ASHRAE 90.1-2007 AMENDMENTS

CITY OF HOUSTON

PUBLIC WORKS AND ENGINEERING DEPT

Effective Date: September 2, 2011

1. PURPOSE

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

1.1 This code shall be known as the *City of Houston Commercial Energy Conservation Code – ASHRAE 90.1-2007*, may be cited as such, and will be referred to herein as "this code." *The City of Houston Construction Code* collectively includes this volume and certain other codes, pamphlets, specifications, and documents that are adopted in or by reference to the Adopting Ordinance, City of Houston Ordinance No. 2010-847.

2. SCOPE

2.1 This ~~standard~~ code provides:

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

b. criteria for determining compliance with these requirements.

2.2 The provisions of this ~~standard~~ code apply to:

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

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

2.3 The provisions of this ~~standard~~ code do not apply to;

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

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

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

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

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

***3.1 General.** Certain terms, abbreviations, and acronyms are defined in this section for the purposes of this ~~standard~~ code. These definitions are applicable to all sections of this ~~standard~~ code. Terms that are not defined shall have their ordinarily accepted meanings within the context in which they are used. Ordinarily accepted meanings shall be based upon American standard English language usage as documented in an unabridged dictionary accepted by the *adopting authority*. Terms that are not defined in this code but are defined in other volumes of the *City of Houston Construction Code* shall have the meanings ascribed to them in those codes.

accessible: having access to but which first may require the removal of an access panel, door, or similar obstruction covering the item described.

accessible, readily: capable of being reached safely and quickly for operation, repair, or inspection without requiring those to whom ready access is requisite to climb over or remove obstacles, or to resort to the use of portable access equipment.

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

ASHRAE: the American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., which publishes the ASHRAE 90.1 Standard. Energy Standard for Buildings Except Low-Rise Residential Buildings.

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

***boiler*:** ~~a self-contained low-pressure appliance for supplying steam or hot water~~ a closed vessel used for heating water or liquid, or for generating steam or vapor by direct application of heat from combustible fuels or electricity.

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

building thermal envelope: the basement walls, exterior walls, floor, roof, and any other building element that enclose conditioned space. This boundary also includes the boundary between conditioned space and any exempt or unconditioned space.

duct: any tube or conduit for transmission of air. This definition shall not include:

a. a vent, a vent connector or a chimney connector,

b. any tube or conduit wherein the pressure of the air exceeds one (1) pound per square inch, or

c. the air passages of listed self-contained systems.

***energy cost budget*:** the annual energy cost for the *budget building design* intended for use in determining minimum compliance with this ~~standard~~ code.

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

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

***Mechanical Code*:** the *City of Houston Mechanical Code*, as adopted by the *authority having jurisdiction*.

***Performance Rating Method*:** a calculation procedure that generates an index of merit for the performance of building designs that substantially exceeds the energy efficiency levels required by this ~~standard~~ code.

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

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

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

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

1. ***cooled space*:** an enclosed space within a building that is cooled by a cooling system whose sensible output capacity exceeds 5 Btu/h·ft^2 of floor area.
2. ***heated space*:** an enclosed space within a building that is heated by a heating system whose output capacity relative to the floor area is greater than or equal to ~~the criteria in Table 3.1~~ 5 Btu/h·ft^2.
3. ***indirectly conditioned space:*** an enclosed space within a building that is not a heated space or a cooled space, which is heated or cooled indirectly by being connected to adjacent space(s) provided:
    a. the product of the U-factor(s) and surface area(s) of the space adjacent to connected space(s) exceeds the combined sum of the product of the U-factor(s) and surface area(s) of the space adjoining the outdoors, unconditioned spaces, and to or from semiheated spaces (e.g., corridors) or
    b. that air from heated or cooled spaces is intentionally transferred (naturally or mechanically) into the space at a rate exceeding 3 ach (e.g., atria).

***NOTE: ALL OTHER PORTIONS OF SECTION 3.1 REMAIN AS SET FORTH IN ASHRAE STANDARD 90.1-2007.**

[Delete TABLE 3.1 Heated Space Criteria Without Substitution]

4.1.1 Scope. The provisions of this code shall apply to the construction, *alteration*, movement, enlargement, replacement, *repair*, *equipment*, use and occupancy, location, maintenance, removal and demolition of buildings, as provided in Section 2 of this code.

4.1.1.1 New Buildings. New buildings shall comply with the ~~standard~~ code as described in Section 4.2.

4.1.1.2 Additions to Existing Buildings. An extension or increase in the floor area or height of a building outside of the *existing building* envelope shall be considered *additions* to *existing buildings* and shall comply with the ~~standard~~ code as described in Section 4.2.

4.1.1.3 Alterations of Existing Buildings. *Alterations* of *existing buildings* shall comply with the ~~standard~~ code as described in Section 4.2.

4.1.1.4 Replacement of Portions of Existing Buildings. Portions of a building envelope, heating, ventilating, air conditioning, service water heating, power, lighting, and other systems and equipment that are being replaced shall be considered as alterations of existing buildings and shall comply with the ~~standard~~ code as described in Section 4.2.

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

4.1.2 Administrative Requirements. Administrative requirements relating to permit requirements, enforcement by the *authority having jurisdiction*, locally adopted energy standards, interpretations, claims of exemption, revocation and rights of appeal shall be as set forth in the applicable volume of the *City of Houston Construction Code* ~~are specified by the *authority having jurisdiction*~~.

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

4.1.4 Reserved. ~~**Validity.** If any term, part, provision, section, paragraph, subdivision, table, chart, or referenced standard of this standard shall be held unconstitutional, invalid, or ineffective, in whole or in part, such determination shall not be deemed to invalidate any remaining term, part, provision, section, paragraph, subdivision, table, chart, or referenced standard of this standard.~~

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

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

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

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

4.2.1.3 Alterations of Existing Buildings: *Alterations* of *existing buildings* shall comply with the provisions of Sections 5, 6, 7, 8, 9, and 10, provided, however, that nothing in this ~~standard~~ code shall require compliance with any provision of this ~~standard~~ code if such compliance will result in the increase of energy consumption of the building.

Exceptions:

a. A *historic* building ~~that has been specifically designated as historically significant by the *adopting authority* or is listed in The National Register of Historic Places or has been determined to be eligible for listing by the US Secretary of the Interior~~ need not comply with ~~these requirements~~ a provision or provisions that would invalidate or jeopardize the historical designation or listing.

b. Where one or more components of an *existing building* or portions thereof are being replaced, the annual energy consumption of the comprehensive design shall not be greater than the annual energy consumption of a substantially identical design, using the same energy types, in which the applicable requirements of Sections 5, 6, 7, 8, 9, and 10, as provided in Section 4.2.1.3, and such compliance is verified by a registered *design professional*, by the use of any calculation methods acceptable to the *authority having jurisdiction*.

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

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

4.2.3 Labeling of Material and Equipment. Materials and equipment shall be labeled in a manner that will allow for a determination of their compliance with the applicable provisions of this ~~standard~~ code.

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

a. wall insulation after the insulation and vapor retarder are in place but before concealment

b. roof/ceiling insulation after roof/insulation is in place but before concealment

c. slab/foundation wall after slab/foundation insulation is in place but before concealment

d. fenestration after all glazing materials are in place

e. mechanical systems and equipment and insulation after installation but before concealment

f. electrical equipment and systems after installation but before concealment

5. BUILDING ENVELOPE

~~**5.1.2.3** In climate zones 3 through 8, a space may be designated as either *semiheated* or *unconditioned* only if approved by the *building official*.~~

5.1.4 Climate. ~~Determine the climate zone for the location. For US locations, follow the procedure in Section 5.1.4.1. For international locations, follow the procedure in Section 5.1.4.2.~~ Exterior design conditions shall be as set forth in Table 5.1.4.

TABLE 5.1.4 Exterior Design Conditions

Condition	Value
Winter, Design Dry-bulb (E_F)	28°F
Summer, Design Dry-bulb	96°F
Summer, Design Wet-bulb	80.5°F
Degree days heating (base 65)	1371
Degree Days cooling (base 50)	7534
Climate Zone	2A

~~**5.1.4.1 United States Locations.** Use Figure B-1 or Table B-1 in Appendix B to determine the required climate zone.~~

~~**Exception:** If there are recorded historical climatic data available for a construction site, they may be used to determine compliance if approved by the *building official*.~~

~~**5.1.4.2 International Locations.** For locations in Canada that are listed in Table B-2 in Appendix B, use this table to determine the required climate zone number and, when a climate zone letter is also required, use Table B-4 and the Major Climate Type Definitions in Appendix B to determine the letter (A, B, or C). For locations in other international countries that are listed in Table B-3, use this table to determine the required climate zone number and, when a climate zone letter is also required, use Table B-4 and the Major Climate Type Definitions in Appendix B to determine the letter (A, B, or C). For all international locations that are not listed either in Table B-2 or B-3, use Table B-4 and the Major Climate Type Definitions in Appendix B to determine both the climate zone letter and number~~.

5.2.2 Projects using the Energy Cost Budget Method (Section 11 of this ~~standard~~ code), must comply with Section 5.4, the mandatory provisions of this section, as a portion of that compliance path.

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

a. joints around *fenestration* and *door* frames

b. junctions between *walls* and foundations, between *walls* at building corners, between *walls* and structural *floors* or *roofs*, and between *walls* and *roof* or *wall* panels

c. openings at penetrations of utility services through *roofs*, *walls*, and *floors*

d. site-built *fenestration* and *doors*

e. building assemblies used as ducts or plenums

f. joints, seams, and penetrations of vapor retarders

g. all other openings in the *building envelope*

5.4.3.3 Loading Dock Weatherseals. ~~In climate zones 4 through 8,~~ Cargo *doors* and loading dock *doors* shall be equipped with weatherseals to restrict *infiltration* when vehicles are parked in the doorway.

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

Exceptions:

a. *Building entrances* with revolving *doors*.

b. *Doors* not intended to be used as a *building entrance.*

c. *Doors* opening directly from a *dwelling unit*.

~~d. *Building entrances* in buildings located in climate zone 1 or 2.~~

~~e. *Building entrances* in buildings located in climate zone 3 or 4 that are less than four stories above grade and less than 10,000 ft^2 in area.~~

~~f. *Building entrances* in buildings located in climate zone 5, 6, 7, or 8 that are less than 1000 ft^2 in area~~.

~~g.~~ *Doors* that open directly from a *space* that is less than 3000 ft^2 in area and is separate from the *building entrance*.

5.4.3.5 Cool roofs. Low slope *roofs* up to 2:12 shall be provided with a roof covering where the exterior surface has:

a. a minimum total solar reflectance of 0.70 when tested in accordance with one of the solar reflectance test methods listed below, and

b. a minimum thermal emittance of 0.75 when tested in accordance with one of the thermal emittance test methods listed below.

Solar Reflectance Test Methods: ASTM C1549, ASTM E903, ASTM E1175, or ASTM E1918.

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

The values for 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.

See Appendix H for guideline.

Exceptions to 5.4.3.5:

a. The portion of the *roof* that is a rooftop garden, or green roof, or rooftop deck not exceeding 1/3 of the aggregate area of the roof, is exempted from the requirements of this section.

b. An area including and adjacent to rooftop photovoltaic and solar thermal equipment, totaling not more than three times the area that is covered with such equipment, is exempt from the requirements of this section.

