ENERGY CONSERVATION BUILDING CODE 2006

Bureau of Energy Efficiency

Energy Conservation Building Code

2006

The Energy Conservation Building Code (ECBC) 2006 has been developed by the International Institute for Energy Conservation (IIEC) under contract with the United States Agency for International Development (USAID) as a part of the Energy Conservation and Commercialization (ECO) Project providing support to the Bureau of Energy Efficiency (BEE) Action Plan.

US Agency for International Development

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Energy Conservation Building Code - Contributing Organizations

- All India Flat Glass Manufacturers Association (AIFGMA)
- Builders Association of India (BAI)
- Building Materials and Technology Promotion Council (BMTPC)
- Bureau of Indian Standards (BIS)
- Carrier Aircon Limited
- Central Building Research Institute, Roorkee (CBRI)
- Central Public Works Department (CPWD)
- Confederation of Construction Products and Services (CCPS)
- Confederation of Indian Industry (CII)
- Council Of Architects (COA)
- Devi Ahilya Vishwa Vidyalaya, Indore
- DSCL Energy Services
- Electric Lamp and Component Manufacturers Association of India (ELCOMA)
- Indian Buildings Congress (IBC)
- Indian Institute of Architects (IIA)
- Indian Institute of Technology, Delhi (IIT-Delhi)
- Indian Institute of Technology, Roorkee (IIT- Roorkee)
- International Copper Promotion Council, India (ICPCI)
- Indian Society of Heating Refrigeration and Air-conditioning Engineers (ISHRAE)
- Lloyd Insulations (India) Limited
- Maharashtra Energy Development Agency, Pune (MEDA)
- Saint-Gobain Glass India Ltd.
- School of Architecture and Planning. Chennai (SAP)
- School of Building Science and Technology, C.E.P.T.
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Table of Contents

1. Purpose

The purpose of this code is to provide minimum requirements for the energy-efficient design and construction of buildings.

2. Scope

The code is mandatory for commercial buildings or building complexes that have a connected load of 500 kW or greater or a contract demand of 600 kVA or greater. The code is also applicable to all buildings with a conditioned floor area of 1,000 m^2 (10,000 ft^2) or greater. The code is recommended for all other buildings.

2.1 Applicable Building Systems

The provisions of this code apply to:

(a) Building envelopes, except for unconditioned storage spaces or warehouses,

(b) Mechanical systems and equipment, including heating, ventilating, and air conditioning,

(c) Service hot water heating,

(d) Interior and exterior lighting, and

(e) Electrical power and motors.

2.2 Exemptions

The provisions of this code do not apply to:

(a) Buildings that do not use either electricity or fossil fuel,

(b) Equipment and portions of building systems that use energy primarily for manufacturing processes, and

(c) Multi-family buildings of three or fewer stories above grade, and single-family buildings.

2.3 Safety, Health and Environmental Codes Take Precedence

Where this code is found to conflict with safety, health, or environmental codes, the safety, health, or environmental codes shall take precedence.

3. Administration and Enforcement

3.1 Compliance Requirements

3.1.1 Mandatory Requirements

Compliance with the requirements of this energy code shall be mandatory for all applicable buildings discussed in §2.

3.1.2 New Buildings

New buildings shall comply with either the provisions of §4 through §8 of this code or the Energy Budget Method of §10.

3.1.3 Additions to Existing Buildings

Where the addition plus the existing building exceeds the conditioned floor area threshold of §2, additions shall comply with the provisions of §4 through §8. Compliance may be demonstrated in either of the following ways:

(a) The addition alone shall comply with the applicable requirements, or

(b) The addition, together with the entire existing building, shall comply with the requirements of this code that would apply to the entire building, as if it were a new building.

Exception to § 3.1.3: When space conditioning is provided by existing systems and equipment, the existing systems and equipment need not comply with this code. However, any new equipment installed must comply with specific requirements applicable to that equipment.

3.1.4 Alterations to Existing Buildings

Where the existing building exceeds the conditioned floor area threshold in §2, portions of a building and its systems that are being altered shall meet the provisions of §4 through §8. The specific requirements for alterations are described in the following subsections.

Exception to § 3.1.4: When the entire building complies with all of the provisions of §4 through §8 as if it were a new building.

3.1.4.1 Building Envelope

Alterations to the building envelope shall comply with the requirements of §4 for fenestration, insulation, and air leakage applicable to the portions of the buildings and its systems being altered.

Exception to § 3.1.4.1: The following alterations need not comply with these requirements provided such alterations do not increase the energy usage of the building:

(a) Replacement of glass in an existing sash and frame, provided the U-factor and SHGC of the replacement glazing are equal to or lower than the existing glazing,

(b) Modifications to roof/ceiling, wall, or floor cavities, which are insulated to full depth with insulation, and

(c) Modifications to walls and floors without cavities and where no new cavities are created.

3.1.4.2 Heating, Ventilation and Air Conditioning

Alterations to building heating, ventilating, and air-conditioning equipment or systems shall comply with the requirements of §5 applicable to the portions of the building and its systems being altered. Any new equipment or control devices installed in conjunction with the alteration shall comply with the specific requirements applicable to that equipment or control device.

3.1.4.3 Service Water Heating

Alterations to building service water heating equipment or systems shall comply with the requirements of § 6 applicable to the portions of the building and its systems being altered. Any new equipment or control devices installed in conjunction with the alteration shall comply with the specific requirements applicable to that equipment or control device.

3.1.4.4 Lighting

Alterations to building lighting equipment or systems shall comply with the requirements of § 7 applicable to the portions of the building and its systems being altered. New lighting systems, including controls, installed in an existing building and any change of building area type as listed in Table 7.3.1 shall be considered an alteration. Any new equipment or control devices installed in conjunction with the alteration shall comply with the specific requirements applicable to that equipment or control device.

Exception to § 3.1.4.4: Alterations that replace less than 50% of the luminaires in a space need not comply with these requirements provided such alterations do not increase the connected lighting load.

3.1.4.5 Electric Power and Motors

Alterations to building electric power systems and motor shall comply with the requirements of § 8 applicable to the portions of the building and its systems being altered. Any new equipment or control devices installed in conjunction with the alteration shall comply with the specific requirements applicable to that equipment or control device.

3.2 Compliance Approaches

The building shall comply with the mandatory provisions (§ 4.2, § 5.2, § 6.2, § 7.2, and § 8.2) and either of the

(a) Prescriptive Method (§ 4.3, § 5.3, § 7.3 and § 7.4), or

Exception to § 3.2(a): The envelope trade-off option of § 4.4 may be used in place of the prescriptive criteria of § 4.3.

(b) Energy Budget Method (Appendix 10).

3.3 Administrative Requirements

Administrative requirements relating to permit requirements, enforcement, interpretations, claims of exemption, approved calculation methods, and rights of appeal are specified by the authority having jurisdiction.

3.4 Compliance Documents

3.4.1 General

Plans and specifications shall show all pertinent data and features of the building, equipment, and systems in sufficient detail to permit the authority having jurisdiction to verify that the building complies with the requirements of this code. Details shall include, but are not limited to:

(a) Building Envelope: insulation materials and their R-values; fenestration U-factors, solar heat gain coefficients (SHGC), visible light transmittance (if the trade-off procedure is used), and air leakage; overhangs and sidefins, building envelope sealing details;

(b) Heating, Ventilation, and Air Conditioning: system and equipment types, sizes, efficiencies, and controls; economizers; variable speed drives; piping insulation; duct sealing, insulation and location; requirement for balance report;

(c) Service Hot Water and Pumping: solar water heating system;

(d) Lighting: lighting schedule showing type, number, and wattage of lamps and ballasts; automatic lighting shutoff, occupancy sensors, and other lighting controls; lamp

efficacy for exterior lamps;

(e) Electrical Power: electric schedule showing transformer losses, motor efficiencies, and power factor correction devices; electric check metering and monitoring system.

3.4.2 Supplemental Information

The authority having jurisdiction may require supplemental information necessary to verify compliance with this code, such as calculations, worksheets, compliance forms, manufacturer's literature, or other data.

4. Envelope

4.1 General

The building envelope shall comply with the mandatory provisions of § 4.2 and either the prescriptive criteria of § 4.3 or the trade-off option of § 4.4.

4.2 Mandatory Requirements

4.2.1 Fenestration

4.2.1.1 U-factors

U-factors shall be determined for the overall fenestration product (including the sash and frame) in accordance with ISO-15099, as specified in Appendix 12, by an accredited independent laboratory, and labeled and certified by the manufacturer or other responsible party. U-factors for sloped glazing and skylights shall be determined at a slope of 20 degrees above the horizontal. For unrated products, use the default table in Appendix 12.

4.2.1.2 Solar Heat Gain Coefficient (SHGC)

SHGC shall be determined for the overall fenestration product (including the sash and frame) in accordance with ISO-15099, as specified in Appendix 12, by an accredited independent laboratory, and labeled and certified by the manufacturer or other responsible party.

Exceptions to § 4.2.1.2:

(a) Shading coefficient (SC) of the center glass alone multiplied by 0.86 is an acceptable alternate for compliance with the SHGC requirements for the overall fenestration area.

