
Batang		3 C
Chengdu		3 A,B
Da Xian		3 A,B
Daocheng/Dabba		6
Dawu		5
Emei Shan		7
Fengjie		3 A,B
Garze		6
Jiulong/Gyaisi		5
Kangding/Dardo		5
Langzhong		3 A,B
Liangping		3 A,B
Litang		7
Luzhou		3 A,B
Mianyang		3 A,B
Nanchong		3 A,B
Neijiang		3 A,B
Pingwu		3 C
Songpan/Sungqu		6
Wanyuan		3 C
Xichang		3 A,B
Ya'An		3 A,B
Yibin		3 A,B
Youyang		3 C
Hong Kong Intl Arpt	SAR	2
Baingoin	Tibet	7
Dengqen		7
Lhasa		5
Lhunze		6
Nagqu		7
Nyingchi		5
Pagri		7
Qamdo		5
Shiquanhe		7
Sog Xian		7
Tingri/Xegar		7

TABLE 9.3 International Climate Zones *(continued)*

Country / City	Province/Region	Zone
Xainza		7
Xigaze		6
Akqi	Xinjiang	6
Alar		5
Altay		7
Andir		5
Bachu		5
Balguntay		6
Bayanbulak		8
Baytik Shan (Mtns)		7
Fuyun		7
Hami		5
Hoboksar		7
Hotan		4
Jinghe		6
Kaba He		7
Karamay		6
Kashi		5
Korla		5
Kuqa		5
Mangnai		7
Pishan		4
Qijiaojing		5
Qitai		6
Ruoqiang		5
Shache		5
Tacheng		6
Tikanlik		5
Turpan		3 A,B
Urumqi		6
Yining		5
Yiwu/Araturuk		7
Baoshan	Yunnan	3 C
Chuxiong		3 C
Dali		3 C
Deqen		6
Guangnan		3 A,B
Huili		3 C
Huize		3 C
Jiangcheng		2
Jinghong		1
Kunming/Wujiaba		3 C
Lancang/Menglangba		2
Lijing		3 C
Lincang		3 A,B
Luxi		3 C
Mengding		2
Mengla		2
Mengzi		2
Ruili		2
Simao		3 A,B
Tengchong		3 C
Yuanjiang		1
Yuanmou		2
Zhanyi		3 C
Zhaotong		4
Dachen Island	Zhejiang	3 A,B
Dinghai		3 A,B
Hangzhou/Jianqiao		3 A,B
Kuocang Shan		5
Lishui		3 A,B
Qixian Shan		4
Qu Xian		3 A,B
Shengsi/Caiyuanzhen		3 A,B
Shengxian		3 A,B
Shipu		3 A,B
Taishan		3 A,B
Tianmu Shan (Mtns)		5
Wenzhou		3 A,B
Cuba		
Guantanamo Bay NAS	Ote	1
Cyprus		
Akrotiri		3 A,B
Larnaca		3 A,B
Paphos		3 A,B
Czech Republic (Former Czechoslovakia)		
Prague/Libus		5
Dominican Republic		
Santo Domingo		1
Egypt		
Cairo		2
Luxor		1
Finland		
Helsinki/Seutula		7

TABLE 9.3 International Climate Zones *(continued)*

Country / City	Province/Region	Zone
France		
Lyon/Satolas		4
Marseille		3 C
Nantes		4
Nice		3 C
Paris/Le Bourget		4
Strasbourg		5
Germany		
Berlin/Schoenfeld		5
Hamburg		5
Hannover		5
Mannheim		5
Greece		
Souda	Crete	3 A,B
Thessalonika/Mikra		3 C
Greenland		
Narssarssuaq		7
Hungary		
Budapest/Lorinc		5
Iceland		
Reykjavik		7
India		
Ahmedabad		1
Bangalore		1
Bombay/Santa Cruz		1
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 A,B
Tel Aviv Port		2

Country / City	Province/Region	Zone
Italy		
Milano/Linate		4
Napoli/Capodichino		3 C
Roma/Fiumicino		3 C
Jamaica		
Kingston/Manley		1
Montego Bay/Sangster		1
Japan		
Fukaura		5
Sapporo		5
Tokyo		3 A,B
Jordan		
Amman		3 A,B
Kenya		
Nairobi Airport		3 A,B
Korea		
Pyongyang		5
Seoul		4
Malaysia		
Kuala Lumpur		1
Penang/Bayan Lepas		1
Mexico		
Guadalajara	Jalisco	3 A,B
Merida	Yucatan	1
Mexico City	Distrito Federal	3 A,B
Monterrey	Nuevo Laredo	2
Tampico	Tamaulipas	1
Veracruz	Veracruz	1
Netherlands		
Amsterdam/Schiphol		5
New Zealand		
Auckland Airport		3 C
Christchurch		4
Wellington		3 C
Norway		
Bergen/Florida		5
Oslo/Fornebu		6
Pakistan		
Karachi Airport		1
Papua New Guinea		
Port Moresby		1