5.5.1 For *conditioned space*, the *exterior building envelope* shall comply with either the "nonresidential" or "residential" requirements in Table~~s~~ 5.5-2 ~~5.5-1 through 5.5-8 for the appropriate climate~~ for climate zone 2.

5.5.2 If a building contains any *semiheated space* or *unconditioned space*, then the *semi-exterior building envelope* shall comply with the requirements for *semiheated space* in Table~~s~~ 5.5-2 ~~5.5-1 through 5.5-8~~ for ~~the appropriate~~ climate ~~for~~ zone 2. (See Figure 5.5.)

TABLE 5.5-1 Building Envelope Requirements for Climate Zone 1 (A,B)* {deleted entirely}

TABLE 5.5-2 Building Envelope Requirements for Climate Zone 2 (A, B)*

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.048	R-20.0 c.i.	U-0.048	R-20.0 c.i.	U-0.218	R-3.8 c.i.
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.167	R-6.0
Attic and Other	U-0.027	R-38.0	U-0.027	R-38.0	U-0.081	R-13.0
Walls, Above-Grade						
Mass	U-0.151[a]	R-5.7 c.i.[a]	U-0.123	R-7.6 c.i.	U-0.580	NR
Metal Building	U-0.113	R-13.0	U-0.113	R-13.0	U-0.184	R-6.0
Steel-Framed	U-0.124	R-13.0	U-0.064	R-13.0 + R-7.5 c.i.	U-0.124	R-13.0
Wood-Framed and Other	U-0.089	R-13.0	U-0.089	R-13.0	U-0.089	R-13.0
Walls, Below-Grade						
Below-Grade Wall	C-1.140	NR	C-1.140	NR	C-1.140	NR
Floors						
Mass	U-0.107	R-6.3 c.i.	U-0.087	R-8.3 c.i.	U-0.322	NR
Steel-Joist	U-0.052	R-19.0	U-0.052	R-19.0	U-0.069	R-13.0
Wood-Framed and Other	U-0.051	R-19.0	U-0.033	R-30.0	U-0.066	R-13.0
Slab-On-Grade Floors						
Unheated	F-0.730	NR	F-0.730	NR	F-0.730	NR
Heated	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.700		U-0.700	
Nonswinging	U-1.450		U-0.500		U-1.450	
Fenestration	**Assembly Max. U**	**Assembly Max. SHGC**	**Assembly Max. U**	**Assembly Max. SHGC**	**Assembly Max. U**	**Assembly Max. SHGC**
Vertical Glazing, 0%–40% of Wall						
Nonmetal framing (all)[b]	U-0.75	SHGC-0.25 all	U-0.75	SHGC-0.25 all	U-1.20	SHGC-NR all
Metal framing (curtainwall/storefront)[c]	U-0.70		U-0.70		U-1.20	
Metal framing (entrance door)[c]	U-1.10		U-1.10		U-1.20	
Metal framing (all other)[c]	U-0.75		U-0.75		U-1.20	
Skylight with Curb, Glass, % of Roof						
0%–2.0%	U_{all}-1.98	$SHGC_{all}$-0.36	U_{all}-1.98	$SHGC_{all}$-0.19	U_{all}-1.98	$SHGC_{all}$-NR
2.1%–5.0%	U_{all}-1.98	$SHGC_{all}$-0.19	U_{all}-1.98	$SHGC_{all}$-0.19	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic, % of Roof						
0%–2.0%	U_{all}-1.90	$SHGC_{all}$-0.39	U_{all}-1.90	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-NR
2.1%–5.0%	U_{all}-1.90	$SHGC_{all}$-0.34	U_{all}-1.90	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All, % of Roof						
0%–2.0%	U_{all}-1.36	$SHGC_{all}$-0.36	U_{all}-1.36	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-NR
2.1%–5.0%	U_{all}-1.36	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-NR

*The following definitions apply: c.i. = continuous insulation (see Section 3.2), NR = no (insulation) requirement.

a Exception to Section A3.1.3.1 applies.
b Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.
c Metal framing includes metal framing with or without thermal break. The "all other" subcategory includes operable windows, fixed windows, and non-entrance doors.
d To be appended to "Fenestration" in Table above.] Reference Section 5.8.2.5 for SHGC and SC definitions.

TABLE 5.5-3 Building Envelope Requirements for Climate Zone 3 (A, B, C)* {deleted entirely}

TABLE 5.5-4 Building Envelope Requirements for Climate Zone 4 (A, B, C)* {deleted entirely}

TABLE 5.5-5 Building Envelope Requirements for Climate Zone 5 (A, B, C)* {deleted entirely}

TABLE 5.5-6 Building Envelope Requirements for Climate Zone 6 (A, B)* {deleted entirely}

TABLE 5.5-7 Building Envelope Requirements for Climate Zone 7* {deleted entirely}

TABLE 5.5-8 Building Envelope Requirements for Climate Zone 8* {deleted entirely}

5.5.3.1 Roof Insulation. All *roofs* shall comply with the insulation values specified in Tables 5.5-2 ~~5.5-1 through 5.5-8 or shall comply with the insulation values specified in Section 5.5.3.1.1 and Table 5.5.3.1. Skylight c~~ Curbs shall be insulated to the level of roofs with insulation entirely above deck or ~~R-5~~ R-8, whichever is less. .

5.5.3.1.1 Reserved. ~~**High Albedo Roofs.** For *roofs*, other than *roofs* over ventilated attics or *roofs* over *semi-heated spaces* or *roofs* over *conditioned spaces* that are not *cooled spaces*, where the exterior surface has~~

~~a. a solar reflectance of 0.70 when tested in accordance with ASTM C1549, ASTM E903, or ASTM E1918 and, in addition, a minimum thermal emittance of 0.75 when tested in accordance with ASTM C1371 or ASTM E408 or~~

~~b. a minimum Solar Reflective Index of 82 when determined in accordance with the Solar Reflectance Index method in ASTM E1980,~~

~~the insulation value for the roof shall comply with the values in Table 5.5.3.1. The values for 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.~~

[Delete TABLE 5.5.3.1 High Albedo Roof Insulation Without Substitution]

5.5.3.2 Above-Grade Wall Insulation. All *above-grade walls* shall comply with the insulation values specified in Tables 5.5-2 ~~5.5-1 through 5.5-8~~. When a *wall* consists of both *above-grade* and *below-grade* portions, the entire *wall* for that story shall be insulated on either the exterior or the interior or be integral.

a. If insulated on the interior, the *wall* shall be insulated to the *above-grade wall* requirements.

b. If insulated on the exterior or integral, the *below-grade wall* portion shall be insulated to the *below-grade wall* requirements, and the *above-grade wall* portion shall be insulated to the *above-grade wall* requirements.

5.5.3.3 Below-Grade Wall Insulation. *Below-grade walls* shall have a *rated R-value* of *insulation* not less that the insulation values specified in Tables 5.5-2 ~~5.5-1 through 5.5-8~~.

Exception: Where framing, including metal and wood studs, is used, compliance shall be based on the maximum assembly *C-factor*.

5.5.3.4 Floor Insulation. All *floors* shall comply with the insulation values specified in Tables 5.5-2 ~~5.5-1 through 5.5-8~~.

5.5.3.5 Slab-on-Grade Floor Insulation. All *slab-on-grade floors*, including *heated slab-on-grade floors* and *unheated slab-on-grade floors*, shall comply with the insulation values specified in Table~~s~~ 5.5-2 ~~5.5-1 through 5.5-8~~.

5.5.3.6 Opaque Doors. All *opaque doors* shall have a *U-factor* not greater than that specified in Table~~s~~ 5.5-2 ~~5.5-1 through 5.5-8~~.

5.5.4.3 Fenestration U-Factor. *Fenestration* shall have a *U-factor* not greater than that specified in Table~~s~~ 5.5-2 ~~5.5-1 through 5.5-8~~ for the appropriate *fenestration area*.

5.5.4.4.1 SHGC of Vertical Fenestration. *Vertical fenestration* shall have a *SHGC* not greater than that specified for "all" orientations in Table~~s~~ 5.5-2 ~~5.5-1 through 5.5-8~~ for the appropriate total *vertical fenestration* area.

Exceptions:

a. For demonstrating compliance for *vertical fenestration* shaded by opaque permanent projections that will last as long as the building itself, the *SHGC* in the proposed building shall be reduced by using the multipliers in Table 5.5.4.4.1. Permanent projections consisting of open louvers shall be considered to provide shading, provided that no sun penetrates the louvers during the peak sun angle on June 21.

b. For demonstrating compliance for *vertical fenestration* shaded by partially opaque permanent projections (e.g., framing with glass or perforated metal) that will last as long as the building itself, the *PF* shall be reduced by multiplying it by a factor of O_s, which is derived as follows:

$$O_s = (A_i \cdot O_i) + (Af \cdot O_f)$$

where

O_s = percent opacity of the shading device

A_i = percent of the area of the shading device that is a partially opaque infill

O_i = percent opacity of the infill—for glass $O_i = (100\% - T_s)$, where T_s is the solar transmittance as determined in accordance with NFRC 300; for perforated or decorative metal panels O_i = percentage of solid material

A_f = percent of the area of the shading device that represents the framing members

O_f = percent opacity of the framing members; if solid, then 100%

And then the *SHGC* in the proposed building shall be reduced by using the multipliers in Table 5.5.4.4.1 for each *fenestration* product.

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

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

When this exception is utilized, separate calculations shall be performed for these sections of the *building envelope*, and these values shall not be averaged with any others for compliance purposes. No credit shall be given here or elsewhere in the building for not fully utilizing the *fenestration area* allowed.

5.5.4.4.2 SHGC of Skylights. *Skylights* shall have an *SHGC* not greater than that specified for "all" orientations in Table~~s~~ 5.5-2 ~~5.5-1 through 5.5-8~~ for the appropriate total *skylight area*.

5.6.1 The *building envelope* complies with the ~~standard~~ code if

a. the proposed building satisfies the provisions of Sections 5.1, 5.4, 5.7, and 5.8, and

b. the *envelope performance factor* of the proposed building is less than or equal to the *envelope performance factor* of the budget building.

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

5.9 Building Envelope Commissioning. For projects larger than 50,000 ft^2 conditioned area, except heated only warehouses and *semiheated spaces*, detailed instructions for commissioning *building envelope* systems (see Appendix E) shall be provided by the designer in plans and specifications.

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

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

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

6.1.1.3.1 New HVAC equipment as a direct replacement of existing HVAC equipment shall comply with the specific minimum *efficiency* requirements in this code applicable to that equipment.