(b) Solar heat gain coefficient (SHGC) of the glass alone is an acceptable alternate for compliance with the SHGC requirements for the overall fenestration product.

4.2.1.3 Air Leakage

Air leakage for glazed swinging entrance doors and revolving doors shall not exceed 5.0 l/s-m^2. Air leakage for other fenestration and doors shall not exceed 2.0 l/s-m^2.

4.2.2 Opaque Construction

U-factors shall be determined from the default tables in Appendix 12 or determined from data or procedures contained in the ASHRAE Fundamentals, 2005.

4.2.3 Building Envelope Sealing

The following areas of the enclosed building envelope shall be sealed, caulked, gasketed, or weather-stripped to minimize air leakage:

(a) Joints around fenestration and door frames,

(b) Openings between walls and foundations and between walls and roof and 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, and

(f) All other openings in the building envelope.

4.3 Prescriptive Requirements

4.3.1 Roofs

Roofs shall comply with either the maximum assembly U-factor or the minimum insulation R-value in Table 4.3.1. R-value is for the insulation alone and does not include building

materials or air films. The roof insulation shall not be located on a suspended ceiling with removable ceiling panels.

*Table 4.3.1 Roof assembly U-factor and Insulation R-value Requirements**

Climate Zone	24-Hour use buildings Hospitals, Hotels, Call Centers etc.		Daytime use buildings Other Building Types	
	Maximum U-factor of the overall assembly (W/m^2-°C)	Minimum R-value of insulation alone (m^2-°C/W)	Maximum U-factor of the overall assembly (W/m^2-°C)	Minimum R-value of insulation alone (m^2-°C/W)
Composite	U-0.261	R-3.5	U-0.409	R-2.1
Hot and Dry	U-0.261	R-3.5	U-0.409	R-2.1
Warm and Humid	U-0.261	R-3.5	U-0.409	R-2.1
Moderate	U-0.409	R-2.1	U-0.409	R-2.1
Cold	U-0.261	R-3.5	U-0.409	R-2.1

*See Appendix 12.3 for typical complying roof constructions.

4.3.1.1 Cool Roofs

Roofs with slopes less than 20 degrees shall have an initial solar reflectance of no less than 0.70 and an initial emittance no less than 0.75. Solar reflectance shall be determined in accordance with ASTM E903-96 and emittance shall be determined in accordance with ASTM E408-71 (RA 1996).

4.3.2 Opaque Walls

Opaque walls shall comply with either the maximum assembly U-factor or the minimum insulation R-value in Table 4.3.2. R-value is for the insulation alone and does not include building materials or air films.

Table 4.3.2 Opaque Wall Assembly U-factor and Insulation R-value Requirements

Climate Zone	Hospitals, Hotels, Call Centers (24-Hour)		Other Building Types (Daytime)	
	Maximum U-factor of the overall assembly (W/m^2-°C)	Minimum R-value of insulation alone (m^2-°C/W)	Maximum U-factor of the overall assembly (W/m^2-°C)	Minimum R-value of insulation alone (m^2-°C/W)
Composite	U-0.352	R-2.35	U-0.352	R-2.35
Hot and Dry	U-0.369	R-2.20	U-0.352	R-2.35
Warm and Humid	U-0.352	R-2.35	U-0.352	R-2.35
Moderate	U-0.431	R-1.80	U-0.397	R-2.00
Cold	U-0.369	R-2.20	U-0.352	R-2.35

See Appendix 12.4 for typical complying wall constructions.

Exception to § 4.3.2: Until December 31, 2007, the wall assembly U-factor is allowed to be U-0.440 maximum or insulation R-2.10 minimum

4.3.3 Vertical Fenestration

Vertical fenestration shall comply with the maximum area weighted U-factor and maximum area weighted SHGC requirements of Table 4.3.3-1. Vertical fenestration area is limited to a maximum of 40% of the gross wall area for the prescriptive requirement.

Table 4.3.3-1 Vertical Fenestration U-factor and SHGC Requirements (U-factor in W/m^2-°C)

Climate	Maximum U-factor	Maximum SHGC
Composite	3.177	0.25
Hot and Dry	3.177	0.25
Warm and Humid	3.177	0.25
Moderate	6.922	0.40
Cold	4.085	0.51

See Appendix 12.2.1 for typical complying vertical fenestration constructions.

Exception to § 4.3.3: Overhangs and/or side fins may be applied in determining the SHGC for the proposed design. An adjusted SHGC, accounting for overhangs and/or sidefins, is calculated by multiplying the SHGC of the unshaded fenestration product times a multiplication (M) factor. If this exception is applied, a separate M Factor shall be determined for each orientation and unique shading condition.

Table 4.3.3-2 SHGC "M" Factor Adjustments for Overhangs and Fins

		Overhang "M" Factors for 4 Projection Factors				Vertical Fin "M" Factors for 4 Projection Factors				Overhang+Fin "M" Factors for 4 Projection Factors			
Project Location	**Orientation**	**0.25-0.49**	**-0.50 - 0.74**	**0.75 - 0.99**	**1.00 +**	**0.25 - 0.49**	**0.50 - 0.74**	**0.75 - 0.99**	**1.00 +**	**0.25 - 0.49**	**0.50 - 0.74**	**0.75 - 0.99**	**1.00 +**
North latitude 15° or greater	N	.88	.80	.76	.73	.74	.67	.58	.52	.64	.51	.39	.31
	E/W	.79	.65	.56	.50	.80	.72	.65	.60	.60	.39	.24	.16
	S	.79	.64	.52	.43	.79	.69	.60	.56	.60	.33	.10	.02
Less than 15° North latitude	N	.83	.74	.69	.66	.73	.65	.57	.50	.59	.44	.32	.23
	E/W	.80	.67	.59	.53	.80	.72	.63	.58	.61	.41	.26	.16
	S	.78	.62	.55	.50	.74	.65	.57	.50	.53	.30	.12	.04

Exception to SHGC Requirements in § 4.3.3: Vertical Fenestration areas located more than 2.2 m (7 ft) above the level of the floor are exempt from the SHGC requirement in Table 4.3.3-1, if the following conditions are complied with:

(a) Total Effective Aperture: The total Effective Aperture for the elevation is less than 0.25, including all fenestration areas greater than 1.0 m (3 ft) above the floor level; and,

(b) An interior light shelf is provided at the bottom of this fenestration area, with an interior projection factor (PF) not less than:

i. 1.0 for E-W, SE, SW, NE, and NW orientations

ii. 0.5 for S orientation, and

iii. 0.35 for N orientation when latitude is < 23 degrees.

4.3.3.1 Minimum Visible Transmission (VT) of Glazing for Vertical Fenestration

To permit the use of available daylighting in place of electric lighting, glazing products used in offices, banks, libraries, classrooms with predominant daytime usage, must have the minimum *visual transmittance* (VT), defined as function of WWR, where Effective Aperture > 0.1, equal to or greater than the Minimum VT requirements of Table 4.3.3.1. The table also indicates recommended VT ranges for daylight applications in such spaces.

Table 4.3.3.1 Minimum VT Requirements

WWR	Minimum VT
0 - 0.3	0.27
0.31-0.4	0.20
0.41-0.5	0.16
0.51-0.6	0.13
0.61-0.7	0.11

4.3.4 Skylights

Skylights shall comply with the maximum U-factor and maximum SHGC requirements of Table 4.3.4 Skylight area is limited to a maximum of 5% of the gross roof area for the prescriptive requirement.

Table 4.3.4 Skylight U-factor and SHGC Requirements (U-factor in W/m^2-°C)

	Maximum U-factor		Maximum SHGC	
Climate	**With Curb**	**w/o Curb**	**0-2% SRR**	**2.1-5% SRR**
Composite	11.24	7.717	0.40	0.25
Hot and Dry	11.24	7.717	0.40	0.25
Warm and Humid	11.24	7.717	0.40	0.25
Moderate	11.24	7.717	0.61	0.4
Cold	11.24	7.717	0.61	0.4

SRR = Skylight roof ratio which is the ratio of the total skylight area of the roof, measured to the outside of the frame, to the gross exterior roof.

See § 12.2.2 for typical complying skylight constructions.

4.4 Building Envelope Trade-Off Option

The building envelope complies with the code if the building envelope performance factor (EPF) of the proposed design is less than the standard design, where the standard design exactly complies with the criteria in § 4.3. The envelope trade-off equation is found in Appendix 13.

5. Heating, Ventilation and Air Conditioning

5.1 General

All heating, ventilation and air conditioning equipment and systems shall comply with the mandatory provisions of § 5.2 and the prescriptive criteria of § 5.3.

5.2 Mandatory Requirements

5.2.1 Natural Ventilation

Natural ventilation shall comply with the design guidelines provided for natural ventilation in the National Building Code of India 2005 Part 8, 5.4.3 and 5.7.1.1

5.2.2 Minimum Equipment Efficiencies

Cooling equipment shall meet or exceed the minimum efficiency requirements presented in Tables 5.2.2-1 through 5.2.2-5. Heating and cooling equipment not listed here shall comply with ASHRAE 90.1-2004 § 6.4.1.