TABLE 9.3 International Climate Zones *(continued)*

Country / City	Province/Region	Zone
Paraguay		
Asuncion/Stroessner		1
Peru		
Lima-Callao/Chavez		2
San Jaun de Marcona		2
Talara		2
Phillipines		
Manila Airport	Luzon	1
Poland		
Krakow/Balice		5
Puerto Rico		
San Juan/Isla Verde WSFO		1
Romania		
Bucuresti/Bancasa		5
Russia (Former Soviet Union)		
Kaliningrad	East Prussia	5
Krasnoiarsk		7
Moscow Observatory		6
Petropavlovsk		7
Rostov-Na-Donu		5
Vladivostok		6
Volgograd		6
Saudi Arabia		
Dhahran		1
Riyadh		1
Senegal		
Dakar/Yoff		1
Singapore		
Singapore/Changi		1
South Africa		
Cape Town/D F Malan		3 A,B
Johannesburg		3 C
Pretoria		3 A,B
Spain		
Barcelona		3 C
Madrid		4
Valencia/Manises		3 A,B
Sweden		
Stockholm/Arlanda		6
Switzerland		
Zurich		5
Syria		
Damascus Airport		3 A,B
Taiwan		
Alisan Shan		4
Chiayi (TW-AFB)		2
Ciayyi		1
Chilung		2
Chinmen		2
Dawu		1
Hengchun		1
Hengchun/Wu Le Tien		1
Hsinchu/Singjo		2
Hua Lien		2
Hwalien		1
Joyutang		2
Kao Hsiung Int. Arpt.		1
Kao Hsiung		1
Kungkuan		2
Kungshan		1
Lan Yu		2
Makung		2
Matsu Island		3 A,B
North Pingtung		1
Peng Hu		1
Penkaiyu		2
Sing Jo		2
Sinkung		1
South Pingtung		1
Taichung		2
Taichung/Shui Nan		2
Tainan (TW-AFB)		1
Tainan		1
Taipei		2
Taipei/Chiang Kai Shek		2
Taipei/Sungshan		2
Taitung		1
Taitung/Fongyentsun		1
Taoyuan (AB)		2
Tung Shih		1
Wu-Chi		2
Yilan		2
Tanzania		
Dar es Salaam		1
Thailand		
Bangkok		1

TABLE 9.3 International Climate Zones *(continued)*

Country / City	Province/Region	Zone
Tunisia		
Tunis/El Aouina		3 A,B
Turkey		
Adana		3 A,B
Ankara/Etimesgut		4
Istanbul/Yesilkoy		3 C
United Kingdom		
Birmingham	England	5
Edinburgh	Scotland	5
Glasgow Apt	Scotland	5
London/Heathrow	England	4
Uruguay		
Montevideo/Carrasco		3 A,B
Venezuela		
Caracas/Maiquetia		1
Vietnam		
Hanoi/Gialam		1

10. NORMATIVE REFERENCES

Organization/Standard(s)	Standard Title	Section Number(s)
ACCA **Air Conditioning Contractors of America** **Washington, DC**		
Manual J (1988)	Residential Load Calculation, Manual J	Table 6.6.1
AAMA **American Architectural Manufacturers Association** **Des Plaines, IL**		
AAMA/WDMA/CAS 101/I.S.2/A440-05	Standard Specification for Windows, Doors and Unit Skylights	Table 5.9.1
ARI **Air-Conditioning and Refrigeration Institute** **Arlington, VA**		
ARI Standard 210/240 (1989)	Unitary Air-Conditioning Equipment and Air-Source Heat Pump Equipment	Table 6.9
ARI Standard 325 (1993)	Ground Water-Source Heat Pumps	Table 6.9
ASHRAE **American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.** **Atlanta, GA**		
ASHRAE Terminology of Heating, Ventilation, Air-Conditioning and Refrigeration (1991)	*ASHRAE Terminology of Heating, Ventilation, Air-Conditioning and Refrigeration*	3.2
ASHRAE Handbook—Fundamentals (2001)	*ASHRAE Handbook—Fundamentals*	5.2.1, 5.2.2, 8.8.3.4.2, 8.8.5.1, 8.8.5.2, 8.8.5.4
ANSI/ASHRAE Standard 119-1988 (RA 1994)	Air Leakage Performance for Detached Single-Family Residential Buildings	5.9, 8.8.3.4.2
ASHRAE GRP-158 (1992)	Cooling and Heating Load Calculation Manual	Table 6.6.1
ANSI/ASHRAE/IESNA Standard 90.1-2001	Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings	7.3, A.3.1
ASHRAE—Passive Solar Heating Analysis (1984, and Supplement One, 1987)	*ASHRAE—Passive Solar Heating Analysis—A Design Guide*	8.8.5.1
ASHRAE Simplified Energy Analysis Using the Modified Bin Method (1983)	*Simplified Energy Analysis Using the Modified Bin Method*	8.8.5.2
ASHRAE WYEC (1981)	ASHRAE Bin and Degree Hour Weather Data for Simplified Energy Calculations and Crow, L.W., Development of Hourly Data for Weather Year for Energy Calculation (WYEC)	8.8.5.4
ASTM **American Society of Testing and Materials** **West Conshokocken, PA**		
ASTM C90 (2005)	Standard Specification for Loadbearing Concrete Masonry Units	5.3
ASTM C1371 (-04a)	Standard Test Method for Determination of Emittance of Materials Near Room Temperature Using Portable Emissometers	5.5