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

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

6.3.2 Criteria: The HVAC *system* must meet ALL of the following criteria:

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

b. Cooling (if any) shall be provided by a unitary packaged or split-system air conditioner that is either air-cooled or evaporatively cooled with *efficiency* meeting the requirements shown in Table 6.8.1A (air conditioners), Table 6.8.1B (heat pumps), or Table 6.8.1D (packaged terminal and room air conditioners and heat pumps) for the applicable equipment category.

c. ~~The *system* shall have an~~ Air economizers (if any) ~~where indicated in Table 6.5.1, with controls as indicated in Tables 6.5.1.1.3A and 6.5.1.1.3B and with~~ shall be provided with either barometric or powered relief dampers sized to prevent overpressurization of the building. ~~Where the cooling *efficiency* meets or exceeds the *efficiency* requirement in Table 6.3.2, no economizer is required.~~ *Outdoor air* dampers for economizer use shall ~~be provided with blade and jamb seals~~ . shall have a maximum leakage rate of of 4 cfm per square foot of damper area at 1 in w.g., when tested in accordance with AMCA Standard 500.

d. Heating (if any) shall be provided by a unitary packaged or split-system heat pump that meets the applicable *efficiency* requirements shown in Table 6.8.1B (heat pumps) or Table 6.8.1D (packaged terminal and room air conditioners and heat pumps), a fuel-fired furnace that meets the applicable *efficiency* requirements shown in Table 6.8.1E (furnaces, duct furnaces, and unit heaters), an electric resistance heater, or a baseboard system connected to a boiler that meets the applicable *efficiency* requirements shown in Table 6.8.1F (boilers).

e. The *outdoor air* quantity supplied by the system shall be less than or equal to 3000 cfm and less than 70% of the supply air quantity at minimum *outdoor air* design conditions unless an energy recovery ventilation system is provided in accordance with the requirements in Section 6.5.6.

f. The *system* shall be controlled by a manual changeover or dual setpoint thermostat.

g. If a heat pump equipped with auxiliary internal electric resistance heaters is installed, controls shall be provided that prevent supplemental heater operation when the heating load can be met by the heat pump alone during both steady-state operation and setback recovery. Supplemental heater operation is permitted during outdoor coil defrost cycles. Two means of meeting this requirement are (1) a digital or electronic thermostat designed for heat pump use that energizes auxiliary heat only when the heat pump has insufficient capacity to maintain setpoint or to warm up the space at a sufficient rate or (2) a multistage space thermostat and an outdoor air thermostat wired to energize auxiliary heat only on the last stage of the space thermostat and when outside air temperature is less than 40°F. Heat pumps whose minimum efficiency is regulated by NAECA and whose HSPF rating both meets the requirements shown in Table 6.8.1B and includes all usage of internal electric resistance heating are exempted from the control requirements of this part (Section 6.3.2[g]).

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

i. *Systems* serving spaces other than hotel/motel guest rooms, and other than those requiring continuous operation, which have both a cooling or heating capacity greater than 15,000 Btu/h and a supply fan motor power greater than 0.75 hp, shall be provided with a time clock that (1) can start and stop the system under different schedules for seven different day-types per week, (2) is capable of retaining programming and time setting during a loss of power for a period of at least ten hours, (3) includes an accessible manual override that allows temporary operation of the system for up to two hours, (4) is capable of temperature setback down to 55°F during off hours, and (5) is capable of temperature setup to 90°F during off hours.

j. Except for piping within *manufacturers'* units, HVAC piping shall be insulated in accordance with Table 6.8.3. Insulation exposed to weather shall be suitable for outdoor service, e.g., protected by aluminum, sheet metal, painted canvas, or plastic cover. Cellular foam insulation shall be protected as above or painted with a coating that is water retardant and provides shielding from solar radiation.

k. Ductwork and plenums shall be insulated in accordance with Section 6.4.4.1.1 ~~Tables 6.8.2A and 6.8.~~2B and shall be sealed in accordance with the Mechanical Code.

l. Construction documents shall require a ducted *system* to be air balanced by a certified technician in accordance with ~~industry accepted procedures~~ one of the following standards:

   1. 6.7.2.3.1 NEBB Procedural Standards – 1999 Procedural standards for building systems commissioning

   2. 6.7.2.3.1 AABC 2002 Associated Air Balance Council Test and Balance procedures

   3. 6.7.2.3.1 ASHRAE Standard 111 – 1988 Practices for Measurement, Testing, Adjusting and Balancing of Building Heating, Ventilation, Air-Conditioning and Refrigeration.

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

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

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

p. Outside air intakes shall have motorized dampers with leakage rate not to exceed 4 cfm at 1.0 in. w.g. cfm per ft^2 of damper area. Outside air dampers and exhaust fans shall be interlocked to close the damper and turn off the fan when the supply air system is de-energized.

[Delete TABLE 6.3.2 Eliminate Required Economizer by Increasing Cooling Efficiency Unitary Systems with Heat Pump Heating Without Substitution]

6.4.1.2 Minimum Equipment Efficiencies – Listed Equipment – Nonstandard Conditions. Water-cooled centrifugal water-chilling packages that are not designed for operation at ARI Standard 550/590 test conditions (and thus cannot be tested to meet the requirements of Table 6.8.1C) of 44°F leaving chilled water temperature and 85°F entering condenser-water temperature with 3 gpm/ton condenser-water flow shall have a minimum full-load COP and a minimum *NPLV* rating as shown in tables referenced below.

a. Centrifugal chillers <150 tons shall meet the minimum full-load COP and IPLV/NPLV in Table 6.8.1H.

b. Centrifugal chillers ≥150 tons and <300 tons shall meet the minimum full-load COP and IPLV/NPLV in Table 6.8.1I.

c. Centrifugal chillers ≥300 tons shall meet the minimum full-load COP and IPLV/NPLV in Table 6.8.1J.

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

X Leaving Chiller-Water Temperature: 40°F to 48°F

X Entering Condenser-Water Temperature: 75°F to 85° F

X Condenser-Water Temperature Rise: 5°F to 15°F

Chillers designed to operate outside of these ranges or applications utilizing fluids or solutions with secondary coolants (e.g., glycol solutions or brines) with a freeze point of 27°F or lower for freeze protection are not covered by this ~~standard~~ code. All chillers shall meet the minimum ARI efficiency performance requirements of Tables 6.8.1H, 6.8.1I, and 6.8.1J, regardless of the operating conditions.

6.4.1.3 Equipment Not Listed. Equipment not listed in the tables referenced in 6.4.1.1 and 6.4.1.2 may be used in the Energy Cost Budget Method and Appendix G.

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

6.4.3.3.2 Setback Controls. Heating systems ~~located in climate zones 2-8~~ shall be equipped with controls that have the capability to automatically restart and temporarily operate the system as required to maintain *zone* temperatures above a heating setpoint adjustable down to 55°F or lower. Cooling systems ~~located in climate zones 1b, 2b, and 3b~~ shall be equipped with controls that have the capability to automatically restart and temporarily operate the system as required to maintain *zone* temperatures below a cooling setpoint adjustable up to ~~90~~ 85°F or higher or to prevent high space humidity levels.

Exception: Radiant floor and ceiling heating *systems*.

6.4.3.3.4 Zone Isolation. *HVAC systems* serving *zones* that are intended to operate or be occupied nonsimultaneously shall be divided into isolation areas. Zones may be grouped into a single isolation area provided it does not exceed 25,000 ft^2 of conditioned floor area nor include more than one floor. Each isolation area shall be equipped with *isolation devices* capable of automatically shutting off the supply of conditioned air and *outdoor air* to and exhaust air from the area. Each isolation area shall be controlled independently by a device meeting the requirements of Section 6.4.3.3.1, Automatic Shutdown. For central systems and plants, controls and devices shall be provided to allow stable system and equipment operation for any length of time while serving only the smallest isolation area served by the system or plant.

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

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

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

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

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

Exceptions:

a. ~~Gravity (nonmotorized) dampers are acceptable in buildings less than three stories in height above grade and for buildings of any height located in climate zones 1, 2, and 3.~~

~~b.~~ Ventilation systems serving *unconditioned spaces*.

b. In systems where dampers are prohibited by the Mechanical Code.

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

Exceptions:

a. ~~Gravity (nonmotorized) dampers are acceptable in buildings less than three stories in height and for buildings of any height located in climate zones 1, 2, and 3.~~

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

b. In systems where dampers are prohibited by the Mechanical Code.

6.4.3.4.4 Dampers. Where *outdoor air* supply and exhaust air dampers are required by Section 6.4.3.4, they shall have a maximum leakage rate of 4 cfm per square foot of damper area at 1 in w.g., when tested in accordance with AMCA Standard 500 ~~as indicated in Table 6.4.3.4.4~~.

[Delete TABLE 6.4.3.4.4 Maximum Damper Leakage Without Substitution]

~~Climate Zones~~	~~Maximum Damper Leakage at 1.0 in. w.g. cfm per ft^2 of damper area~~	
~~Climate~~	~~Motorized~~	~~Nonmotorized~~
~~1, 2, 6, 7, 8~~	~~4~~	~~Not Allowed~~
~~All Others~~	~~10~~	~~20[a]~~

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

6.4.4.1.1 General. Insulation required by this section shall be installed in accordance with the Mechanical Code and Table 6.4.4.1.1 ~~industry-accepted standards (see Informative Appendix E)~~. These requirements do not apply to HVAC equipment. Insulation shall be protected from damage, including that due to sunlight, moisture, equipment maintenance and wind, but not limited to the following:

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

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

TABLE 6.4.4.1.1 Insulation Of Ducts

Duct Location	Insulation Types Mechanically Cooled and Outside Air	Insulation Types Heating Only
1. On roof or exterior of building	R-8, V, W	R-8,W
2. Located inside the building thermal envelope	R-5,V	R-5
3. Located outside the building thermal envelope	R-8,V	R-8 W

Note: Where ducts are used for both heating and cooling, the minimum insulation shall be as required for the most restrictive condition.

V. Vapor Retarders: Material with a perm rating not exceeding 0.5 perm (29 ng/Pa●s●m^2). All joints to be sealed.

W. Approved weatherproof barrier.

6.4.4.1.2 Duct and Plenum Insulation. All supply and return ducts and plenums installed as part of an HVAC air distribution system shall be thermally insulated in accordance with ~~Tables 6.8.2A and 6.8.2B~~ Section 6.4.4.1.1 .

Exceptions:

a. Factory-installed plenums, casings, or ductwork furnished as a part of HVAC equipment tested and rated in accordance with Section 6.4.1.

b. Ducts or plenums located in heated spaces, *semiheated spaces*, or cooled spaces.

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

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

[Delete TABLE 6.4.4.2A Minimum Duct Seal Level[a] Duct Type Without Substitution]

[Delete TABLE 6.4.4.2B Duct Seal Levels Without Substitution]

6.4.4.2.1 Duct Sealing. Ductwork and plenums shall be sealed in accordance with the Mechanical Code ~~Table 6.4.4.2A (Table 6.4.4.2B provides definitions of seal levels), as required to meet the requirements of Section 6.4.4.2.2 and with standard industry practice (see Informative Appendix E)~~ and SMACNA Method A.

6.4.4.2.2 Duct Leakage Tests. Ductwork that is designed to operate at static pressures in excess of 3 in. w.c. shall be leak-tested according to industry-accepted test procedures (see Informative Appendix E). Representative sections totaling no less than 25% of the total installed duct area for the designated pressure class shall be tested. Duct systems with pressure ratings in excess of 3 in. w.c. shall be identified on the drawings. The maximum permitted duct leakage shall be ~~no more than 1% of the total peak airflow in the section tested.~~

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

~~where~~

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

~~C_L = duct leakage class, cfm/100 ft^2 at 1 in. w.c.,~~

~~6 for rectangular sheetmetal, rectangular fibrous, and round flexible ducts,~~

~~3 for round/flat oval sheetmetal or fibrous glass ducts; and~~

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

$$CL = F / P^{0.65}$$

where:

F = The measured leakage rate in cfm per 100 square feet of duct surface.

P = The static pressure of the test.