Table 5.2.2-1 Unitary Air Conditioning Equipment

Equipment Class	Minimum COP	Minimum IPLV	Test Standard
Unitary Air Cooled Air Conditioner ≥19 and <40 kW (≥5.4 and <11 tons)	3.08		ARI 210/240
Unitary Air Cooled Air Conditioner ≥40 to <70 kW (≥11 to <20 tons)	3.08		ARI 340/360
Unitary Air Cooled Air Conditioner ≥70 kW (≥20 tons)	2.93	2.99	ARI 340/360
Unitary Water Cooled Air Conditioner <19 kW (<5.4 tons)	4.10		ARI 210/240
Unitary Water Cooled Air Conditioner ≥19 and <40 kW (≥5.4 and <11 tons)	4.10		ARI 210/240
Unitary Water Cooled Air Conditioner ≥<40 kW (≥11 tons)	3.22	3.02	ARI 210/240

Table 5.2.2-2 Chillers

Equipment Class	Minimum COP	Minimum IPLV	Test Standard
Air Cooled Chiller <530 kW (<150 tons)	2.90	3.16	ARI 550/590-1998
Air Cooled Chiller ≥530 kW (≥150 tons)	3.05	3.32	ARI 550/590-1998
Centrifugal Water Cooled Chiller < 530 kW (<150 tons)	5.80	6.09	ARI 550/590-1998
Centrifugal Water Cooled Chiller ≥530 and <1050 kW (≥150 and <300 tons)	5.80	6.17	ARI 550/590-1998
Centrifugal Water Cooled Chiller ≥ 1050 kW (≥ 300 tons)	6.30	6.61	ARI 550/590-1998
Reciprocating Compressor, Water Cooled Chiller all sizes	4.20	5.05	ARI 550/590-1998
Rotary Screw and Scroll Compressor, Water Cooled Chiller <530 kW (<150 tons)	4.70	5.49	ARI 550/590-1998
Rotary Screw and Scroll Compressor, Water Cooled Chiller ≥530 and <1050 kW (≥150 and <300 tons)	5.40	6.17	ARI 550/590-1998
Rotary Screw and Scroll Compressor, Water Cooled Chiller ≥ 1050 kW (≥ 300 tons)	5.75	6.43	ARI 550/590-1998

Table 5.2.2-3 Heat Pumps Heating Mode

Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Performance Required[a]	Test Procedure[b]
Air Cooled (Heating Mode)	<19 kW (Cooling Capacity)	Split System	6.8 HSPF (before 1/23/2006) 7.4 HSPF (as of 1/23/2006)	ARI 210/240
		Single Package	6.6 HSPF (before 1/23/2006) 7.4 HSPF (as of 1/23/2006)	
Air Cooled (Heating Mode)	≥19 kW and <40 kW (Cooling Capacity)	8°C db/6°C wb Outdoor air	3.2 COP	ARI 340/360
		-8°C db/-9°C wb Outdoor Air	2.2 COP	
	≥40 kW (Cooling Capacity)	8°C db/6°C wb Outdoor air	3.1 COP	
		-8°C db/-9°C wb Outdoor Air	2.0 COP	

[a] IPLVs and Part load rating conditions are only applicable to equipment with capacity modulation.

[b] Section 12 of ASHRAE 90.1-2004 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

Table 5.2.2-4 Furnaces

Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Performance Required[a]	Test Procedure[b]
Warm Air Furnace, Gas-Fired	<66 kW		78% AFUE or 80% E_t[d]	DOE 10 CFR Part 430 or ANSI Z21.47
	≥66 kW	Maximum Capacity[e]	80% E_c[c]	ANSA Z21.47
Warm Air Furnace, Oil-Fired	<66 kW		78% AFUE or 80% E_t[d]	DOE 10 CFR Part 430 or ANSI Z21.47
	≥66 kW	Maximum Capacity[e]	81% E_t[f]	UL 727
Warm- Air Duct Furnaces, Gas-Fired	All Capacities	Maximum Capacity[e]	80% E_c[g]	ANSI Z83.9
Warm Air Unit Heaters, Gas-Fired	All Capacities	Maximum Capacity[e]	80% E_c[g]	ANSI Z83.8
Warm Air Unit Heaters, Oil-Fired	All Capacities	Maximum Capacity[e]	80% E_c[g]	UL 731

[a] E_t = thermal efficiency. See test procedure for detailed discussion.

[b] Section 12 of ASHRAE 90.1-2004 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

[c] E_c = combustion efficiency. Units must also include an interrupted or intermittent ignition device (IID), have jacket losses not exceeding 0.75% of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.

[d] Combination units not covered by NAECA (3-phase power or cooling capacity greater than or equal to 65,000 Btu/h may comply with either rating.

[e] Minimum and maximum ratings as provided for and allowed by the unit's controls.

[f] E_t = thermal efficiency. Units must also include and interrupted or intermittent ignition device (IDD), have jacket losses not exceeding 0.75% of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternativ3 to a flue damper for those furnaces where combustion air is drawn form the conditioned space.

[g] E_c = combustion efficiency (100% less flue losses). See test procedure for detailed discussion.

Table 5.2.2-5 Boilers

Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Performance Required[b]	Test Procedure[c]
Boilers, Gas-Fired	<88 kW	Hot Water	80% AFUE	DOE 10 CFR Part 430
		Steam	75% AFUE	
	≥88 kW and ≤733 kW	Maximum Capacity[d]	75% E_t[b]	H.I. Htg Boiler Std.
	>733 kW[a]	Hot Water	80% E_c	
	>733 kW[a]	Steam	80% E_c	
Boilers, Oil-Fired	<88 kW		80% AFUE	DOE 10 CFR Part 430
	≥88 kW and ≤733 kW	Maximum Capacity[d]	78% E_t[b]	H.I. Htg Boiler Std.
	>733 kW[a]	Hot Water	83% E_c	
	>733 kW[a]	Steam	83% E_c	
Oil-Fired (Residual)	≥88 kW and ≤733 kW	Maximum Capacity[d]	78% E_t[b]	H.I. Htg Boiler Std.
	>733 kW[a]	Hot Water	83% E_c	
	>733 kW[a]	Steam	83% E_c	

[a] These requirements apply to boilers with rated input of 2,345 kW or less that are not packaged boilers, and to all packaged boilers. Minimum efficiency requirements for boilers cover all capacities of packaged boilers.

[b] E_t = thermal efficiency. See reference document for detailed information.

[c] Section 12 of ASHRAE 90.1-2004 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

[d] Minimum and maximum ratings as provided for and allowed by the unit's controls.

5.2.3 Controls

5.2.3.1 All mechanical cooling and heating systems shall be controlled by a timeclock that:

(a) Can start and stop the system under different schedules for three different day-types per week,

(b) Is capable of retaining programming and time setting during a loss of power for a period of at least 10 hours, and

(c) Includes an accessible manual override that allows temporary operation of the system for up to 2 hours.

Exceptions to 5.2.3.1:

(a) Cooling systems < 28 kW (8 tons)

(b) Heating systems < 7 kW (2 tons)

5.2.3.2 All heating and cooling equipment shall be temperature controlled. Where a unit provides both heating and cooling, controls shall be capable of providing a temperature dead band of 3°C (5°F) within which the supply of heating and cooling energy to the zone is shut off or reduced to a minimum. Where separate heating and cooling equipment serve the same temperature zone, thermostats shall be interlocked to prevent simultaneous heating and cooling.

5.2.3.3 All cooling towers and closed circuit fluid coolers shall have either two speed motors, pony motors, or variable speed drives controlling the fans.

5.2.4 Piping and Ductwork

5.2.4.1 Piping for heating systems with a design operating temperature of 60°C (140°F) or greater shall have at least R-0.70 (R-4) insulation. Piping for heating systems with a design operating temperature less than 60°C (140°F) but greater than 40°C (104°F), piping for cooling systems with a design operating temperature less than 15°C (59°F), and refrigerant suction piping on split systems shall have at least R-0.35 (R-2) insulation. Insulation exposed to weather shall be protected by aluminum sheet metal, painted canvas, or plastic cover. Cellular foam insulation shall be protected as above, or be painted with water retardant paint.

5.2.4.2 Ductwork shall be insulated in accordance with Table 5.2.4.2.

Table 5.2.4.2 Ductwork Insulation

	Required Insulation[a]	
Duct Location	**Supply Ducts**	**Return Ducts**
Exterior	R-1.4 (R-8)	R- 0.6 (R-3.5)
Ventilated Attic	R-1.4 (R-8)	R- 0.6 (R-3.5)
Unventilated Attic without Roof Insulation	R-1.4 (R-8)	R- 0.6 (R-3.5)
Unventilated Attic with Roof Insulation	R- 0.6 (R-3.5)	No Requirement
Unconditioned Space[b]	R- 0.6 (R-3.5)	No Requirement
Indirectly Conditioned Space[c]	No Requirement	No Requirement
Buried	R- 0.6 (R-3.5)	No Requirement

[a] Insulation R-value is measured on a horizontal plane in accordance with ASTM C518 at a mean temperature of 24°C (75°F) at the installed thickness

[b] Includes crawlspaces, both ventilated and non-ventilated

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

5.2.4.3 Ductwork shall be sealed in accordance with Table 5.2.4.3.

Table 5.2.4.3 Ductwork Sealing

	Supply Ducts			
Duct Location	**< 500 Pa (2 inch w.g.)**	**≥500 Pa (2 inch w.g.)**	**Exhaust Ducts**	**Return Ducts**
Outside Conditioned Space	←	←	None	←
Unconditioned Spaces	↑	←	None	→
Indirectly Conditioned Spaces	→	↑	→	None
Return Air Plenums	→	↑	→	None
Cooled Spaces	None	→1	→	None

← All joints and longitudinal seams, and at all duct wall penetrations. Snaplock longitudinal are not allowed. Pressure sensitive tape shall not be used as the primary sealant.