Organization/Standard(s)	Standard Title	Section Number(s)
ASTM C1549 (-04)	Standard Test Method for Determination of Solar Reflectance Near Ambient Temperature Using a Portable Solar Reflectometer	5.5
ASTM E96 (1992)	Standard Test Methods for Water Vapor Transmission of Materials	3.3, 6.4
ASTM E283 (1991)	Standard Test Method for Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors	Table 5.9.1, 8.8.3.4.2
ASTM E408 (1971) (Reapproved 2002)	Standard Test Method for Total Normal Emittance of Surfaces Using Inspection-Meter Techniques	5.5
ASTM E779 (2003)	Standard Test Method for Determining Air Leakage Rate by Fan Pressurization	8.8.3.4.3
ASTM E903 (1996)	Standard Test Method for Solar Absorptance, Reflectance, and Trasmittance of Materials Using Integrating Spheres	5.5
ASTM E1918 (1997)	Standard Test Method for Measuring Solar Reflectance of Horizontal and Low-Sloped Surfaces in the Field	5.5
ASTM E1980 (-01)	Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-Sloped Opaque Surfaces	5.5
NREL National Renewable Energy Laboratory Golden, CO		
TMY2 Data	Typical Meteorological Year	8.8.5.4
NFRC National Fenestration Rating Council Silver Spring, MD		
NFRC 100 (2001)	Procedures for Determining Fenestration Product U-Factors	5.8
NFRC 200 (2001)	Procedures for Determining Fenestration Product Solar Heat Gain Coefficients at Normal Incident	5.8
NFPA National Fire Protection Association Quincy, MA		
ANSI Z223.1/NFPA 54 (2002)	National Fuel Gas Code	6.6.2
NFPA 31 (2001)	Standard for the Installation of Oil Equipment; Solid Fuel Burning Equipment	6.6.2
NFPA 211 (2000)	Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances	6.6.2

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

NORMATIVE APPENDIX A ENVELOPE PERFORMANCE PATH TRADE-OFF METHOD

A1. SCOPE

This section shall be used to evaluate envelope trade-off options by the performance path methodology to demonstrate compliance. This section shall not be used to evaluate envelope trade-off options against HVAC equipment types or efficiencies, heating and cooling distribution system efficiencies, air infiltration performance, or domestic water heating equipment performance.

A2. METHODOLOGY

The methodology is to calculate total heating and cooling energy costs of the proposed envelope design options and compare those to the energy costs of the prescriptive envelope criteria from Section 5.1. Compliance is achieved when the proposed envelope energy costs (PEEC) are less than or equal to the prescriptive criteria energy costs (CEC).

A2.1 Basic Assumptions. All of the basic assumptions used in calculating the energy costs are identical to those used in developing the prescriptive envelope criteria. The specific assumptions relate to the type and efficiencies of the HVAC equipment for heating and cooling, the air distribution system efficiencies, heating and cooling energy prices, and economic variables. All of these assumptions are imbedded in the constants listed for each climate zone in Table A2.1. These assumptions are intended to predict the energy costs under average conditions. However, the energy costs of any specified building may differ due to variations in construction, occupancy, operation, maintenance, HVAC systems, and weather.

A2.2 Proposed Envelope Design Assumptions. The analyses of the proposed envelope design options shall take into account all qualities, details, and characteristics of the design that significantly affect energy use and cost. The geometry, orientation, and exposure of each envelope trade-off option must be the same for the proposed envelope design and the design that meets the prescriptive criteria. The characteristics and all significant energy conservation features shall be documented in the construction documents.

A2.3 Mandatory Requirements. The proposed envelope design shall comply with the requirements for calculations, testing, and rating specified in Section 5. The proposed envelope design shall also comply with all other requirements of Section 5 if the effect of the requirements on the energy costs of the prescriptive design is not fully and accurately included in the calculations performed in this section.

A2.4 Professional Judgment. The modeling techniques and assumptions prescribed in this standard shall be used where specified and no professional judgment is required. However, professional judgment is required where the standard does not prescribe specific modeling techniques and assumptions. Two rules shall be used when applying professional judgment. First, the proposed design and prescriptive design shall both be analyzed using the same techniques and assumptions except where differences in conservation features require a different approach. Second, simplifying assumptions that reduce the energy use of the proposed design in relation to the prescriptive design shall not be used.

A3. WEIGHTED AVERAGE THERMAL PERFORMANCE FACTORS (U-FACTORS, C-FACTORS, SHGC)

When more than one type of construction for an envelope component is present, a weighted value shall be used to demonstrate compliance.