Documentation shall be furnished by the installer demonstrating that representative sections totaling at least 25 percent of the duct area have been tested and that all tested sections meet the requirements of this section.

6.5.1 Reserved. ~~**Economizers.** Each cooling system that has a fan shall include either an air or water economizer meeting the requirements of Sections 6.5.1.1 through 6.5.1.4.~~

~~**Exceptions:** Economizers are not required for the systems listed below.~~

~~a. Individual fan-cooling units with a supply capacity less than the minimum listed in Table 6.5.1.~~

~~b. Systems that include nonparticulate air treatment as required by Section 6.2.1 in Standard 62.1.~~

~~c. Where more than 25% of the air designed to be supplied by the system is to spaces that are designed to be humidified above 35°F dew-point temperature to satisfy process needs.~~

~~d. Systems that include a condenser heat recovery system required by Section 6.5.6.2.~~

~~e. Systems that serve *residential* spaces where the system capacity is less than five times the requirement listed in Table 6.5.1.~~

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

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

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

~~i. Where the cooling *efficiency* meets or exceeds the *efficiency* requirements in Table 6.3.2.~~

[Delete TABLE 6.5.1 Minimum Systems Size for Which an Economizer is Required Without Substitution]

6.5.1.1 Air Economizers <u>(When used.)</u>

TABLE 6.5.1.1.3A High-Limit Shutoff Control Options for Air Economizers

~~Climate Zones~~	Allowed Control Types	Prohibited Control Types
~~1b, 2b, 3b, 3c, 4b, 4c, 5b, 5c, 6b, 7, 8~~	~~Fixed dry bulb~~ ~~Differential dry bulb~~ ~~Electronic enthalpy[a]~~ ~~Differential enthalpy~~ ~~Dew-point and dry-bulb temperatures~~	~~Fixed enthalpy~~
~~1a, 2a, 3a, 4a~~	Fixed dry bulb Fixed enthalpy Electronic enthalpy[a] Differential enthalpy Dew-point and dry-bulb temperature	Differential dry bulb
~~All Other Climates~~	~~Fixed dry bulb~~ ~~Differential dry bulb~~ ~~Fixed enthalpy~~ ~~Electronic enthalpy[a]~~ ~~Differential enthalpy~~ ~~Dew-point and dry-bulb temperature~~	

[a] Electronic enthalpy controllers are devices that use a combination of humidity and dry-bulb temperature in their switching algorithm.

TABLE 6.5.1.1.3B High-Limit Shutoff Control Settings for Air Economizers

Device Type	~~Climate~~	Required High Limit (Economizer Off When):	
		Equation	**Description**
Fixed dry bulb	~~1b, 2b, 3b, 3c, 4b, 4c, 5b, 5c, 6b, 7, 8~~	~~T_{OA} > 75°F~~	~~*Outdoor air* temperature exceeds 75°F~~
	~~5a, 6a, 7a~~	~~T_{OA} > 70°F~~	~~*Outdoor air* temperature exceeds 70°F~~
	~~All other zones~~	T_{OA} > 65°	*Outdoor air* temperature exceeds 65°F
~~Differential dry bulb~~	~~1b, 2b, 3b, 3c, 4b, 4c, 5a, 5b, 5c, 6a, 6b, 7, 8~~	~~$T_{OA} > T_{RA}$~~	~~*Outdoor air* temperature Exceeds return air temperature.~~
Fixed enthalpy	~~All~~	h_{OA} > 28 Btu/lb[a]	*Outdoor air* enthalpy exceeds 28 Btu/lb of dry air[a]
Electronic enthalpy	~~All~~	(T_{OA}, RH_{OA}) > A	*Outdoor air* temperature/RH exceeds the "A" setpoint curve[~~b~~a]
Differential enthalpy	~~All~~	$h_{OA} > h_{RA}$	*Outdoor air* enthalpy exceeds return air enthalpy
Dew point and dry-bulb temperatures	~~All~~	DP_{oa}>55°F or T_{oa}>75°F	*Outdoor air* dry bulb exceeds 75°F or outside dew point exceeds 55°F (65 gr/lb)

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

~~b~~ Set point "A" corresponds to a curve on the psychometric chart that goes through a point at approximately 75°F and 40% relative humidity and is nearly parallel to dry-bulb lines at low humidity levels and nearly parallel to enthalpy lines at high humidity levels.

6.5.2.1 Zone Controls. *Zone* thermostatic controls shall be capable of operating in sequence the supply of heating and cooling energy to the *zone*. Such controls shall prevent

1. *reheating*,
2. *recooling*,
3. mixing or simultaneously supplying air that has been previously mechanically heated and air that has been previously cooled, either by mechanical cooling or by economizer systems, and
4. other simultaneous operation of heating and cooling systems to the same *zone*.

Exceptions:

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

1. the volume of *outdoor air* required to meet the ventilation requirements of ~~Section 6.2 of Standard 62.1~~ Table 4-1 of the Houston Mechanical Code, for the *zone*,
2. ~~0.4~~ 0.5 cmf/ft^2 of the *zone* conditioned floor area,
3. ~~30~~ 50% of the *zone* design peak supply rate,
4. 300 cfm—this exception is for zones whose peak flow rate totals no more than 10% of the total fan system flow rate, or
5. any higher rate that can be demonstrated, to the satisfaction of the *authority having jurisdiction*, to reduce overall system annual energy usage by offsetting reheat/recool energy losses through a reduction in *outdoor air* intake for the system.

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

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

6.5.2.2.2 Two-Pipe Changeover System. Systems that use a common distribution system to supply both heated and chilled water shall not be used. ~~are acceptable provided all of the following are met:~~

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

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

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

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

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

b. ~~For climate zones 3 through 8,~~ If a closed-circuit tower (fluid cooler) is used, either an automatic valve shall be installed to bypass all but a minimal flow of water around the tower (for freeze protection) or low-leakage positive closure dampers shall be provided. If an open-circuit tower is used directly in the heat pump loop, an automatic valve shall be installed to bypass all heat pump water flow around the tower. If an open-circuit tower is used in conjunction with a separate heat exchanger to isolate the tower from the heat pump loop, then heat loss shall be controlled by shutting down the circulation pump on the cooling tower loop.

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

Exceptions: For the purposes of humidity control.

~~a. The system is capable of reducing supply air volume to 50% or less of the design airflow rate or the minimum rate specified in Section 6.2 of Standard 62.1, whichever is larger, before simultaneous heating and cooling takes place.~~

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

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

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

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

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

~~**6.5.2.4 Humidification.** Systems with hydronic cooling and humidification systems designed to maintain inside humidity at a dew-point temperature greater than 35°F shall use a water economizer if an economizer is required by Section 6.5.1.~~

6.5.3.1 Reserved.~~Fan Power Limitation.~~

.

~~**6.5.3.1.1** Each HVAC system at fan system design conditions shall not exceed the allowable *fan system motor nameplate hp* (Option 1) or *fan system bhp* (Option 2) as shown in Table~~

~~6.5.3.1.1A. This includes supply fans, return/relief fans, exhaust fans, and fan-powered terminal units associated with systems providing heating or cooling capability.~~

~~Exceptions:~~

a. ~~Hospital and laboratory systems that utilize flow control devices on exhaust and/or return to maintain space pressure relationships necessary for occupant health and safety or environmental control may use variable-volume fan power limitation.~~

b. ~~Individual exhaust fans with motor nameplate horsepower of 1 hp or less.~~

c. ~~Fans exhausting air from fume hoods. ***Note:*** If this exception is taken, no related exhaust side credits shall be taken from Table 6.5.3.1.1B and the Fume Hood Exhaust Exception Deduction must be taken from Table 6.5.3.1.1B..~~

[Delete TABLE 6.5.3.1.1A Fan Power Limitation[a] Without Substitution]

6.5.3.2 VAV Fan Control (Including Systems Using Series Fan Power Boxes).

6.5.3.2.1 Part-Load Fan Power Limitation. Individual VAV fans with motors ~~10~~ 5 hp and larger shall meet one of the following:

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

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

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

6.5.3.2.2 VAV Fans with Motor Requirement of 1 hp and Less. ~~Static Pressure Sensor Location.~~ ~~Static pressure sensors used to control VAV fans shall be placed in a position such that the controller setpoint is no greater than one-third the total design fan static pressure, except for systems with zone reset control complying with Section 6.5.3.2.3. If this results in the sensor being located downstream of major duct splits, multiple sensors shall be installed in each major branch to ensure that static pressure can be maintained in each.~~ Individual VAV fans with motor requirements of 1 hp and less fan powered terminal units shall be driven by electronically commutated motors (ECM).

Exception: Parallel flow boxes with intermittent heating only fan operation.

~~**6.5.3.2.3 Setpoint Reset.** For systems with DDC of individual zone boxes reporting to the central control panel, static pressure setpoint shall be reset based on the *zone* requiring the most pressure; i.e., the setpoint is reset lower until one *zone* damper is nearly wide open.~~

6.5.4.1 Hydronic Variable Flow Systems. HVAC pumping systems that include control valves designed to modulate or step open and close as a function of load shall be designed for variable fluid flow and shall be capable of reducing pump flow rates to 50% or less of the design flow rate. Individual pumps serving variable flow systems having a pump head exceeding 100 ft and motor exceeding 50 hp shall have controls and/or devices (such as variable speed control) that will result in pump motor demand of no more than 30% of design wattage at 50% of design water flow. The controls or devices shall be controlled as a function of desired flow or to maintain a minimum required differential pressure. Differential

pressure shall be measured at or near the most remote heat exchanger or the heat exchanger requiring the greatest differential pressure.

Exceptions:

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

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

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

6.5.5 Reserved ~~Heat Rejection Equipment~~

~~**6.5.5.1 General.** Section 6.5.5 applies to heat rejection equipment used in comfort cooling systems such as air-cooled condensers, open cooling towers, closed-circuit cooling towers, and evaporative condensers.~~

~~**Exception:** Heat rejection devices whose energy usage is included in the equipment *efficiency* ratings listed in Tables 6.8.1A through 6.8.1D.~~

~~**6.5.5.2 Fan Speed Control.** Each fan powered by a motor of 7.5 hp or larger shall have the capability to operate that fan at two-thirds of full speed or less and shall have controls that automatically change the fan speed to control the leaving fluid temperature or condensing temperature/pressure of the heat rejection device.~~

~~**Exceptions:**~~

~~a. Condenser fans serving multiple refrigerant circuits.~~

~~b. Condenser fans serving flooded condensers.~~

~~c. Installations located in climate zones 1 and 2.~~

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

6.5.6.1 Exhaust Air Energy Recovery. Individual fan systems that have both a design supply air capacity of 5000 cfm or greater and have a minimum *outdoor air* supply of 70% or greater of the design supply air quantity shall have an energy recovery system. ~~with at least 50% recovery effectiveness. Fifty percent energy recovery effectiveness shall mean a change in the enthalpy of the *outdoor air* supply equal to 50% of the difference between the *outdoor air* and return air at design conditions. Provision shall be made to bypass or control the heat recovery system to permit air economizer operation as required by Section 6.5.1.1..~~

Exceptions:

a. Laboratory fume hood systems and biological safety cabinets. ~~meeting Section 6.5.7.2~~.

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

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

d. Commercial kitchen hoods used for collecting and removing grease vapors and smoke.