↑ All joints and longitudinal seams. Pressure sensitive tape shall not be used as the primary sealant.

→ Transverse joints only.

1 Ducts within the conditioned space to which they supply air or from which they exhaust air need not be sealed.

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

Unless otherwise shown in design documents, ductwork between the supply fan and variable air volume boxes shall be considered to be in the ≥500 Pa (2 in. w.g.) pressure classification, while all other ductwork of any application shall be considered 250 Pa (1 in. w.g.) pressure classification.

5.2.5 System Balancing

5.2.5.1 General

Construction documents shall require that all HVAC systems be balanced in accordance with generally accepted engineering standards.

Construction documents shall require that a written balance report be provided to the owner or the designated representative of the building owner for HVAC systems serving zones with a total conditioned area exceeding 500 m^2 (5,000 ft^2).

5.2.5.1.1 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 0.75 kW (1.0 hp), fan speed shall be adjusted to meet design flow conditions.

5.2.5.1.2 Hydronic System Balancing

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

Exceptions to § 5.2.5.1.2:

(a) Impellers need not be trimmed nor pump speed adjusted for pumps with pump motors of 7.5 kW (10 hp) or less,

(b) Impellers need not be trimmed when throttling results in no greater than 5% of the nameplate horsepower draw, or 2.2 kW (3 hp), whichever is greater.

5.2.6 Condensers

5.2.6.1 Condenser Locations

Care shall be exercised in locating the condensers in such a manner that heat sink is free of interference from heat discharge by devices located in adjoining spaces and also does not interfere with such other systems installed nearby.

5.2.6.2 Treated Water for Condensers

All high-rise buildings using centralized cooling water system shall use soft water for the condenser and chilled water system.

5.3 Prescriptive Requirements

Compliance shall be demonstrated with the requirements in § 5.3.1 through § 5.3.2 for each HVAC system that meets the following criteria:

(a) Serves a single zone,

(b) Cooling (if any) is provided by a unitary packaged or split-system air conditioner or heat pump,

(c) Heating (if any) is provided by a unitary packaged or split-system heat pump, fuel-fired furnace, electric resistance heater, or baseboards connected to a boiler, and

(d) Outside air quantity is less than 1,400 l/s (3000 cfm) and less than 70% of supply air at design conditions.

Other HVAC systems shall comply with ASHRAE 90.1-2004, § 6.5.

5.3.1 Economizers

5.3.1.1 Air Side Economizer

Each individual cooling fan system that has a design supply capacity over 1,200 l/s (2,500 cfm) and a total mechanical cooling capacity over 22 kW (6.3 tons) shall include either:

(a) An air economizer capable of modulating outside-air and return-air dampers to supply 100 percent of the design supply air quantity as outside-air; or

(b) A water economizer capable of providing 100% of the expected system cooling load at outside air temperatures of 10°C (50°F) dry-bulb/7.2°C (45°F) wet-bulb and below.

Exception to § 5.3.1.1:

(a) Projects in the Hot-Dry and Warm-Humid climate zones are exempt.

(b) Individual ceiling mounted fan systems < 3,200 l/s (6,500 cfm) are exempt.

5.3.1.2 Where required by 5.3.1.1 economizers shall be capable of providing partial cooling even when additional mechanical cooling is required to meet the cooling load.

5.3.1.3 Air-side economizers shall be tested in the field following the requirements in Appendix 15 to ensure proper operation.

Exception to 5.3.1.3: Air economizers installed by the HVAC system equipment manufacturer and certified to the building department as being factory calibrated and tested per the procedures in Appendix 15.

5.3.2 Variable Flow Hydronic Systems

5.3.2.1 Chilled or hot-water systems shall be designed for variable fluid flow and shall be capable of reducing pump flow rates to no more than the larger of:

(a) 50% of the design flow rate, or

(b) the minimum flow required by the equipment manufacturer for proper operation of the chillers or boilers.

5.3.2.2 Water cooled air-conditioning or heat pump units with a circulation pump motor greater than or equal to 3.7 kW (5 hp) shall have two-way automatic isolation valves on each water cooled air-conditioning or heat pump unit that are interlocked with the compressor to shut off condenser water flow when the compressor is not operating.

5.3.2.3 Chilled water or condenser water systems that must comply with either 5.3.2.1 or 5.3.2.2 and that have pump motors greater than or equal to 3.7 kW (5 hp) shall be controlled by variable speed drives.

6. Service Hot Water and Pumping

6.1 General

All service water heating equipment and systems shall comply with the mandatory provisions of § 6.2.

6.2 Mandatory Requirements

6.2.1 Solar Water Heating

Residential facilities, hotels and hospitals with a centralized system shall have solar water heating for at least 1/5 of the design capacity.

Exception to § 6.2.1: Systems that use heat recovery for at least 1/5 of the design capacity.

6.2.2 Equipment Efficiency

Service water heating equipment shall meet or exceed the minimum efficiency requirements presented in Table 6.2.2.

Table 6.2.2 Minimum Efficiencies for Service Water Heating Equipment

Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Performance Required[a]	Test Procedure[b]
Electric Water Heaters	≤12 kW	Resistance ≥76 L	0.93-0.00132V EF	DOE 10 CFR Part 430
	>12 kW	Resistance ≥76 L	20 + 35 √V SL, Btu/h	ANSI Z21.10.3
	≤24 Amps and ≤250 Volts	Heat Pump	0.93-0.00132V EF	DOE 10 CFR Part 430
Gas Storage Water Heaters	≤23 kW	≥76 L	0.62-0.0019V EF	DOE 10 CFR Part 430
	>23 kW	<310 W/L	80% E_t (Q/800 + 110 √V) SL, Btu/h	ANSI Z21.10.3
Gas Instantaneous Water Heaters	>15 kW and <59 kW	≥310 W/L and <8 L	0.62-0.0019V EF	DOE 10 CFR Part 430
	≥59 kW[c]	≥310 W/L and <38 L	80% E_t	ANSI Z21.10.3
	≥59 kW	≥310 W/L and ≥38 L	80% E_t (Q/800 + 110 √V) SL, Btu/h	
Oil Storage Water Heaters	≤31 kW	≥76 L	0.59-0.0019V EF	DOE 10 CFR Part 430
	>31 kW	<310 W/L	78% E_t (Q/800 + 110 √V) SL, Btu/h	ANSI Z21.10.3
Oil Instantaneous Water Heaters	≤62 kW	≥310 W/L and <8 L	0.59-0.0019V EF	DOE 10 CFR Part 430
	>62 kW	≥310 W/L and <38 L	80% E_t	ANSI Z21.10.3
	>62 kW	≥310 W/L and ≥38 L	78% E_t (Q/800 + 110 √V) SL, Btu/h	
Hot Water Supply Boilers, Gas and Oil	≥62 kW and <3664 kW	≥310 W/L and <38 L	80% E_t	ANSI Z21.10.3
Hot Water Supply Boilers, Gas		≥310 W/L and ≥38 L	80% E_t (Q/800 + 110 √V) SL, Btu/h	
Hot Water Supply Boilers, Oil		≥310 W/L and ≥38 L	78% E_t (Q/800 + 110 √V) SL, Btu/h	
Pool Heaters Oil and Gas	All		78% E_t	ASHRAE 146
Heat Pump Pool Heaters	All		4.0 COP	ASHRAE 146
Unfired Storage Tanks	All		R-2.2	(none)

[a] Energy factor (EF) and thermal efficiency (E_t) are minimum requirements, while standby loss (SL) is maximum Btu/h based on a 38.9°C temperature difference between stored water and ambient requirements. In the EF equation, *V* is the rated volume in liters. In the SL equation, V is the rated volume in liters and *Q* is the nameplate input rate in W.

[b] Section 12 of ASHRAE 90.1-2004 contains a complete specification, including the year version, of the referenced test procedure.

[c] Instantaneous water heaters with input rates below 58.62 W must comply with these requirements if the water heater is designed to heat water to temperatures 82.2°C or higher.

6.2.3 Supplementary Water Heating System

Supplementary heating system shall be designed to maximize the energy efficiency of the system and shall incorporate the following design features in cascade:

(a) Maximum heat recovery from hot discharge system like condensers of air conditioning units,

(b) Use of gas fired heaters wherever gas is available, and

(c) Electric heater as last resort.

6.2.4 Piping Insulation

Piping insulation shall comply with § 5.2.4.1. The entire hot water system including the storage tanks, pipelines shall be insulated conforming to the relevant IS standards on materials and applications.