A3.1 Thermal Properties of Envelope Options. Thermal properties of envelope options shall be determined using the procedures contained in Standard 90.1 or from Normative Appendix A in the same standard, "Assembly U-factor, C-factor, and F-factor Determination."

A3.2 Area-Weighted U-Factors (Above-Grade Ceilings, Walls, Floors, and Fenestration). When the criteria are expressed in terms of U-factors, the area-weighted U-factor (U_o) is determined by Equation A-1.

$$U_o = (U_1 \cdot A_1 + U_2 \cdot A_2 + \ldots + U_n A_n)/(A_1 + A_2 + \ldots + A_n) \tag{A-1}$$

where

U_o = overall area-weighted U-factor, Btu/h·ft^2·°F

U_1 = U-factor of first construction type, Btu/h·ft^2·°F

U_2 = U-factor of second construction type, Btu/h·ft^2·°F

U_n = U-factor of nth construction type, Btu/h·ft^2·°F

A_1 = area of first construction type, ft^2

A_2 = area of second construction type, ft^2

A_n = area of nth construction type, ft^2

A3.3 Area-Weighted R-Values (Doors). The criteria for doors are presented as R-values. The R-values are converted into an area-weighted U-factor (U_o) by Equation A-2 for use in the envelope trade-off analysis.

$$U_o = (A_1/(0.85+R_1) + A_2/(0.85+R_2) + \ldots + A_n/(0.85+R_n)) / (A_1 + A_2 + \ldots + A_n) \tag{A-2}$$

where

U_o = overall area-weighted U-factor, Btu/h·ft^2·°F

R_1 = R-value of first door construction type, h·ft^2·°F/Btu

R_2 = R-value of second door construction type, h·ft^2·°F/Btu

R_n = R-value of nth door construction type, h·ft^2·°F/Btu

A_1 = area of first door construction type, ft^2

A_2 = area of second door construction type, ft^2

A_n = area of nth door construction type, ft^2

A3.4 Area-Weighted Average SHGC. When more than one fenestration construction type is present, the area-weighted SHGC is determined by Equation A-3.

$$SHGC_o = (SHGC_1 \cdot A_1 + SHGC_2 \cdot A_2 + \ldots + SHGC_n \cdot A_n) / (A_1 + A_2 + \ldots + A_n) \tag{A-3}$$

where

$SHGC_o$ = overall area-weighted SHGC, dimensionless

$SHGC_1$ = SHGC of first fenestration construction type, dimensionless

$SHGC_2$ = SHGC of second fenestration construction type, dimensionless

$SHGC_n$ = SHGC of nth fenestration construction type, dimensionless

Table A2.1 Heating and Cooling Energy Cost Multipliers for Envelope Trade-off Analysis

No.	Item
1	Ceilings with Attics
2	Ceilings without Attics
3	Above Grade Frame Wall and Band Joists
4	Above-grade Concrete, Masonry or Log walls—Exterior or Integral Insulation
5	Above-grade Concrete, Masonry or Log walls—Interior Insulation
6	Walls Adjacent to Unconditioned Space
7	Doors
8	Fenestration—Vertical Glazing—U-factors
9	Fenestration—Vertical Glazing—SHGC
10	Skylights—U-factors
11	Skylights—SHGC
12	Floors over Exterior Ambient Conditions
13	Floors over Unconditioned Spaces
14	Basement Walls—Concrete or Masonry—Deep—1 ft above, 7 ft below grade—Top Half Insulated
15	Basement Walls—Concrete or Masonry—Deep—1 ft above, 7 ft below grade—Entire Wall Insulated
16	Basement Walls—Concrete or Masonry—Shallow 4 ft above, 4 ft below grade—Entire Wall insulated
17	Slab-on-Grade—2 ft
18	Slab-on-Grade—4 ft
19	Crawl Space Walls—Concrete or Masonry
20	Crawl Space Walls—Wood
21	Basement Walls—Wood—Deep—1 ft above, 7 ft below grade
22	Basement Walls—Wood—Shallow—4 ft above, 4 ft below grade