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

f. Heating systems in climate zones ~~1 through 3~~ 2.

g. ~~Cooling systems in climate zones 3c, 4c, 5b, 5c, 6b, 7, and 8.~~

~~h.~~ Where the largest exhaust source is less than 75% of the design *outdoor air* flow.

~~i.~~ h. Systems requiring dehumidification that employ energy recovery in series with the cooling coil.

~~**6.5.6.2 Heat Recovery for Service Water Heating.**~~

~~**6.5.6.2.1** Condenser heat recovery systems shall be installed for heating or preheating of service hot water provided all of the following are true:~~

~~a. The facility operates 24 hours a day.~~

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

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

~~**6.5.6.2.2** The required heat recovery system shall have the capacity to provide the smaller of~~

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

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

~~**Exceptions:**~~

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

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

6.5.7 ~~Exhaust Hoods~~ Reserved

~~**6.5.7.1 Kitchen Hoods.** Individual kitchen exhaust hoods larger than 5000 cfm shall be provided with makeup air sized for at least 50% of exhaust air volume that is~~

~~a. unheated or heated to no more than 60°F and~~

~~b. uncooled or cooled without the use of mechanical cooling.~~

~~**Exceptions:**~~

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

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

~~**6.5.7.2 Fume Hoods.** Buildings with fume hood systems having a total exhaust rate greater than 15,000 cfm shall include at least one of the following features:~~

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

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

~~c. Heat recovery systems to precondition makeup air from fume hood exhaust in accordance with Section 6.5.6.1, Exhaust Air Energy Recovery, without using any exception.~~

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

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

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

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

6.7.1 General. The *Authority having jurisdiction* shall be permitted to ~~may~~ require submittal of compliance documentation and supplemental information in accord with Section 4.2.2 of this ~~standard~~ code.

6.7.2 Completion Requirements: The following requirements are mandatory provisions and are necessary for compliance with the ~~standard~~ code.

6.7.2.3.2 Air System Balancing. Air systems shall be balanced in a manner to first minimize throttling losses. Then, for fans with *fan system power* greater than 1 hp, fan speed shall be adjusted to meet design flow conditions. Each supply outlet and zone terminal device shall be equipped with means for air balancing.

6.7.2.3.3 Hydronic System Balancing. Hydronic systems shall be proportionately balanced in a manner to first minimize throttling losses; then the pump impeller shall be trimmed or pump speed shall be adjusted to meet design flow conditions. Individual hydronic heating and cooling coils shall be equipped with means for balancing and pressure test connections.

Exceptions: Impellers need not be trimmed nor pump speed adjusted

a. for pumps with pump motors of 10 hp or less or

b. when throttling results in no greater than 5% of the nameplate horsepower draw, or 3 hp, whichever is greater, above that required if the impeller was trimmed.

6.7.2.4 Control Verification. HVAC control systems shall be tested to ensure that control elements are calibrated, adjusted, and in proper working condition, and in accordance with the designed sequence of operations.

6.7.2.5 System Commissioning. HVAC control systems shall be tested to ensure that control elements are calibrated, adjusted, and in proper working condition. For projects larger than 50,000 ft^2 conditioned

area, except heated only warehouses and semiheated spaces, detailed instructions for commissioning HVAC systems (see Informative Appendix E) shall be provided by the designer in plans and* specifications.

TABLE 6.8.1A Electronically Operated Unitary Air Conditioners and Condensing Units—Minimum Efficiency Requirements

EQUIPMENT TYPE	SIZE CATEGORY	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY[b]	TEST PROCEDURE[a]
Air conditioners, Air cooled	< 65,000 Btu/h[d]	Split system	13.0 SEER	AHRI 210/240
		Single package	13.0 SEER	
	≥ 65,000 Btu/h and < 135,000 Btu/h	Split System and single package	10.3 EER[c] (before Jan 1, 2010) 11.2 EER[c] (as of Jan 1, 2010)	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Split System and single package	9.7 EER[c] (before Jan 1, 2010) 11.0 EER[c] (as of Jan 1, 2010)	AHRI 340/360
	≥ 240,000 Btu/h and < 760,000 Btu/h	Split system and single package	9.5 EER[c] 9.7 IPLV[C] (before Jan 1, 2010) 10.00 EER[c] 9.7 IPLV[c] (as of Jan 1, 2010)	
	≥ 760,000 Btu/h	Split system and single package	9.2 EER[c] 9.4 IPLV[C] (before Jan 1, 2010) 9.7 EER[c] 9.4 IPLV[C] (as of Jan 1, 2010)	
Through-the-wall, Air cooled	< 30,000 Btu/h[d]	Split system	10.9 SEER (before Jan 23, 2010) 12.0 SEER (as of Jan 23, 2010	AHRI 210/240
		Single package	10.6 SEER (before Jan 23, 2010) 12.0 SEER (as of Jan 23, 2010)	
Air conditioners, Water and evaporatively cooled	< 65,000 Btu/h	Split system and single package	12.1 EER	AHRI 210/240
	≥ 65,000 Btu/h and < 135,000 Btu/h	Split system and single package	11.5 EER[c]	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Split system and single package	11.0 EER[c]	AHRI 340/360
	≥ 240,000 Btu/h	Split system and single package	11.5 EER[c]	

For SI: 1 British thermal unit per hour = 0.2931 W.

a. Chapter 6 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
b. IPLVs are only applicable to equipment with capacity modulation.
c. Deduct 0.2 from the required EERs and IPLVs for units with a heating section other than electric resistance heat.
d. Single-phase-air-cooled air conditioners < 65,000 Btu/h are regulated by the National Appliance Energy Conservation Act of 1987 (NAECA); SEER values are those set by NAECA.

6.8.2 Reserved ~~Duct Insulation Tables~~

~~TABLE 6.8.2A Minimum Duct Insulation R-Value[a], Cooling and Heating Only Supply Ducts and Return Ducts~~

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

~~[a] Insulation R-values, measured in (h·ft²·°F)/Btu, are for the insulation as installed and do not include film resistance. The required minimum thicknesses do not consider water vapor transmission and possible surface condensation. Where exterior walls are used as plenum walls, wall insulation shall be as required by the most restrictive condition of Section 6.4.4.2 or Section 5. Insulation resistance measured on a horizontal plane in accordance with ASTM C518 at a mean temperature of 75°F at the installed thickness.~~

~~[b] Includes crawl spaces, both ventilated and nonventilated.~~

~~[c] Includ3es return air plenums with or without exposed roofs above.~~

~~TABLE 6.8.2B Minimum Duct Insulation R-Value[a], Combined Heating and Cooling Supply Ducts and Return Ducts~~

	~~Duct Location~~						
~~Climate Zone~~	~~Exterior~~	~~Ventilated Attic~~	~~Unvented Attic Above Insulated Ceiling~~	~~Unvented Attic with Roof Insulation[a]~~	~~Unconditioned Space[b]~~	~~Indirectly Conditioned Space[c]~~	~~Buried~~
				~~Supply Ducts~~			
~~1~~	~~R-6~~	~~R-6~~	~~R-8~~	~~R-3.5~~	~~R-3.5~~	~~none~~	~~R-3.5~~
~~2~~	~~R-6~~	~~R-6~~	~~R-6~~	~~R-3.5~~	~~R-3.5~~	~~none~~	~~R-3.5~~
~~3~~	~~R-6~~	~~R-6~~	~~R-6~~	~~R-3.5~~	~~R-3.5~~	~~none~~	~~R-3.5~~
~~4~~	~~R-6~~	~~R-6~~	~~R-6~~	~~R-3.5~~	~~R-3.5~~	~~none~~	~~R-3.5~~
~~5~~	~~R-6~~	~~R-6~~	~~R-6~~	~~R-1.9~~	~~R-3.5~~	~~none~~	~~R-3.5~~
~~6~~	~~R-8~~	~~R-6~~	~~R-6~~	~~R-1.9~~	~~R-3.5~~	~~none~~	~~R-3.5~~
~~7~~	~~R-8~~	~~R-6~~	~~R-6~~	~~R-1.9~~	~~R-3.5~~	~~none~~	~~R-3.5~~
~~8~~	~~R-8~~	~~R-8~~	~~R-8~~	~~R-1.9~~	~~R-6~~	~~none~~	~~R-6~~
				~~Return Ducts~~			
~~1 to 8~~	~~R-3.5~~	~~R-3.5~~	~~R-3.5~~	~~none~~	~~none~~	~~none~~	~~none~~

~~[a] Insulation R-values, measured in (h·ft²·°F)/Btu, are for the insulation as installed and do not include film resistance. The required minimum thicknesses do not consider water vapor transmission and possible surface condensation. Where exterior walls are used as plenum walls, wall insulation shall be as required by the most restrictive condition of Section 6.4.4.2 or~~

~~Section 5. Insulation resistance measured on a horizontal plane in accordance with ASTM C518 at a mean temperature of 75°F at the installed thickness.~~

~~[b] Includes crawl spaces, both ventilated and non-ventilated.~~

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

~~**TABLE 6.8.3 Minimum Pipe Insulation Thickness[a]**~~

~~Fluid Design Operating Temp. Range (°F)~~	~~Insulation Conductivity Conductivity Btu·in./(h·ft²·°F)~~	~~Mean Rating Temp. °F~~	~~Nominal Pipe or Tube Size (in.) <1~~	~~1 to <1 1/2~~	~~1 1/2 to <4~~	~~4 to <8~~	~~≥8~~
~~Heating Systems (Steam, Steam Condensate, and Hot Water)[b,c]~~							
~~>350~~	~~0.32–0.34~~	~~250~~	~~2.5~~	~~3.0~~	~~3.0~~	~~4.0~~	~~4.0~~
~~251–350~~	~~0.29–0.32~~	~~200~~	~~1.5~~	~~2.5~~	~~3.0~~	~~3.0~~	~~3.0~~
~~201–250~~	~~0.27–0.30~~	~~150~~	~~1.5~~	~~1.5~~	~~2.0~~	~~2.0~~	~~2.0~~
~~141–200~~	~~0.25–0.29~~	~~125~~	~~1.0~~	~~1.0~~	~~1.0~~	~~1.5~~	~~1.5~~
~~105–140~~	~~0.22–0.28~~	~~100~~	~~0.5~~	~~0.5~~	~~1.0~~	~~1.0~~	~~1.0~~
~~Domestic and Service Hot Water Systems~~							
~~105+~~	~~0.22–0.28~~	~~100~~	~~0.5~~	~~0.5~~	~~1.0~~	~~1.0~~	~~1.0~~
~~Cooling Systems (Chilled Water, Brine, and Refrigerant)[d]~~							
~~40–60~~	~~0.22–0.28~~	~~100~~	~~0.5~~	~~0.5~~	~~1.0~~	~~1.0~~	~~1.0~~
~~<40~~	~~0.22–0.28~~	~~100~~	~~0.5~~	~~1.0~~	~~1.0~~	~~1.0~~	~~1.5~~

~~[a] For insulation outside the stated conductivity range, the minimum thickness (T) shall be determined as follows: $T = r\{(1 + t/r)^{K/k} - 1\}$~~

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

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

~~[c] Piping insulation is not required between the control valve and coil on run-outs when the control valve is located within 4 ft of the coil and the pipe size is 1 in. or less.~~

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

TABLE 6.8.3 Minimum Pipe Insulation[a, b, c, d]

Fluid	≤1.5"	>1.5"- 4"[e]	>4"[e]
Steam	1 ½	3	4
Heating Hot Water	1 ½	2	2
Service Hot Water	1	2	2
Chilled Water, Brine or Refrigerant	1	1 ½	2

[a] Based on insulation having a conductivity (k) not exceeding 0.27 Btu per in./h·ft²·°F.