6.2.5 Heat Traps

Vertical pipe risers serving storage water heaters and storage tanks not having integral heat traps and serving a non-recirculating system shall have heat traps on both the inlet and outlet piping as close as practical to the storage tank.

6.2.6 Swimming Pools

Heated pools shall be provided with a vapor retardant pool cover on or at the water surface. Pools heated to more than 32°C (90°F) shall have a pool cover with a minimum insulation value of R-2.1 (R-12).

Exception to § 6.2.6: Pools deriving over 60% of their energy from site-recovered energy or solar energy source.

6.2.7 Compliance Documentation

The application for approval shall furnish detailed calculation showing the design to ensure that at least 20% of the heating requirement shall be met from solar heat/heat recovery and not more than 80% of the heat shall be met from electrical heating. Wherever gas is available, not more than 20% of the heat shall be met from electrical heating.

7. Lighting

7.1 General

Lighting systems and equipment shall comply with the mandatory provisions of § 7.2 and the prescriptive criteria of § 7.3 and § 7.4. The lighting requirements in this section shall apply to:

(a) Interior spaces of buildings,

(b) Exterior building features, including facades, illuminated roofs, architectural features, entrances, exits, loading docks, and illuminated canopies, and,

(c) Exterior building grounds lighting that is provided through the building's electrical service.

Exceptions to § 7.1:

(a) Emergency lighting that is automatically off during normal building operation and is powered by battery, generator, or other alternate power source; and,

(b) Lighting in dwelling units.

7.2 Mandatory Requirements

7.2.1 Lighting Control

7.2.1.1 Automatic Lighting Shutoff

Interior lighting systems in buildings larger than 500 m^2 (5,000 ft^2) shall be equipped with an automatic control device. Within these buildings, all office areas less than 30 m^2 (300 ft^2) enclosed by walls or ceiling-height partitions, all meeting and conference rooms, all school classrooms, and all storage spaces shall be equipped with occupancy sensors. For other spaces, this automatic control device shall function on either

(a) A scheduled basis at specific programmed times. An independent program schedule shall be provided for areas of no more than 2,500 m^2 (25,000 ft^2) and not more than one floor; or,

(b) Occupancy sensors that shall turn the lighting off within 30 minutes of an occupant leaving the space. Light fixtures controlled by occupancy sensors shall have a wall-mounted, manual switch capable of turning off lights when the space is occupied.

Exception to § 7.2.1.1: Lighting systems designed for 24-hour use.

7.2.1.2 Space Control

Each space enclosed by ceiling-height partitions shall have at least one control device to independently control the general lighting within the space. Each control device shall be activated either manually by an occupant or automatically by sensing an occupant. Each control device shall

(a) Control a maximum of 250 m^2 (2,500 ft^2) for a space less than or equal to 1,000 m^2 (10,000 ft^2), and a maximum of 1,000 m^2 (10,000 ft^2) for a space greater than 1,000 m^2 (10,000 ft^2).

(b) Be capable of overriding the shutoff control required in 7.2.1.1 for no more than 2 hours, and

(c) Be readily accessible and located so the occupant can see the control.

Exception to § 7.2.1.2(c): The required control device may be remotely installed if required for reasons of safety or security. A remotely located device shall have a pilot light indicator as part of or next to the control device and shall be clearly labeled to identify the controlled lighting.

7.2.1.3 Control in Daylighted Areas

Luminaires in daylighted areas greater than 25 m^2 (250 ft^2) shall be equipped with either a manual or automatic control device that:

(a) Is capable of reducing the light output of the luminaires in the daylighted areas by at least 50%, and

(b) Controls only the luminaires located entirely within the daylighted area.

7.2.1.4 Exterior Lighting Control

Lighting for all exterior applications not exempted in § 7.4 shall be controlled by a photosensor or astronomical time switch that is capable of automatically turning off the exterior lighting when daylight is available or the lighting is not required.

7.2.1.5 Additional Control

The following lighting applications shall be equipped with a control device to control such lighting independently of general lighting:

(a) Display/Accent Lighting. Display or accent lighting greater than 300 m^2 (3,000 ft^2) area shall have a separate control device.

(b) Case Lighting. Lighting in cases used for display purposes greater than 300 m^2 (3,000 ft^2) area shall be equipped with a separate control device.

(c) Hotel and Motel Guest Room Lighting. Hotel and motel guest rooms and guest suites shall have a master control device at the main room entry that controls all permanently installed luminaires and switched receptacles.

(d) Task Lighting. Supplemental task lighting including permanently installed under shelf or under cabinet lighting shall have a control device integral to the luminaires or be controlled by a wall-mounted control device provided the control device complies with 7.2.1.2(c).

(e) Nonvisual Lighting. Lighting for nonvisual applications, such as plant growth and food-warming, shall be equipped with a separate control device.

(f) Demonstration Lighting. Lighting equipment that is for sale or for demonstrations in lighting education shall be equipped with a separate control device accessible only to authorized personnel.

7.2.2 Exit Signs

Internally-illuminated exit signs shall not exceed 5 W per face.

7.2.3 Exterior Building Grounds Lighting

Lighting for exterior building grounds luminaires which operate at greater than 100 W shall contain lamps having a minimum efficacy of 60 lm/W unless the luminaire is controlled by a motion sensor or exempt under § 7.1.

7.3 Interior Lighting Power

The installed interior lighting power for a building or a separately metered or permitted portion of a building shall be calculated in accordance with § 7.3.3 and shall not exceed the interior lighting power allowance determined in accordance with either § 7.3.1 or § 7.3.2. Tradeoffs of interior lighting power allowance among portions of the building for which a different method of calculation has been used are not permitted.

Exception to § 7.3: The following lighting equipment and applications shall not be considered when determining the interior lighting power allowance, nor shall the wattage for such lighting be included in the installed interior lighting power. However, any such lighting shall not be exempt unless it is an addition to general lighting and is controlled by an independent control device.

(a) Display or accent lighting that is an essential element for the function performed in

galleries, museums, and monuments,

(b) Lighting that is integral to equipment or instrumentation and is installed by its manufacturer,

(c) Lighting specifically designed for medical or dental procedures and lighting integral to medical equipment,

(d) Lighting integral to food warming and food preparation equipment,

(e) Lighting for plant growth or maintenance,

(f) Lighting in spaces specifically designed for use by the visually impaired,

(g) Lighting in retail display windows, provided the display area is enclosed by ceiling-height partitions,

(h) Lighting in interior spaces that have been specifically designated as a registered interior historic landmark,

(i) Lighting that is an integral part of advertising or directional signage,

(j) Exit signs,

(k) Lighting that is for sale or lighting educational demonstration systems,

(l) Lighting for theatrical purposes, including performance, stage, and film or video production, and

(m) Athletic playing areas with permanent facilities for television broadcasting.

7.3.1 Building Area Method

Determination of interior lighting power allowance (watts) by the building area method shall be in accordance with the following:

(a) Determine the allowed lighting power density from Table 7.3.1 for each appropriate building area type.

(b) Calculate the gross lighted floor area for each building area type.

(c) The interior lighting power allowance is the sum of the products of the gross lighted floor area of each building area times the allowed lighting power density for that building area types.

Table 7.3.1 Interior Lighting Power - Building Area Method

Building Area Type	LPD (W/m^2)	Building Area Type	LPD (W/m^2)
Automotive Facility	9.7	Multifamily	7.5
Convention Center	12.9	Museum	11.8
Court House	12.9	Office	10.8
Dining: Bar Lounge/Leisure	14.0	Parking Garage	3.2
Dining: Cafeteria/Fast Food	15.1	Penitentiary	10.8
Dining: Family	17.2	Performing Arts Theater	17.2
Dormitory	10.8	Police/Fire Station	10.8
Exercise Center	10.8	Post Office	11.8
Gymnasium	11.8	Religious Building	14.0
Healthcare-Clinic	10.8	Retail	16.1
Hospital/Health Care	12.9	School/University	12.9
Hotel	10.8	Sports Arena	11.8
Library	14.0	Town Hall	11.8
Manufacturing Facility	14.0	Transportation	10.8
Motel	10.8	Warehouse	8.6
Motion Picture Theater	12.9	Workshop	15.1

In cases where both a general building area type and a specific building area type are listed, the specific building area type shall apply.

7.3.2 Space Function Method

Determination of interior lighting power allowance (watts) by the space function method shall be in accordance with the following:

(a) Determine the appropriate building type from Table 7.3.2 and the allowed lighting power density.

(b) For each space enclosed by partitions 80% or greater than ceiling height, determine the gross interior floor area by measuring to the center of the partition wall. Include the floor area of balconies or other projections. Retail spaces do not have to comply with the 80% partition height requirements.

(c) The interior lighting power allowance is the sum of the lighting power allowances for all spaces. The lighting power allowance for a space is the product of the gross lighted floor area of the space times the allowed lighting power density for that space.