Heating Energy Cost Multipliers (HECM) by Climate Zones									
No.	1	2	3A,B	3C	4	5	6	7	8
1	0.41	2.25	4.77	5.34	8.51	11.43	14.45	18.33	25.67
2	0.36	1.99	4.22	4.72	7.53	10.11	12.78	16.21	22.71
3	0.33	1.82	3.85	4.31	6.88	9.23	11.67	14.80	20.74
4	0.33	1.82	3.85	4.31	6.88	9.23	11.67	14.80	20.74
5	0.33	1.82	3.85	4.31	6.88	9.23	11.67	14.80	20.74
6	0.09	0.47	0.99	1.11	1.77	2.37	3.00	3.81	5.33
7	0.33	1.82	3.85	4.31	6.88	9.23	11.67	14.80	20.74
8	0.32	1.73	3.67	4.11	6.55	8.79	11.11	14.10	19.75
9	–0.20	–1.09	–2.32	–2.60	–4.14	–5.56	–7.03	–8.91	–12.48
10	0.32	1.73	3.67	4.11	6.55	8.79	11.11	14.10	19.75
11	–1.55	–2.87	–4.69	–5.10	–7.38	–9.48	–11.65	–14.45	–19.74
12	0.33	1.82	3.85	4.31	6.88	9.23	11.67	14.80	20.74
13	0.09	0.47	0.99	1.11	1.77	2.37	3.00	3.81	5.33
14	0.41	2.25	4.77	5.34	8.51	11.43	14.45	18.33	25.67
15	0.57	3.12	6.60	7.40	11.79	15.83	20.00	25.38	35.55
16	0.88	4.85	10.27	11.50	18.34	24.62	31.11	39.47	55.30
17	0.06	0.30	0.64	0.72	1.15	1.54	1.94	2.47	3.46
18	0.07	0.39	0.83	0.92	1.47	1.98	2.50	3.17	4.44
19	0.37	2.03	4.31	4.83	7.70	10.33	13.06	16.56	23.20
20	0.51	2.77	5.87	6.57	10.48	14.07	17.78	22.56	31.60
21	0.81	4.41	9.36	10.48	16.70	22.42	28.34	35.95	50.36
22	1.39	7.62	16.14	18.08	28.82	38.69	48.89	62.03	86.89

Table A2.1 Heating and Cooling Energy Cost Multipliers for Envelope Trade-off Analysis *(continued)*

	Cooling Energy Cost Multipliers (CECM) by Climate Zones								
No.	1	2	3A,B	3C	4	5	6	7	8
1	2.94	2.39	1.66	1.24	1.01	0.89	0.78	0.44	0.32
2	2.50	2.04	1.41	1.05	0.86	0.76	0.66	0.38	0.27
3	1.47	1.20	0.83	0.62	0.51	0.44	0.39	0.22	0.16
4	1.20	0.98	0.68	0.51	0.42	0.36	0.32	0.18	0.13
5	1.16	0.95	0.65	0.49	0.40	0.35	0.31	0.18	0.13
6	0.59	0.48	0.33	0.25	0.20	0.18	0.16	0.09	0.06
7	1.47	1.20	0.83	0.62	0.51	0.44	0.39	0.22	0.16
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	5.48	4.46	3.09	2.31	1.89	1.66	1.45	0.83	0.60
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	23.84	17.69	11.24	8.53	7.39	6.83	6.39	5.36	5.10
12	1.47	1.20	0.83	0.62	0.51	0.44	0.39	0.22	0.16
13	0.59	0.48	0.33	0.25	0.20	0.18	0.16	0.09	0.06
14	0.59	0.48	0.33	0.25	0.20	0.18	0.16	0.09	0.06
15	0.88	0.72	0.50	0.37	0.30	0.27	0.23	0.13	0.10
16	2.06	1.68	1.16	0.87	0.71	0.62	0.54	0.31	0.23
17	0.44	0.36	0.25	0.19	0.15	0.13	0.12	0.07	0.05
18	0.44	0.36	0.25	0.19	0.15	0.13	0.12	0.07	0.05
19	1.47	1.20	0.83	0.62	0.51	0.44	0.39	0.22	0.16
20	2.79	2.27	1.58	1.17	0.96	0.84	0.74	0.42	0.31
21	2.64	2.15	1.49	1.11	0.91	0.80	0.70	0.40	0.29
22	5.29	4.31	2.98	2.23	1.82	1.60	1.40	0.80	0.58

A_1 = area of first fenestration construction type, ft^2
A_2 = area of second fenestration construction type, ft^2
A_n = area of *n*th fenestration construction type, ft^2

A3.5 Perimeter-Weighted C-Factors (Basement and Crawlspace Walls). When the criteria are expressed in terms of C-factors, the perimeter-weighted C-factor (C_o) is determined by Equation A-4.

$$C_o = (C_1 \cdot P_1 + C_2 \cdot P_2 + \ldots + C_n \cdot P_n)/(P_1 + P_2 + \ldots + P_n) \tag{A-4}$$

where

C_o = overall perimeter-weighted C-factor, Btu/h·ft·°F
C_1 = C-factor of first envelope construction type, Btu/h·ft·°F
C_2 = C-factor of second envelope construction type, Btu/h·ft·°F
C_n = C-factor of *n*th envelope construction type, Btu/h·ft·°F
P_1 = perimeter of first envelope construction type, ft
P_2 = perimeter of second envelope construction type, ft
P_n = perimeter of *n*th envelope construction type, ft

A3.6 Perimeter-Weighted Average R-Values (Slabs). The criteria for slabs are presented as R-values. The R-values are converted into an area-weighted U-factor (U_o) by Equation A-5 for use in the envelope trade-off analysis.