[b] For insulation with a thermal conductivity not equal to 0.27 Btu · inch/h · ft² · °F at a mean temperature of 75°F, the minimum required pipe thickness is adjusted using the following equation;

$T = r[(1+t/r)K/k-1]$

where:

T = Adjusted insulation thickness (in).

r = Actual pipe radius (in).

t = Insulation thickness from applicable cell in table (in).

K = New thermal conductivity at 75°F (Btu · in/hr · ft2 · °F).

k = 0.27 Btu · in/hr · ft2 · °F.

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

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

[e] Nominal pipe size.

7.1.1.2 Additions to Existing Buildings. Service water heating *systems* and *equipment* shall comply with the requirements of this section.

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

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

7.4.3 Service Hot Water Piping Insulation. The following piping shall be insulated to levels shown in Section 6, Table 6.8.3:

a. **r**ecirculating system piping, including the supply and return piping of a circulating tank type water heater.

b. ~~the first 8 ft of outlet~~ All piping for a constant temperature nonrecirculating storage *system*.

c. the inlet pipe between the storage tank and a heat trap in a nonrecirculating storage *system*.

d. pipes that are externally heated (such as heat trace or impedance heating).

7.7.1 General. The *authority having jurisdiction* may require submittal of compliance documentation and supplemental information, in accord with Section 4.2.2 of this ~~standard~~ code.

9.1.2 Lighting Alterations. The replacement of lighting *systems* in any building space shall comply with the *LPD* requirements of Section 9 applicable to that space. New lighting *systems* shall comply with the applicable *LPD* requirements of Section 9. Any new *control devices* as a direct replacement of existing *control devices* shall comply with the specific requirements of Section 9.4.1.2(b).

Exception: For *alterations* that replace less than 50% of the *luminaires* in a *space* only those *luminaires* that are replaced need comply with this section ~~need not comply with these requirements provided that such *alterations* do not increase the installed interior lighting power~~.

9.4.1.2 Space Control. Each space enclosed by ceiling-height partitions shall have at least one *control device* to independently *control* the *general lighting* within the space. Each manual device shall be readily accessible and located so the occupants can see the controlled lighting.

a. A control device shall be installed that automatically turns lighting off within 30 minutes of all occupants leaving a space. ~~, except spaces with multi-scene control, in~~

~~1. classrooms (not including shop classrooms, laboratory classrooms, and preschool through 12th grade classrooms),~~

~~2. conference/meeting rooms, and~~

~~3. employee lunch and break rooms~~.

~~These spaces are not required to be connected to other automatic lighting shutoff controls.~~

Exception to 9.4.1.2a: Classrooms, conference/meeting rooms, and employee lunch and break rooms with bi-level switching.

b. ~~For all other spaces,~~ Each *control device* shall be activated either manually by an occupant or automatically by sensing an occupant. Each *control device* shall *control* a maximum of 2500 ft^2 area for a space 10,000 ft^2 or less and a maximum of 10,000 ft^2 area for a space greater than 10,000 ft^2 and be capable of overriding any time-of-day scheduled shutoff *control* for no more than four hours.

Exception to 9.4.1.2(b): Remote location shall be permitted for reasons of safety or security when the remote control device has an indicator pilot light as part of or next to the control device and the light is clearly labeled to identify the controlled lighting.

9.4.1.2.1 Additional controls. Each area that is required to have a manual control shall have additional controls that meet the requirements of Sections 9.4.1.2.2.2 and 9.4.1.2.2.3.

9.4.1.2.2 Light reduction controls. Each area that is required to have a manual control shall also allow the occupant to reduce the connected lighting load in a reasonably uniform illumination pattern by at least 50 percent. Lighting reduction shall be achieved by one of the following or other *approved* method:

a. Controlling all lamps or luminaires;

b. Dual switching of alternate rows of luminaires, alternate luminaires or alternate lamps;

c. Switching the middle lamp luminaires independently of the outer lamps; or

d. Switching each luminaire or each lamp.

Exceptions:

a. Areas that have only one luminaire.

b. Areas that are controlled by an occupant-sensing device.

c. Corridors, storerooms, restrooms or public lobbies.

d. *Sleeping unit* (see Section 505.2.3).

d. Spaces that use less than 0.6 watts per square foot (6.5 W/m2).

9.4.1.2.3 Automatic lighting shutoff. Buildings larger than 5,000 square feet (465m^2) shall be equipped with an automatic control device to shut off lighting in those areas. This automatic control device shall function on either:

a. A scheduled basis, using time-of-day, with an independent program schedule that controls the interior lighting in areas that do not exceed 25,000 ft^2 and are not more than one floor; or

b. An occupant sensor that shall turn lighting off within 30 minutes of an occupant leaving a space; or

c. A signal from another control or alarm system that indicates the area is unoccupied.

Exception: The following shall not require an automatic control device:

a. *Sleeping unit* (see Section 505.2.3).

b. Lighting in spaces where patient care is directly provided.

c. Spaces where an automatic shutoff would endanger occupant safety or security.

9.4.1.2.4 Occupant override. Where an automatic time switch control device is installed to comply with Section 9.4.1.2.2.3, Item 1, it shall incorporate an override switching device that:

a. Is readily *accessible*.

b. Is located so that a person using the device can see the lights or the area controlled by that switch, or so that the area being lit is annunciated.

c. Is manually operated.

d. Allows the lighting to remain on for no more than 2 hours when an override is initiated.

e. Controls an area not exceeding 5,000 square feet (465 m^2).

Exceptions:

a. In malls and arcades, auditoriums, single-tenant retail spaces, industrial facilities and arenas, where captive-key override is utilized, override time shall be permitted to exceed 2 hours.

b. In malls and arcades, auditoriums, single-tenant retail spaces, industrial facilities and arenas, the area controlled shall not exceed 20,000 square feet (1860 m^2).

9.4.1.2.5 Holiday scheduling. If an automatic time switch control device is installed in accordance with Section 505.2.2.2, Item 1, it shall incorporate an automatic holiday scheduling feature that turns off all loads for at least 24 hours, then resumes the normally scheduled operation.

Exception: Retail stores and associated malls, restaurants, grocery stores, places of religious worship and theaters.

9.4.1.2.6 Daylight zone control. Daylight zones, as defined by this code, shall be provided with individual controls that control the lights independent of general area lighting. Contiguous daylight zones adjacent to vertical fenestration are allowed to be controlled by a single controlling device provided that they do not include zones facing more than two adjacent cardinal orientations (i.e., north, east, south, west). Daylight zones under skylights more than 15 feet (4572 mm) from the perimeter shall be controlled separately from daylight zones adjacent to vertical fenestration.

Exception: Daylight spaces enclosed by walls or ceiling height partitions and containing two or fewer light fixtures are not required to have a separate switch for general area lighting.

9.4.1.2.7 Sleeping unit controls. *Sleeping unit*s in hotels, motels, boarding houses or similar buildings shall have at least one master switch at the main entry door that controls all permanently wired luminaires and switched receptacles, except those in the bathroom(s). Suites shall have a control meeting these requirements at the entry to each room or at the primary entry to the suite.

9.4.1.3 Exterior Lighting Control. Lighting for all exterior applications not exempted in Section 9.1 shall have automatic controls capable of turning off exterior lighting when sufficient daylight is available or when the lighting is not required during nighttime hours. Lighting not designated for dusk-to-dawn operation shall be controlled by either

a. a combination of a photosensor and a time switch or

b. an astronomical time switch.

Lighting designated for dusk-to-dawn operation shall be controlled by an astronomical time switch or photosensor. All time switches shall be capable of retaining programming and the time setting during loss of power for a period of at least ten hours.

Exception: Lighting for covered vehicle entrances or exits from buildings or parking structures where required for safety, security, or eye adaptation.

10. OTHER EQUIPMENT

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

11. ENERGY COST BUDGET METHOD

11.1.1 Energy Cost Budget Method Scope. The building Energy Cost Budget Method is an alternative to the prescriptive provisions of this ~~standard~~ code. It may be employed for evaluating the compliance of all proposed designs except designs with no mechanical system.

Informative Note: *The energy cost budget and the design energy cost calculations are applicable only for determining compliance with this ~~standard~~ code. They are not predictions of actual energy consumption or costs of the proposed design after construction. Actual experience will differ from these calculations due to variations such as occupancy, building operation and maintenance, weather, energy use not covered by this ~~standard~~ code, changes in energy rates between design of the building and occupancy, and precision of the calculation tool.*

11.2.5 Exceptional Calculation Methods. Where no *simulation program* is available that adequately models a design, material, or device, the *authority having jurisdiction* may approve an exceptional calculation method to be used to demonstrate compliance with Section 11. Applications for approval of an exceptional method to include theoretical and empirical information verifying the method's accuracy shall include the following documentation to demonstrate that the exceptional calculation method and results

a. make no change in any input parameter values specified by this ~~standard~~ code and the *adopting authority*;

b. provide input and output documentation that facilitates the enforcement agency's review and meets the formatting and content required by the *adopting authority*; and

c. are supported with instructions for using the method to demonstrate that the *energy cost budget* and *design energy cost* required by Section 11 are met.

TABLE 11.3.1 Modeling Requirements for Calculating Design Energy Cost and Energy Cost Budget *(continued)*

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11. Service Hot-Water Systems The service hot-water system type and all related performance parameters, such as equipment capacities and efficiencies, in the *proposed building design* shall be determined as follows: a. Where a complete service hot-water system exists, the model shall reflect the actual system type using actual component capacities and efficiencies. b. Where a service hot-water system has been designed, the service hot-water model shall be consistent with design documents. c. Where no service hot-water system exists or is specified, no service hot-water heating shall be modeled.	The service hot-water system type and related performance in the *budget building design* shall be identical to the *proposed building design.* **Exceptions~~:~~** ~~a.~~ Where Section 7.5 applies, the boiler shall be split into a separate space heating boiler and hotwater heater with *efficiency* requirements set to the least efficient allowed. ~~b. For 24-hour-per-day facilities that meet the prescriptive criteria for use of condenser heat recovery systems described in Section 6.5.6.2, a system meeting the requirements of that section shall be included in the *baseline building design* regardless of the exceptions to Section 6.5.6.2. If a condenser heat recovery system meeting the requirements described in Section 6.5.6.2 cannot be modeled, the requirement for including such a system in the actual building shall be met as a prescriptive requirement in accordance with Section 6.5.6.2 and no heat recovery system shall be included in the *proposed* or *budget building design*~~

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

NORMATIVE APPENDIX A
RATED R-VALUE OF INSULATION AND ASSEMBLY U-FACTOR, C-FACTOR, AND FACTOR DETERMINATIONS

A2.3.3 U-factor. *U-factors* for *metal building roofs* shall be taken from Table A2.3 It is not acceptable to use ~~these~~ the continuous insulation *U-factors* if additional insulated sheathing is not continuous.

A3.1.3.1 *U-factors* for *mass walls* shall be taken from Table A3.1A or determined by the procedure in this subsection. It is acceptable to use the *U-factors* in Table A3.1A for all *mass walls*, provided that the grouting is equal to or less than that specified. *HC* for *mass walls* shall be taken from Table A3.1B or A3.1C.