Table 7.3.2 Interior Lighting Power – Space Function Method

Space Function	LPD (W/m^2)	Space Function	LPD (W/m^2)
Office-enclosed	11.8	Library	
Office-open plan	11.8	Card File & Cataloging	11.8
Conference/Meeting/Multipurpose	14.0	Stacks	18.3
Classroom/Lecture/Training	15.1	Reading Area	12.9
Lobby	14.0	Hospital	
For Hotel	11.8	Emergency	29.1
For Performing Arts Theater	35.5	Recovery	8.6
For Motion Picture Theater	11.8	Nurse Station	10.8
Audience/Seating Area	9.7	Exam Treatment	16.1
For Gymnasium	4.3	Pharmacy	12.9
For Exercise Center	3.2	Patient Room	7.5
For Convention Center	7.5	Operating Room	23.7
For Religious Buildings	18.3	Nursery	6.5
For Sports Arena	4.3	Medical Supply	15.1
For Performing Arts Theater	28.0	Physical Therapy	9.7
For Motion Picture Theater	12.9	Radiology	4.3
For Transportation	5.4	Laundry – Washing	6.5
Atrium-first three floors	6.5	Automotive – Service Repair	7.5
Atrium-each additional floor	2.2	Manufacturing	
Lounge/Recreation	12.9	Low Bay (<8m ceiling)	12.9
For Hospital	8.6	High Bay (>8m ceiling)	18.3
Dining Area	9.7	Detailed Manufacturing	22.6
For Hotel	14.0	Equipment Room	12.9
For Motel	12.9	Control Room	5.4
For Bar Lounge/Leisure Dining	15.1	Hotel/Motel Guest Rooms	11.8
For Family Dining	22.6	Dormitory – Living Quarters	11.8
Food Preparation	12.9	Museum	
Laboratory	15.1	General Exhibition	10.8
Restrooms	9.7	Restoration	18.3
Dressing/Locker/Fitting Room	6.5	Bank Office – Banking Activity Area	16.1
Corridor/Transition	5.4	Religions Buildings	
For Hospital	10.8	Worship-pulpit, choir	25.8
For Manufacturing Facility	5.4	Fellowship Hall	9.7
Stairs-active	6.5	Retail	
Active Storage	8.6	Sales Area	18.3
For Hospital	9.7	Mall Concourse	18.3
Inactive Storage	3.2	Sports Arena	
For Museum	8.6	Ring Sports Area	29.1
Electrical/Mechanical	16.1	Court Sports Area	24.8
Workshop	20.5	Indoor Field Area	15.1
Sleeping Quarters	3.2	Warehouse	

Table 7.3.2 Interior Lighting Power – Space Function Method

Space Function	LPD (W/m^2)	Space Function	LPD (W/m^2)
Convention Center – Exhibit Space	14.0	Fine Material Storage	15.1
		Medium/Bulky Material Storage	9.7
		Parking Garage – Garage Area	2.2
		Transportation	
		Airport – Concourse	6.5
		Air/Train/Bus – Baggage Area	10.8
		Terminal – Ticket Counter	16.1

7.3.3 Installed Interior Lighting Power

The installed interior lighting power calculated for compliance with § 7.3 shall include all power used by the luminaires, including lamps, ballasts, current regulators, and control devices except as specifically exempted in § 7.1.

Exception to § 7.3.3: If two or more independently operating lighting systems in a space are controlled to prevent simultaneous user operation, the installed interior lighting power shall be based solely on the lighting system with the highest power.

7.3.3.1 Luminaire Wattage

Luminaire wattage incorporated into the installed interior lighting power shall be determined in accordance with the following:

(a) The wattage of incandescent luminaires with medium base sockets and not containing permanently installed ballasts shall be the maximum labeled wattage of the luminaires.

(b) The wattage of luminaires containing permanently installed ballasts shall be the operating input wattage of the specified lamp/ballast combination based on values from manufacturers' catalogs or values from independent testing laboratory reports.

(c) The wattage of all other miscellaneous luminaire types not described in (a) or (b) shall be the specified wattage of the luminaires.

(d) The wattage of lighting track, plug-in busway, and flexible-lighting systems that allow the addition and/or relocation of luminaires without altering the wiring of the system shall be the larger of the specified wattage of the luminaires included in the system or 135 W/m (45 W/ft). Systems with integral overload protection, such as fuses or circuit breakers, shall be rated at 100% of the maximum rated load of the limiting device.

7.4 Exterior Lighting Power

For building exterior lighting applications specified in Table 7.4, the connected lighting power shall not exceed the specified lighting power limits specified for each of these applications. Trade-offs between applications are not permitted. Exterior lighting for all other applications (except those included in the Exceptions to § 7.4) shall comply with the requirements of § 7.2.3.

Table 7.4 Exterior Building Lighting Power

Exterior Lighting Applications	Power Limits
Building entrance (with canopy)	13 W/m^2 (1.3 W/ft^2) of canopied area
Building entrance (without canopy)	90 W/lin m (30 W/lin f) of door width
Building exit	60 W/lin m (20 W/lin f) of door width
Building facades	2 W/m^2 (0.2 W/ft^2) of vertical facade area

Exceptions to § 7.4: Lighting used for the following exterior applications is exempt when equipped with an independent control device:

(a) Specialized signal, directional, and marker lighting associated with transportation;

(b) Lighting used to highlight features of public monuments and registered historic landmark structures or buildings;

(c) Lighting that is integral to advertising signage; or

(d) Lighting that is specifically designated as required by a health or life safety statute, ordinance, or regulation.

8. Electrical Power

8.1 General

Electric equipment and systems shall comply with the mandatory requirements of § 8.2.

8.2 Mandatory Requirements

8.2.1 Transformers

8.2.1.1 Maximum Allowable Power Transformer Losses

Power transformers of the proper ratings and design must be selected to satisfy the minimum acceptable efficiency at their full load rating. In addition, the transformer must be selected such that it minimizes the total of its initial cost in addition to the present value of the cost of its total lost energy while serving its estimated loads during its respective life span. Transformers used in buildings shall be constructed with high quality grain oriented low loss silicon steel and virgin electrolytic grade copper and the manufacturer's certificate to this effect shall be obtained.

Table 8.2.1.1 Maximum Allowable Losses of 11,22 kV Transformers

	Maximum Allowable Losses at Full Load in % of Rating	
Transformer Capacity, kVa	**11 kV Transformer**	**22 kV Transformer**
100	2.5	2.7
160	2.3	2.2
250	2.1	1.8
400	1.5	1.5
630	1.4	1.5
800	1.4	1.5
1000	1.2	1.2

Reference conditions: 100% of nameplate load at temperature of 75^{o} C

8.2.1.2 Measurement and Reporting of Transformer Losses

All measurement of losses shall be carried out by using calibrated digital meters of class 0.5 or better accuracy and certified by the manufacturer. All transformers of capacity of 500 kVA and above would be equipped with additional metering class current transformers (CTs) and potential transformers (PTs) additional to requirements of Utilities so that periodic loss monitoring study may be carried out.

8.2.2 Energy Efficient Motors

Motors shall comply with the following:

(a) All permanently wired polyphase motors of 0.375 kW or more serving the building and expected to operate more than 1,500 hours per year and all permanently wired polyphase motors of 50kW or more serving the building and expected to operate more than 500 hours per year shall have a minimum acceptable nominal full load motor efficiency not less than shown in Table 8.2.2 or the BIS for energy efficient motors.

(b) Motors of horsepower differing from those listed in the table shall have efficiency greater than that of the next listed kW motor.

(c) Motor horsepower ratings shall not exceed 200% of the calculated maximum load being served.

(d) Motor nameplates shall list the nominal full-load motor efficiencies and the full-load power factor.

(e) Motor users should insist on proper rewinding practices for any rewound motors. If the proper rewinding practices cannot be assured, the damaged motor should be replaced with a new, efficient one rather than suffer the significant efficiency penalty associated with typical rewind practices.

(f) Certificates shall be obtained and kept on record indicating the motor efficiency. Whenever a motor is rewound, appropriate measures shall be taken so that the core characteristics of the motor is not lost due to thermal and mechanical stress during removal of damaged parts. After rewinding, a new efficiency test shall be performed and a similar record shall be maintained.

Table 8.2.2 Minimum Acceptable Motor Efficiencies

	Efficiency (%)	
Motor Size (kW)	**2 Pole**	**4 Pole**
1.1 (1.5 hp)	82.2	83.8
1.5 (2 hp)	84.1	85.0
2.2 (3 hp)	85.6	86.4
3.0 (4 hp)	86.7	87.4
4.0 (5.5 hp)	87.6	88.3
5.5 (7.5 hp)	88.5	89.2
7.5 (10 hp)	89.5	90.1
11.0 (15 hp)	90.6	91.0
15.0 (20 hp)	91.3	91.8
18.5 (25 hp)	91.8	92.2
22.0 (30 hp)	92.2	92.6
30.0 (40 hp)	92.9	93.2
37.0 (50 hp)	93.3	93.6
45.0 (60 hp)	93.7	93.9
55.0 (75 hp)	94.0	94.2
75.0 (100 hp)	94.6	94.7

8.2.3 Power Factor Correction

All electricity supplies exceeding 100 A, 3 phase shall maintain their power factor between 0.98 lag and unity at the point of connection.

8.2.4 Check-Metering and Monitoring

(a) Buildings whose maximum demand is greater than 250 kVA shall have the electrical distribution system with their energy consumption being check-metered.