$$U_o = (P_1/(1 + R_1) + P_2/(1 + R_2) + \ldots + P_n/(1 + R_n))/(P_1 + P_2 + \ldots + P_n) \tag{A-5}$$

where

U_o = overall perimeter-weighted U-factor, Btu/h·ft^2·°F
R_1 = R-value of first slab construction type, h·ft^2·°F/Btu
R_2 = R-value of second slab construction type, h·ft^2·°F/Btu
R_n = R-value of *n*th slab construction type, h·ft^2·°F/Btu
P_1 = perimeter of first slab construction type, ft
P_2 = perimeter of second slab construction type, ft
P_n = perimeter of *n*th slab construction type, ft

A4 Equations for Envelope Trade-Off Calculations. The equations presented in this subsection shall be used in all building envelope trade-off calculations. The total heating and cooling energy costs are determined using Equation A-6.

$$EC = HEAT + COOL \tag{A-6}$$

where

EC = total heating and cooling energy costs for an envelope construction option, \$/yr
HEAT = heating energy cost for an envelope construction option, \$/yr
COOL = cooling energy cost for an envelope construction option, \$/yr

Equation A-6 shall be used to determine the total energy costs for the proposed envelope options (PEO) and the total energy costs for the prescriptive envelope criteria options (PEC).

A4.1 Above-Grade Opaque Envelope Options. The analysis of above-grade opaque envelope options shall use the following equations:

$$\text{HEAT} = U_o \cdot A \cdot \text{HECM} \qquad \text{(A-7)}$$

where

U_o = overall area-weighted thermal transmittance, Btu/h·ft^2·°F

A = total surface area of above-grade opaque constructions, ft^2

HECM = heating energy cost multiplier for a specific climate zone (see Table A2.1)

and

$$\text{COOL} = U_o \cdot A \cdot \text{CECM} \qquad \text{(A-8)}$$

where

CECM = cooling energy cost multiplier for a specific climate zone (see Table A2.1)

A4.1.1 Ceilings with Attics. Ceilings with attics separate conditioned space from exterior weather conditions with a ventilated attic space above the insulation. The ceilings can be horizontal surfaces, sloped surfaces, or tray-type construction. The framing can be truss or rafter construction made of wood or cold-formed steel.

A4.1.2 Ceilings without Attics. Ceilings without attics separate conditioned space from exterior weather conditions without an attic space above the insulation. Cathedral ceilings or flat roofs do not have a ventilated attic space above the insulation but may have a small (one-inch) air space for moisture removal. The framing can be truss or rafter construction made of wood or cold-formed steel.

A4.1.3 Above-Grade Frame Walls and Band Joists. Above-grade frame walls are exterior walls that separate conditioned space from exterior weather conditions. The framing construction can be wood or cold-formed steel.

A4.1.4 Above-Grade Concrete, Masonry, or Log Walls. Above-grade concrete, masonry, or log walls are exterior walls that separate conditioned space from exterior weather conditions. The walls shall be modeled as exterior or integral insulation assemblies or as interior insulation assemblies depending upon the location of the insulation relative to the mass of the walls. The insulation positions are reflected in the heating and cooling energy cost multipliers in Table A2.1.

A4.1.5 Doors. Doors separate conditioned space from exterior weather conditions, enclosed garages, and enclosed porches. The construction can be any material.

A4.1.6 Floors Over Exterior Ambient Conditions. Floors over exterior ambient conditions separate conditioned space from exterior weather conditions. Examples of exterior ambient conditions include overhangs, carports, enclosed garages, and enclosed porches. The framing construction can be wood or cold-formed steel.

A4.1.7 Floors Over Unconditioned Spaces. Floors over unconditioned spaces separate conditioned space from unconditioned space. Examples of unconditioned space include vented crawlspace and basement. The framing construction can be wood or cold-formed steel.

A4.1.8 Walls Adjacent to Unconditioned Spaces. Walls adjacent to unconditioned spaces separate conditioned space from unconditioned space. Examples of interior walls that separate conditioned space from unconditioned space include vented crawlspace, basement, and mechanical rooms. The framing construction can be any material.

A4.2 Vertical Fenestration Envelope Options. Vertical fenestration separates conditioned space from exterior weather conditions. The analysis of vertical fenestration options shall use the following equations. These equations assume that the fenestration is uniformly distributed on the four cardinal orientations No restrictions on the fenestration area are allowed.

$$\text{HEAT} = U_{fo} \cdot A \cdot \text{HECM} + \text{SHGC}_{fo} \cdot A \cdot \text{HECM} \qquad \text{(A-9)}$$

where

A = area of all fenestration, ft^2

U_{fo} = overall area-weighted fenestration thermal transmittance, Btu/h·ft^2·°F

SHGC_{fo} = overall area-weighted solar heat gain coefficient for fenestration, dimensionless

and

$$\text{COOL} = U_{fo} \cdot A \cdot \text{CECM} + \text{SHGC}_{fo} \cdot A \cdot \text{CECM} \qquad \text{(A-10)}$$