Exception: For *mass walls*, where the requirement in Table~~s~~ 5.5-2 ~~5.5-1 through 5.5-8~~ is for a maximum assembly U-0.151 followed by footnote "a," ASTM C90 concrete block walls, ungrouted or partially grouted at 32 in. or less on center vertically and 48 in. or less on center horizontally, shall have ungrouted cores filled with material having a maximum thermal conductivity of 0.44 Btu·in./ h·ft^2·°F. Other *mass walls* with integral insulation shall meet the criteria when their *U-factors* are equal to or less than those for the appropriate thickness and density in the "Partly Grouted Cells Insulated" column of Table A3.1C.

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

NORMATIVE APPENDIX B
BUILDING ENVELOPE CLIMATE CRITERIA

B1. GENERAL

This normative appendix provides the information to determine both United States and international climate zones. For U.S. locations, use either Figure B-1 ~~or Table B-1~~ to determine the climate zone number and letter that are required for determining compliance regarding various sections and tables in this ~~standard~~ code. Figure B-1 contains the county-by-county climate zone map for the United States. ~~Table B-1 lists each state and major counties within the state and shows the climate number and letter for each county listed.~~

TABLE B-1 U.S. Climate Zones {deleted entirely}

TABLE B-2 Canadian Climatic Zones {deleted entirely}

TABLE B-3 International Climate Zones {deleted entirely}

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

NORMATIVE APPENDIX C
METHODOLOGY FOR BUILDING ENVELOPE TRADE-OFF OPTION IN SUBSECTION 5.6

C3.2 The *U-factor* of each *opaque* element of the base envelope design shall be equal to the criteria from Table~~s~~ 5.5-2 ~~5.5-1 through 5.5-8~~ for the appropriate climate for each construction classification. *The HC of mass wall* elements in the base envelope design shall be identical to the proposed design. *Mass walls* in the base envelope design shall have interior insulation, when required.

C3.5 The *U-factor* for *fenestration* in the base envelope design shall be equal to the criteria from Table~~s~~ 5.5-2 ~~5.5-1 through 5.5-8~~ for the appropriate climate. The *SHGC* for *fenestration* in the base envelope design shall be equal to the criteria from Table~~s~~ 5.5-2 ~~5.5-1 through 5.5-8.~~ For portions of those tables where there are no requirements, the *SHGC* shall be equal to 0.64 for *north-oriented* and 0.46 for all other *vertical fenestration*, 0.77 for plastic *skylights* on a curb, and 0.72 for all other *skylights* with a curb and without. The VLT for *fenestration* in the base envelope design shall be the VLT factor from Table C3.5 times the *SHGC* criteria as determined in this subsection.

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

NORMATIVE APPENDIX D
CLIMATIC DATA

(This appendix is not part of this ~~standard~~ code. It is merely informative and does not contain requirements necessary for conformance to the ~~standard~~ code. 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 E
INFORMATIVE REFERENCES

This appendix contains informative references for the convenience of users of ~~Standard 90.1-2007~~ this code and to acknowledge source documents when appropriate. Some documents are also included in Section 12, "Normative References," because there are other citations of those documents within the ~~standard~~ code that are normative.

6.7.2.4 5 ASHRAE Guideline 1-1996 *The HVAC Commissioning Process*

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

INFORMATIVE APPENDIX F
ADDENDA DESCRIPTION INFORMATION

(This appendix is not part of this ~~standard~~ code. It is merely informative and does not contain requirements necessary for conformance to the ~~standard~~ code. 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 G
PERFORMANCE RATING METHOD**

G1. GENERAL

G1.1 Performance Rating Method Scope. This building performance rating method is a modification of the Energy Cost Budget (ECB) Method in Section 11 and is intended for use in rating the energy *efficiency* of building designs that exceed the requirements of this ~~standard~~ code. This appendix does NOT offer an alternative compliance path for minimum standard compliance; that is the intent of Section 11, Energy Cost Budget Method. Rather, this appendix is provided for those wishing to use the methodology developed for this ~~standard~~ code to quantify performance that substantially exceeds the requirements of ~~Standard 90.1~~ this code. It may be useful for evaluating the performance of all *proposed designs*, including *alterations* and *additions* to *existing buildings*, except designs with no mechanical systems.

G1.2 Performance Rating. This performance rating method requires conformance with the following provisions:

All requirements of 5.4, 6.4, 7.4, 8.4, 9.4, and 10.4 are met. These sections contain the mandatory provisions of the ~~standard~~ code, and are prerequisites for this rating method. The improved performance of the proposed building design is calculated in accordance with provisions of this appendix using the following formula:

$$\text{Percentage improvement} = 100 \times (\textit{Baseline building performance} - \textit{Proposed building performance}) / \textit{Baseline building performance}$$

Notes:

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

TABLE G3.1 Modeling Requirements for Calculating Proposed and Baseline Building Performance (Continued)

No. Proposed Building Performance	Baseline Building Performance
5. Building Envelope All components of the *building envelope* in the *proposed design* shall be modeled as shown on architectural drawings or as built for existing building envelopes. **Exceptions:** The following building elements are permitted to differ from architectural drawings. a. All uninsulated assemblies (e.g., projecting balconies, perimeter edges of intermediate floor stabs, concrete floor beams over parking garages, roof parapet) shall be separately modeled using either of the following techniques: 1. Separate model of each assemblies within the energy simulation model. 2. Separate calculation of the U-factor for each of these assemblies. The U-factors of these assemblies are then averaged with larger adjacent surfaces using an area-weighted average method. This average U-factor is modeled within the energy simulation model. Any other envelope assembly that covers less than 5% of the total area of that assembly type (e.g., exterior walls) need not be separately described provided that it is similar to an assembly being modeled. If not separately described, the area of an envelope assembly shall be added to the area of an assembly of that same type with the same orientation and thermal properties. b. Exterior surfaces whose azimuth orientation and tilt differ by less than 45 degrees and are otherwise the same may be described as either a single surface or by using multipliers. c. For exterior roofs, the roof surface may be modeled with a reflectance of 0.45 if the reflectance of the *proposed design* roof is greater than 0.70 and its emittance is greater than 0.75 or has a minimum SRI of 82. Reflectance values shall be based on testing in accordance with ASTM C1549, ASTM E903, or ASTM E1918, and the emittance values shall be based on testing in accordance with ASTM C1371 or ASTM E408, and SRI shall be based on ASTM E1980 calculated at medium wind speed. All other roof surfaces shall be modeled with a reflectance of 0.30. d. Manual fenestration shading devices such as blinds or shades shall not be modeled.	Equivalent dimensions shall be assumed for each exterior envelope component type as in the *proposed design*; i.e., the total gross area of exterior walls shall be the same in the proposed and *baseline building designs*. The same shall be true for the areas of roofs, floors, and doors, and the exposed perimeters of concrete slabs on grade shall also be the same in the *proposed* and *baseline building designs*. The following additional requirements shall apply to the modeling of the *baseline building design*: a. **Orientation.** The *baseline building performance* shall be generated by simulating the building with its actual orientation and again after rotating the entire building 90, 180, 270 degrees, then averaging the results. The building shall be modeled so that it does not shade itself. b. **Opaque assemblies.** Opaque assemblies used for new buildings or *additions* shall conform with the following common, lightweight assembly types and shall match the appropriate assembly maximum U-factors in Table~~s~~ 5.5-2 ~~5.5-1 through 5.5-8~~: • Roofs – Insulation entirely above deck • *Above-grade walls* – Steel-framed • Floors – Steel-joist • Opaque door types shall match the proposed design and conform to the U-factor requirements from the same tables. • Slab-on-grade floors shall match the F-factor for unheated slabs from the same tables. Opaque assemblies used for *alterations* shall conform with Section 5.1.3. c. **Vertical Fenestration.** Vertical fenestration areas for new buildings and *additions* shall equal that in the *proposed design* or 40% of gross above-grade wall area, whichever is smaller, and shall be distributed on each face of the building in the same proportions in the *proposed design.* Fenestration U-factors shall match the appropriate requirements in Table~~s~~ 5.5-2 ~~5.5-1 through 5.5-8~~. Fenestration SHGC shall match the appropriate requirements in Table~~s~~ 5.5-2 ~~5.5-1 through 5.5-8~~. All vertical glazing shall be

Automatically controlled fenestration shades or blinds may be modeled. Permanent shading devices such as fins, overhangs, and light shelves may be modeled.	assumed to be flush with the exterior wall, and no shading projections shall be modeled. Manual window shading devices such as blinds or shades shall not be modeled. The fenestration areas for envelope *alterations* shall reflect the limitations on area, U-factor, and SHGC as described in 5.1.3. d. **Skylights and Glazed Smoke Vents.** Skylight area shall be equal to that in the proposed building design or 5% of the gross roof area that is part of the *building envelope*, whichever is smaller. If the skylight area of the proposed building design is greater than 5% of the gross roof area, baseline skylight area shall be decreased by an identical percentage in all roof components in which skylights are located to reach the 5% skylight-to-roof ratio. Skylight orientation and tilt shall be the same as in the proposed building design. Skylight U-factor and SHGC properties shall match the appropriate requirements in Table~~s~~ 5.5-2 ~~5.5-1 through 5.5-8~~. e. **Roof albedo.** All roof surfaces shall be modeled with a reflectivity of 0.30. f. **Existing Buildings.** For existing *building envelopes*, the *baseline building design* shall reflect existing conditions prior to any revisions that are part of the scope of work being evaluated.

TABLE G3.1 Modeling Requirements for Calculating Proposed and Baseline Building Performance (Continued)

No.	Proposed Building Performance	Baseline Building Performance
6. Lighting		
	Lighting power in the *proposed design* shall be determined as follows: a. Where a complete lighting system exists, the actual lighting power for each thermal block shall be used in the model. b. Where a lighting system has been designed, lighting power shall be determined in accordance with Sections 9.1.3 and 9.1.4. c. Where lighting neither exists nor is specified, lighting power shall be determined in accordance with the Building Area Method for the appropriate building type. d. Lighting system power shall include all lighting system components shown or provided for on the	Lighting power in the *baseline building design* shall be determined using the same categorization procedure (building area or space function) and categories as the *proposed design* with lighting power set equal to the maximum allowed for the corresponding method and category in Section 9.2. No automatic lighting controls (e.g., programmable controls or automatic controls for daylight utilization) shall be modeled in the *baseline building design*, as the lighting schedules used are understood to reflect the mandatory control requirements in this ~~standard~~ code.

plans (including lamps and ballasts and task and furniture mounted fixtures). **Exception:** For multifamily *dwelling units*, hotel/motel guest rooms, and other spaces in which lighting systems are connected via receptacles and are not shown or provided for on building plans, assume identical lighting power for the *proposed* and *baseline building designs* in the simulations. e. Lighting power for parking garages and building facades shall be modeled. f. Credit may be taken for the use of automatic controls for daylight utilization but only if their operation is either modeled directly in the building simulation or modeled in the building simulation through schedule adjustments determined by a separate daylighting analysis approved by the *rating authority*. g. For automatic lighting controls in addition to those required for minimum code compliance under Section 9.4.1, credit may be taken for automatically controlled systems by reducing the connected lighting power by the applicable percentages listed in Table G3.2. Alternatively, credit may be taken for these devices by modifying the lighting schedules used for the *proposed design*, provided that credible technical documentation for the modifications are provided to the *rating authority*.	