(b) Services exceeding 1000 kVA shall have permanently installed electrical metering to record demand (kVA), energy (kWh), and total power factor. The metering shall also display current (in each phase and the neutral), voltage (between phases and between each phase and neutral), and total harmonic distortion (THD) as a percentage of total current.

(c) Services not exceeding 1000 kVA but over 65 kVA shall have permanently installed electric metering to record demand (kW), energy (kWh), and total power factor (or kVARh).

(d) Services not exceeding 65 kVA shall have permanently installed electrical metering to record energy (kWh).

8.2.5 Power Distribution Systems

8.2.5.1 Thermal Monitoring of Main Distribution System

All the power junction boxes and main power distribution board and cable termination points shall be provided with temperature monitoring mechanism comprising of sensors in the enclosed chambers and properly visible temperature indicators outside. Record of temperature during commissioning and subsequently on a daily basis shall be maintained.

8.2.5.2 Power Distribution System Losses

The power cabling shall be adequately sized as to maintain the distribution losses not to exceed 1% of the total power usage. Record of design calculation for the losses shall be maintained.

9. Appendix A - Definitions, Abbreviations, and Acronyms

9.1 General

Certain terms, abbreviations, and acronyms are defined in this section for the purposes of this code. These definitions are applicable to all sections of this code. Terms that are not defined shall have their ordinarily accepted meanings within the context in which they are used. Webster's Third New International Dictionary of the English Language, Unabridged, copyright 1986, shall be considered as providing ordinarily accepted meanings.

9.2 Definitions

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

Alteration: any change, rearrangement, replacement, or addition to a building or its systems and equipment; any modification in construction or building equipment

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

Area: see roof and wall, conditioned floor, daylighted, façade, fenestration, lighted floor

Astronomical time switch: an automatic time switch that makes an adjustment for the length of the day as it varies over the year

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

Automatic: self-acting, operating by its own mechanism when actuated by some non-manual influence, such as a change in current strength, pressure, temperature, or mechanical configuration.

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

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

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

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

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

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

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

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

Building complex: a group of buildings in a contiguous area under single ownership

Building entrance: any doorway, set of doors, turnstiles, or other form of portal that is

ordinarily used to gain access to the building by its users and occupants

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

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

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

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

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

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

Circuit breaker: a device designed t open and close a circuit by nonautomatic means and to open the circuit automatically at a predetermined over-current without damage to itself when properly applied within its rating

Class of construction: for the building envelope, a subcategory of roof, wall, floor, slab-on-grade floor, opaque door, vertical fenestration, or skylight

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

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

Commercial building: all buildings except for multi-family buildings of three stories or fewer above grade and single-family buildings

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

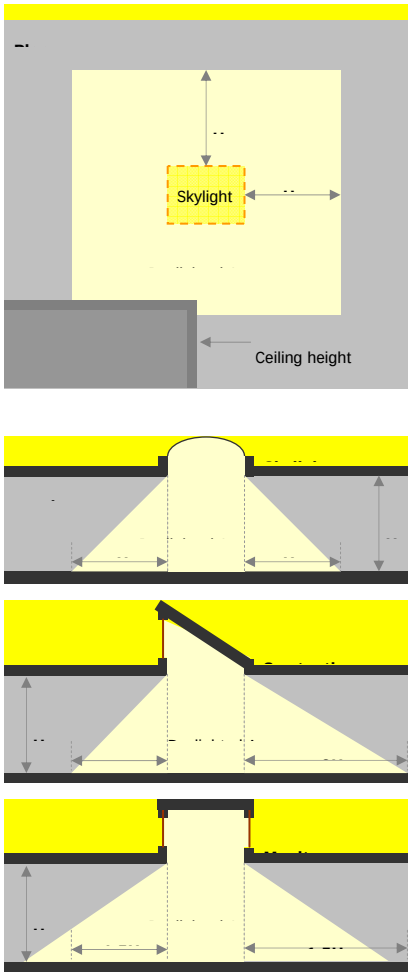
Control: to regulate the operation of equipment

Control device: a specialized device used to regulate the operation of equipment

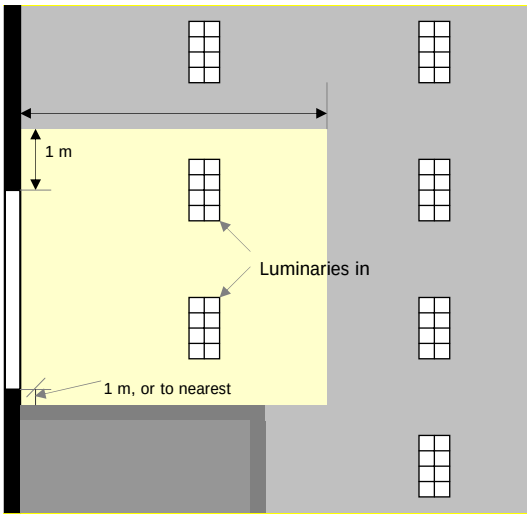
Cool roof: a property of a surface that describes its ability to reflect and reject heat. Cool roof surfaces have both a light color (high solar reflectance) and a high emittance (can reject heat back to the environment)

Daylighted area: the daylight illuminated floor area under horizontal fenestration (skylight) or adjacent to vertical fenestration (window), described as follows

(a) Horizontal Fenestration: the area under a skylight, monitor, or sawtooth configuration with an effective aperture greater than 0.001 (0.1%). The daylighted area is calculated as the horizontal dimension in each direction equal to the top aperture dimension in that direction plus either the floor-to-ceiling height (H) for skylights, or 1.5 H for monitors, or H or 2H for the sawtooth configuration, or the distance to the nearest 1000 mm (42 in) or higher opaque partition, or one-half the distance to an adjacent skylight or vertical glazing, whichever is least, as shown in the plan and section figures below.



(b) Vertical Fenestration: the floor area adjacent to side apertures (vertical fenestration in walls) with an effective aperture greater than 0.06 (6%). The daylighted area extends into the space perpendicular to the side aperture a distance either two times the head height of the side aperture or to the nearest 1.35 m (54 in) or higher opaque partition, whichever is less. In the direction parallel to the window, the daylighted area extends a horizontal dimension equal to the width of the window plus either 1 m (3.3 ft) on each side of the aperture, the distance to an opaque partition, or one-half the distance to an adjacent skylight or window, whichever is least.



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

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

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

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

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

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

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

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

Door area: total area of the door measured using the rough opening and including the door slab and the frame.

Dwelling unit: a single unit providing complete independent living facilities for one or more persons, including permanent provisions for living, seeping, eating, coking, and sanitation

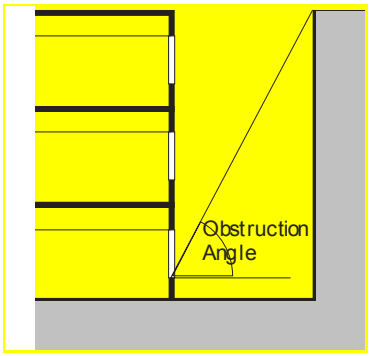
Economizer, air: a duct and damper arrangement and automatic control system that together allow a cooling system to supply outdoor air to reduce or eliminate the need for mechanical cooling during mild or cold weather

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

Effective aperture: Visible Light Transmittance x Window-to-wall Ratio. (EA = VLT x WWR)

Effective aperture, horizontal fenestration: a measure of the amount of daylight that enters a space through horizontal fenestration (skylights). It is the ratio of the skylight area times the visible light transmission divided by the gross roof area above the daylighted area. See also daylighted area.

Effective aperture, vertical fenestration: a measure of the amount of daylight that enters a space through vertical fenestration. It is the ratio of the daylight window area times its visible light transmission plus half the vision glass area times its visible light transmission and the sum is divided by the gross wall area. Daylighted window area is located 2.2 m (7 ft) or more above the floor and vision window area is located above 1 m (3 ft) but below 2.2 m (7 ft). The window area, for the purposes of determining effective aperture shall not include windows located in light wells when the angle of obstruction (α) of objects obscuring the sky dome is greater than 70^{o}, measured from the horizontal, nor shall it include window area located below a height of 1 m (3 ft). See also daylighted area.



Efficacy: the lumens produced by a lamp/ballast system divided by the total watts of input power (including the ballast), expressed in lumens per watt

Efficiency: performance at a specified rating condition

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

Enclosed building: a building that is totally enclosed by walls, floors, roofs, and openable devices such as doors and operable windows

Energy: the capacity for doing work. It takes a number of forms that may be transformed from one into another such as thermal (heat), mechanical (work), electrical, and chemical. Customary measurements are watts (W)

Energy Efficiency Ratio (EER): the ratio of net cooling capacity in Btu/h to total rate of electric input in watts under designated operating conditions

Energy Factor (EF): a measure of water heater overall efficiency

Envelope performance factor: the trade-off value for the building envelope performance compliance option calculated using the procedures specified in Appendix 13. For the purposes of determining building envelope requirements the classifications are defined as follows:

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

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

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

Equipment, existing: equipment previously installed in an existing building

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

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

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

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

(b) Vertical fenestration: all fenestration other than skylights. Trombe wall assemblies, where glazing is installed within 300 mm (12 in). of a mass wall, are considered walls, not fenestration.