A4.3 Skylight Options. The analysis of skylight options shall use the following equations. These equations assume that the skylights are uniformly distributed on the four cardinal orientations. This analysis shall be used when the skylight area exceeds the 1% of the conditioned floor area allowed under the prescriptive criteria in Section 5.2. When the skylight area exceeds the 1% limit, the ceiling area shall be reduced to reflect the increased area of the skylights and the ceiling shall be included in the envelope trade-off analysis.

$$\text{HEAT} = U_{so} \cdot A \cdot \text{HECM} + \text{SHGC}_{so} \cdot A \cdot \text{HECM} \qquad \text{(A-11)}$$

where

A = area of all skylights, ft^2

U_{so} = overall area-weighted skylight thermal transmittance, Btu/h·ft^2·°F

SHGC_{so} = overall area-weighted solar heat gain coefficient for skylights, dimensionless

and

$$\text{COOL} = U_{so} \cdot A \cdot \text{CECM} + \text{SHGC}_{so} \cdot A \cdot \text{CECM} \qquad \text{(A-12)}$$

A4.4 Below-Grade Envelope Options. The analysis of below-grade envelope options shall use the following equations. The thermal conductance of the below-grade envelope options shall exclude the interior and exterior air film coefficients and the surrounding soil.

$$\text{HEAT} = C_o \cdot P \cdot \text{HECM} \quad \text{(A-13)}$$

where

C_o = overall perimeter-weighted thermal conductance, Btu/h·ft·°F

P = total perimeter of below-grade constructions, ft

and

$$\text{COOL} = C_o \cdot P \cdot \text{CECM} \quad \text{(A-14)}$$

Select the below-grade exterior insulation U-factor from Table 5.12 if the proposed design has exterior below-grade wall insulation. Select the below-grade interior insulation U-factor from Table 5.12 if the proposed design has interior below-grade wall insulation or no below-grade wall insulation.

A4.4.1 Basement Walls. Basement walls separate conditioned space from exterior weather conditions. The wall construction can be concrete, masonry, or wood, and the depth of the basement wall below grade can vary, as can the depth of the insulation used. All of these variables are reflected in the heating and cooling energy cost multipliers in Table A2.1.

A4.3.2 Crawlspace Walls. Crawlspace walls separate the crawlspace from exterior weather conditions. The wall constructions can be masonry, concrete, or wood, which are reflected in the heating and cooling energy cost multipliers in Table A2.1.

A4.5 Slab-on-Grade Envelope Options. The analysis of slab-on-grade envelope options shall use the following equations. The depth of the slab edge insulation is reflected in the heating and cooling energy cost multipliers in Table A2.1.

$$\text{HEAT} = U_o \cdot P \cdot \text{HECM} \quad \text{(A-15)}$$

where

U_o = perimeter-weighted thermal transmittance of the slab edge insulation, Btu/h·ft·°F

P = total perimeter of insulated slab edge, ft

and

$$\text{COOL} = U_o \cdot P \cdot \text{CECM} \quad \text{(A-16)}$$

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

INFORMATIVE APPENDIX B
INFORMATIVE REFERENCES

This appendix contains informative references for the convenience of users of Standard 90.2 and to acknowledge source documents when appropriate.

Organization/Standard(s)	Standard Title	Section Number(s)
CRRC **Cool Roof Rating Council** **Oakland, CA** www.coolroofs.org		
CRRC-1 (2002)	Cool Roof Rating Council Product Rating Program	5.5

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

INFORMATIVE APPENDIX C
ADDENDA DESCRIPTION INFORMATION

ANSI/ASHRAE Standard 90.2-2007 incorporates ANSI/ASHRAE Standard 90.2-2004 and Addenda a, b, c, d, e, f, g, h, i, and k to ANSI/ASHRAE Standard 90.2-2004. Table C1 lists each addendum and their respective ASHRAE and ANSI approval dates, and describes the way in which the standard is affected by the change.

TABLE C1
Addenda to ANSI/ASHRAE Standard 90.2-2004

Addenda to 90.2-2004	Sections Affected	Description of Changes[a]	ASHRAE Standards Committee Approval Date	ASHRAE Board of Directors Approval Date	ANSI Approval Date
90.2a	Section 8.7.1	This addendum has modified the language for duct location in the Annual Energy Cost Budget Method.	1/21/06	1/26/06	4/10/06
90.2b	Tables 5.2 and 5.11 and Sections 8.7.8 and A4.4	This addendum has modified the below grade insulation requirements in climate zones 3–8.	1/21/06	1/26/06	4/10/06
90.2c	Section 3	This addendum has modified the definition of *conditioned space.*	1/27/06	3/2/07	3/3/07
90.2d	Sections 3 and 5	This addendum added a definition and requirements for *mass walls*.	1/27/06	3/2/07	3/3/07
90.2e	Section 5.3 and Tables 5.2 and 5.11	This addendum added insulation requirements for walls adjacent to unconditioned spaces and defines the situations where these requirements apply.	1/27/06	3/2/07	3/3/07
90.2f	Tables 5.2 and 5.11	This addendum modified the requirements for vertical glazed assemblies in climate zones 4 and 5.	1/21/06	1/26/06	4/10/06
90.2g	Adds Tables 5.5.1 and 5.5.2; removes Table 5.5; modifies Section 5.5	This addendum modified the requirements for high albedo roofs.	1/21/06	1/26/06	4/10/06
90.2h	Table 9.3	This addendum added climatic data for China and Taiwan, and corrects errors in the climatic data for Malaysia and Mexico.	1/21/06	1/26/06	4/10/06
90.2i	Table 5.9.1 and Section 10	This addendum updated some of the normative references in the standard.	1/21/06	1/26/06	4/10/06
90.2k	Informative Appendix D	This addendum removed Informative Appendix D.	1/27/07	3/2/07	3/3/07

[a] These descriptions may not be complete and are provided for information only.