TABLE G3.1 Modeling Requirements for Calculating Proposed and Baseline Building Performance (Continued)

11. Service Hot-Water Systems The service hot-water system type and all related performance parameters, such as equipment capacities and efficiencies, in the *proposed design* shall be determined as follows: a. Where a complete service hot-water system exists, the *proposed design* shall reflect the actual system type using actual component capacities and efficiencies. b. Where a service hot-water system has been specified, the service hot-water model shall be consistent with design documents. c. Where no service hot-water system exists or has been specified but the building will have service hot-water loads, a service hot-water system shall be modeled that matches the system in the *baseline building design* and serves the same hotwater loads.	The service hot-water system in the *baseline building design* shall use the same energy source as the corresponding system in the *proposed design* and shall conform with the following conditions: a. Where the complete service hot-water system exists, the *baseline building design* shall reflect the actual system type using the actual component capacities and efficiencies. b. Where a new service hot-water system has been specified, the system shall be sized according to the provisions of Section 7.4.1 and the equipment shall match the minimum *efficiency* requirements in Section 7.4.2. Where the energy source is electricity, the heating method shall be electrical resistance. c. Where no service hot-water system exists or

d. For buildings that will have no service hot-water loads, no service hot-water system shall be modeled.	has been specified but the building will have service hot-water loads, a service water system(s) using electrical-resistance heat and matching minimum *efficiency* requirements of Section 7.4.2 shall be assumed and modeled identically in the *proposed* and *baseline building designs*. d. For buildings that will have no service hot-water loads, no service hot-water heating shall be modeled. e. Where a combined system has been specified to meet both space heating and service water heating loads, the baseline building system shall use separate systems meeting the minimum *efficiency* requirements applicable to each system individually. f. Reserved. ~~For large, 24-hour-per-day facilities that meet the prescriptive criteria for use of condenser heat recovery systems described in Section 6.5.6.2, a system meeting the requirements of that section shall be included in the *baseline building design* regardless of the exceptions to Section 6.5.6.2.~~ ~~**Exception:** If a condenser heat recovery system meeting the requirements described in Section 6.5.6.2 cannot be modeled, the requirement for including such a system in the actual building shall be met as a prescriptive requirement in accordance with Section 6.5.6.2, and no heat-recovery system shall be included in the *proposed* or *baseline building designs*.~~ g. Service hot-water energy consumption shall be calculated explicitly based upon the volume of service hot water required and the entering makeup water and the leaving service hot-water temperatures. Entering water temperatures shall be estimated based upon the location. Leaving temperatures shall be based upon the end-use requirements. h. Where recirculation pumps are used to ensure prompt availability of service hot water at the end use, the energy consumption of such pumps shall be calculated explicitly.

	i. Service water loads and usage shall be the same for both the *baseline building design* and the *proposed design* and shall be documented by the calculation procedures described in Section 7.2.1. **Exceptions:** 1. Service hot-water usage can be demonstrated to be reduced by documented water conservation measures that reduce the physical volume of service water required. Examples include low-flow shower heads. Such reduction shall be demonstrated by calculations. 2. Service hot-water energy consumption can be demonstrated to be reduced by reducing the required temperature of service mixed water, by increasing the temperature, or by increasing the temperature of the entering makeup water. Examples include alternative sanitizing technologies for dishwashing and heat recovery to entering makeup water. Such reduction shall be demonstrated by calculations. 3. Service hot-water usuage can be demonstrated to be reduced by reducing the hot fraction of mixed water to achieve required operational temperature. Examples include shower or laundry heat recovery to incoming cold-water supply, reducing the hot-water fraction required to meet required mixed-water temperature. Such reduction shall be demonstrated by calculations.

INFORMATIVE APPENDIX H COOL ROOF GUIDELINE

H1. BACKGROUND

Cool roofs are highly reflective and limit heat absorption in a roof to reduce temperatures as much as 60 degrees lower than a typical roof. According to the *Cool Roof Rating Council* http://www.coolroofs.org/, there are hundreds of products that have been tested to meet the Houston criteria and more continue to be tested. Qualified roof covering materials include a broad spectrum from coatings to modified bitumen, metal, single ply, and the exposed surface of a built-up roof.

H2. DEFINITIONS

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

Building Envelope, Exterior: the elements of a building that separate conditioned spaces from the exterior.

Building Envelope, Semi-exterior: the elements of a building that separate conditioned space from unconditioned space or that enclose semiheated spaces through which thermal energy may be transferred to or from the exterior, or to or from unconditioned spaces, or to or from conditioned spaces.

Positive Roof Drainage. The drainage condition in which consideration has been made for all loading deflections of the roof deck, and additional slope has been provided to ensure drainage of the roof within 48 hours of precipitation. ***(IBC)***

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

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

b. ***metal building roof:*** a roof that is constructed with:

1. a metal, structural, weathering surface,

2. has no ventilated cavity, and

3. has the insulation entirely below deck (i.e., does not include composite concrete and metal deck construction nor a roof framing system that is separated from the superstructure by a wood substrate) and whose structure consists of one or more of the following configurations:

(a) metal roofing in direct contact with the steel framing members or

(b) insulation between the metal roofing and the steel framing members or

(c) insulated metal roofing panels installed as described in 1 or 2.

c. ***roof with insulation entirely above deck:*** a roof with all insulation:

1. installed above (outside of) the roof structure and

2. continuous (i.e., uninterrupted by framing members).

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

Roof Covering. The covering applied to the roof deck for weather resistance, fire classification or appearance. ***(IBC)***

Roof Recover. The process of installing an additional roof covering over a prepared existing roof covering without removing the existing roof covering. ***(IBC)***

Roof Replacement. The process of removing the existing roof covering, repairing any damaged substrate & installing a new roof covering. ***(IBC)***

Reroofing. The process of recovering or replacing an existing roof covering. See "Roof recover" and "Roof replacement." ***(IBC)***

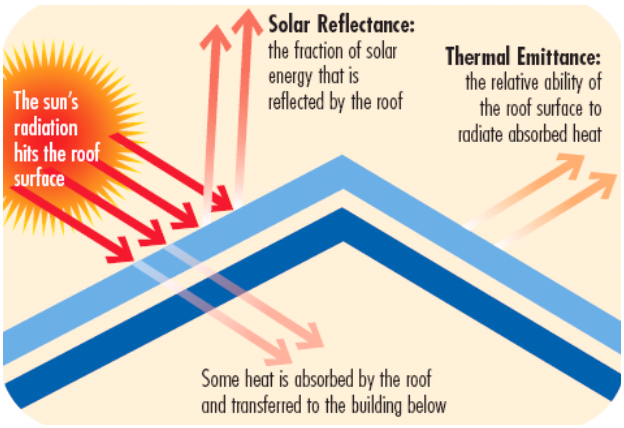
Roof Repair. Reconstruction or renewal of any part of an existing roof for the purposes of its maintenance. ***(IBC)***

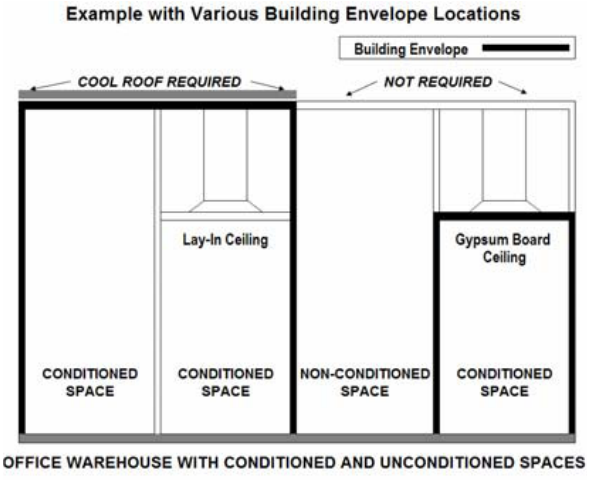
H3. REQUIREMENT

There are two (2) basic tests which classify the roof covering material. Results range from 0.0 to 1.0:

Solar Reflectance**:** the ratio of the light reflected by a surface to the light incident upon it. Minimum 0.70 required.

Thermal Emittance**:** the ratio of the radiant heat flux emitted by a specimen to that emitted by a blackbody at the same temperature and under the same conditions. Minimum 0.75 required.





H4. EXISTING BUILDING ENVELOPE

When there is no change to the status of an existing roof building envelope it does not need to meet 1 the new guidelines. If the roof is already a building envelope and is not being reconstructed it may remain unchanged. For example, where a retail strip center has a change of occupancy to a restaurant and the roof is unaffected, it is not required to meet new provisions. If the existing roof was not a building envelope,

and will not become part of the building envelope due to changing the space below to conditioned space, the existing roof may remain.

H5. APPLICABILITY

Commercial Buildings or Multi-Family Residential Buildings over 3 stories, with a roof slope up to 2:12 pitch when any of the following occur:

1. **New building** (or addition) enclosing conditioned space where the roof serves as a portion of the building envelope.
2. **Conversion of a building** (or space) from unconditioned to conditioned space where the roof serves as a portion of the building envelope.
3. **Alteration or repair** (re-roof) to existing roofs where the roof serves as a portion of the building envelope. Alterations made to an existing roof that affect the existing building envelope must comply. Those that do not affect an existing building envelope may remain unchanged. These are the situations that affect whether the cool roof requirement applies:

SCOPE OF WORK	EXISTING ROOF COVERING	EXISTING INSULATION	REQUIREMENT
1. COMPLETE REMOVAL OF ROOF MATERIALS TO DECK	Removed	Above Deck Removed	Roof Insulation and Cool Roof
		Below Deck Remains	No Requirement
2. REPLACE PORTIONS OF ROOF FULL DEPTH (THICKNESS) [a]	Patches	Patches	Repair affected area to existing
	Edge-to-edge, and Corner-to-corner	Removed	Replace that portion of the roof insulation and cool roof
	NOT an Edge-to-edge, or Corner-to-corner but > 50 % total area	Removed	Roof Insulation and Cool Roof
3. REPLACE ROOF COVERING ONLY (RECOVER)	Removed	Exposed	Roof Insulation and Cool Roof
		Not Exposed	No Requirement
4. APPLY COATINGS ONLY	Remains	Remains or None	No Requirement

a. The roof area will be between expansion joints or between area dividers such as parapet s or edges.

H6. EXEMPTIONS

The provisions of this code do not apply to: (a) single-family houses, multi-family structures of three stories or fewer above grade, manufactured houses (mobile homes) and manufactured houses (modular), (b) buildings that do not use either electricity or fossil fuel, or (c) equipment and portions of building systems that use energy primarily to provide for industrial, manufacturing, or commercial processes. *When a space is conditioned solely for process energy needs, including product storage requirements such as humidity control or refrigeration, it is not required to meet the cool roof provisions.*

H7. ELEMENTS

H7.1 Gravel Roofs

Crushed stone and gravel roof coverings are prohibited in the City of Houston. This does not apply to ballast rock with minimum 1 ½ inch diameter.

H7.2 Lay-in Ceilings

Lay-in ceilings with insulation are not considered part of the building envelope because they allow air infiltration.

H7.3 Re-roofs

Roof covering replacements require positive roof drainage.