NOTE

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

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 at the Annual Meeting (normally June) if proposed changes are received by the Manager of Standards (MOS) no later than December 31. Proposals received after December 31 shall be considered by the SSPC no later than at the Annual Meeting of the following year.

Proposed changes must be submitted to the MOS in the latest published format available from the MOS. However, the MOS may accept proposed changes in an earlier published format if the MOS concludes that the differences are immaterial to the proposed change submittal. If the MOS concludes that a current form must be utilized, the proposer may be given up to 20 additional days to resubmit the proposed changes in the current format.

ELECTRONIC PREPARATION/SUBMISSION OF FORM FOR PROPOSING CHANGES

An electronic version of each change, which must comply with the instructions in the Notice and the Form, is the preferred form of submittal to ASHRAE Headquarters at the address shown below. The electronic format facilitates both paper-based and computer-based processing. Submittal in paper form is acceptable. The following instructions apply to change proposals submitted in electronic form.

Use the appropriate file format for your word processor and save the file in either a recent version of Microsoft Word (preferred) or another commonly used word-processing program. Please save each change proposal file with a different name (for example, "prop01.doc," "prop02.doc," etc.). If supplemental background documents to support changes submitted are included, it is preferred that they also be in electronic form as word-processed or scanned documents.

ASHRAE will accept the following as equivalent to the signature required on the change submittal form to convey non-exclusive copyright:

Files attached to an e-mail:	Electronic signature on change submittal form (as a picture; *.tif, or *.wpg).
Files on a CD:	Electronic signature on change submittal form (as a picture; *.tif, or *.wpg) or a letter with submitter's signature accompanying the CD or sent by facsimile (single letter may cover all of proponent's proposed changes).

Submit an e-mail or a CD containing the change proposal files to:
Manager of Standards
ASHRAE
1791 Tullie Circle, NE
Atlanta, GA 30329-2305
E-mail: change.proposal@ashrae.org
(Alternatively, mail paper versions to ASHRAE address or fax to 404-321-5478.)

The form and instructions for electronic submittal may be obtained from the Standards section of ASHRAE's Home Page, www.ashrae.org, or by contacting a Standards Secretary, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305.
Phone: 404-636-8400. Fax: 404-321-5478. E-mail: standards.section@ashrae.org.

FORM FOR SUBMITTAL OF PROPOSED CHANGE TO AN ASHRAE STANDARD UNDER CONTINUOUS MAINTENANCE

NOTE: Use a separate form for each comment. Submittals (Microsoft Word preferred) may be attached to e-mail (preferred), submitted on a CD, or submitted in paper by mail or fax to ASHRAE, Manager of Standards, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: change.proposal@ashrae.org. Fax: +1-404/321-5478.

1. Submitter:

Affiliation:

Address: City: State: Zip: Country:

Telephone: Fax: E-Mail:

I hereby grant the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) the non-exclusive royalty rights, including non-exclusive rights in copyright, in my proposals. I understand that I acquire no rights in publication of the standard in which my proposals in this or other analogous form is used. I hereby attest that I have the authority and am empowered to grant this copyright release.

Submitter's signature: ____ Date: ____________________________

All electronic submittals must have the following statement completed:

I *(insert name)* ____, through this electronic signature, hereby grant the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) the non-exclusive royalty rights, including non-exclusive rights in copyright, in my proposals. I understand that I acquire no rights in publication of the standard in which my proposals in this or other analogous form is used. I hereby attest that I have the authority and am empowered to grant this copyright release.

2. Number and year of standard:

3. Page number and clause (section), subclause, or paragraph number:

4. I propose to: *(check one)*

[ ] Change to read as follows

[ ] Delete and substitute as follows

[ ] Add new text as follows

[ ] Delete without substitution

Use underscores to show material to be added (added) and strike through material to be deleted (~~deleted~~). Use additional pages if needed.

5. Proposed change:

6. Reason and substantiation:

7. Will the proposed change increase the cost of engineering or construction? If yes, provide a brief explanation as to why the increase is justified.

[ ] Check if additional pages are attached. Number of additional pages: _______

[ ] Check if attachments or referenced materials cited in this proposal accompany this proposed change. Please verify that all attachments and references are relevant, current, and clearly labeled to avoid processing and review delays. *Please list your attachments here:*

Rev. 3-9-2007

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

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