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

Floor area gross: the sum of the floor areas of the spaces within the building including basements, mezzanine and intermediate-floored tiers, and penthouses with headroom height of 2.5 m (7.5 ft) or greater. It is measured from the exterior faces of exterior walls or from the centerline of walls separating buildings, but excluding covered walkways, open roofed-over areas, porches and similar spaces, pipe trenches, exterior terraces or steps, chimneys, roof overhangs, and similar features.

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

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

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

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

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

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

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

Generally accepted engineer standard: a specification, rule, guide, or procedure in the filed of engineer, or related thereto, recognized and accepted as authoritative.

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

Guest room: any room or rooms used or intended to be used by a guest for sleeping purposes.

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

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

Historic: a building or space that has been specifically designed as historically significant.

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

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

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

Integrated part-load value (IPLV): a single number figure of merit based on part-load

EER, COP, or KW/ton expressing part-load efficiency for air-conditioning and heat pump equipment on the basis of weighted operation at various load capacities for the equipment.

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

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

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

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

Lighted floor area, gross: the gross floor area of lighted spaces.

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

Lighting, emergency: lighting that provides illumination only when there is a general lighting failure.

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

Lighting Efficacy (LE): the quotient of the total lumens emitted from a lamp or lamp/ballast combination divided by the watts of input power, expressed in lumens per watt.

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

Lighting power allowance:

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

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

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

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

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

Manual (non-automatic): requiring personal intervention for control. Non-automatic does not necessarily imply a manual controller, only that personal intervention is necessary.

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

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

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

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

Multifamily high-rise: multifamily structures of four or more stories above grade

Multifamily low-rise: multifamily structures of three or less stories above grade

Multiplication factor (M): indicates the relative reduction in annual solar cooling load from overhangs and/or side fins with given projection factors, relative to the respective horizontal and vertical fenestration dimensions.

Non-automatic: see *manual*.

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

Opaque: all areas in the building envelope, except fenestration and building service openings such as vents and grilles.

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

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

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

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

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

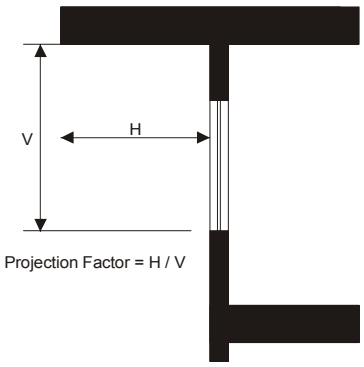
Permanently installed: equipment that is fixed in place and is not portable or movable.

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

Pool: any structure, basin, or tank containing an artificial body of water for swimming, diving, or recreational bathing. The terms include, but no limited to, swimming pool, whirlpool, spa, hot tub.

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

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



Projection factor, sidefin: the ratio of the horizontal depth of the external shading projection divided by the distance from the window jamb to the farthest point of the external shading projection, in consistent units.

R-value (thermal resistance): the reciprocal of the time rate of heat flow through a unit area induced by a unit temperature difference between two defined surfaces of material or construction under steady-state conditions. Units of R are m^2-°C/W (h-ft^2-°F/Btu). For the prescriptive building envelope option, R-value is for the insulation alone and does not include building materials or air films.

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

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

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

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

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

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

Roof: the upper portion of the building envelope, including opaque areas and fenestration, that is horizontal or tilted at an angle of less than 60° from horizontal

Roof area, gross: the area of the roof measured from the exterior faces of walls or from the centerline of party walls

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

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

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

Shading Coefficient (SC): the ratio of solar heat gain at normal incidence through glazing to that occurring through 3 mm (1/8 in) thick clear, double-strength glass. Shading coefficient, as used herein, does not include interior, exterior, or integral shading devices

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

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

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

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

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

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

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

(a) Conditioned space: a cooled space, heated space, or directly conditioned space.

(b) Semi-heated space: an enclosed space within a building that is heated by a heating system whose output capacity is greater or equal to 10.7 W/m^2 (3.4 $Btu/h\text{-}ft^{2)}$ of floor area but is not a conditioned space.

(c) An enclosed space within a building that is not conditioned space or a semi-heated space. Crawlspaces, attics, and parking garages with natural or mechanical ventilation are not considered enclosed spaces.

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

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

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

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

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

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

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

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

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

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

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

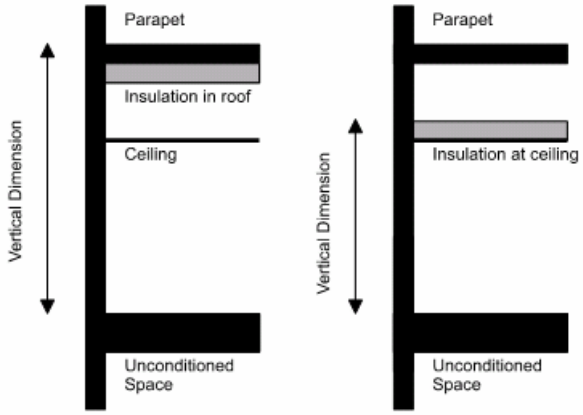
Ventilation: the process of supplying or removing air by natural or mechanical means to or from any space. Such air is not required to have been conditioned.

Wall: that portion of the building envelope, including opaque area and fenestration, that is vertical or tilted at an angle of 60° from horizontal or greater. This includes above- and below-grade walls, between floor spandrels, peripheral edges of floors, and foundation walls.

(a) wall, above grade: a wall that is not below grade

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

Wall area, gross: the overall area off a wall including openings such as windows and doors, measured horizontally from outside surface to outside service and measured vertically from the top of the floor to the top of the roof. If roof insulation is installed at the ceiling level rather than the roof, then the vertical measurement is made to the top of the ceiling. (Note that § 4.3.1 does not allow roof insulation to be located on a suspended ceiling with removable ceiling panels.) The gross wall area includes the area between the ceiling and the floor for multi-story buildings.



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

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

9.3 Abbreviations and Acronyms

AFUE	Annual fuel utilization efficiency
ANSI	American National Standards Institute
ARI	Air-Conditioning and Refrigeration Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASTM	American Society for Testing and Materials
BIS	Bureau of Indian Standards
Btu	British thermal unit
Btu/h	British thermal units per hour
Btu/ft^2-°F	British thermal units per square foot per degree Fahrenheit
Btu/h-ft^2	British thermal units per hour per square foot
Btu/h-ft-°F	British thermal units per lineal foot per degree Fahrenheit
Btu/h-ft^2-°F	British thermal units per hour per square foot per degree Fahrenheit
C	Celsius
cfm	cubic feet per minute
cm	centimeter
COP	coefficient of performance
DOE	U.S. Department of Energy
EER	energy efficiency ratio
EF	energy factor
F	Fahrenheit

ft	foot
h	hour
HC	heat capacity
h-ft^2-°F/Btu	hour per square foot per degree Fahrenheit per British thermal unit
h-m^2-°C/W	hour per square meter per degree Celsius per Watt
hp	horsepower
HSPF	heating seasonal performance factor
HVAC	heating, ventilation, and air conditioning
I-P	inch-pound
in.	inch
IPLV	integrated part-load value
kVA	kilovolt-ampere
kW	kilowatt
kWh	kilowatt-hour
LE	lighting efficacy
lin	linear
lin ft	linear foot
lin m	linear meter
lm	lumen
LPD	lighting power density
m	meter
mm	millimeter
NAECA	National Appliance Energy Conservation Act
PF	projection factor
PTAC	packaged terminal air conditioner
R	R-value (thermal resistance)
SC	shading coefficient
SHGC	solar heat gain coefficient
SL	standby loss
VAV	variable air volume
VLT	visible light transmission
W	watt
W/ft^2	watts per square feet
W/m^2	watts per square meter
W/m^2-°C	watts per square meter per degree Celsius
W/m^2	watts per hour per square meter
W/m-°C	watts per lineal meter per degree Celsius
W/m^2-°C	watts per hour per square meter per degree Celsius
Wh	watthour

10. Appendix B – Whole Building Performance Method

10.1 General

10.1.1 Scope

The whole building performance method is an alternative to the prescriptive requirements contained in § 1 through § 1 of this standard. It applies for all building types covered by the standard.

10.1.2 Compliance

A building complies with the whole building performance method when the estimated annual energy use of the proposed design is less than the standard design, even though it may not comply with the specific requirements of the prescriptive requirements in § 1 through § 1. The mandatory requirements of § 1 through § 1 (§ 4.2, § 5.2, § 6.2, § 7.2 and § 8.2) shall be satisfied with the whole building performance method.

10.1.3 Annual Energy Use

Annual energy use for the purposes of the whole building performance method shall be calculated in kilowatt-hours (kWh) of electricity use per year. Energy sources other than electricity which are used is used in the building shall be converted to kWh of electric energy at the rate of 0.75 kWh per megaJoule.

10.1.4 Trade-offs Limited to Building Permit

The whole building performance method may be used for building permit applications that include less than the whole building; however, any design parameters that are not part of the building permit application shall be identical for both the proposed design and the standard design. Future improvements to the building shall comply with both the mandatory and prescriptive requirements.

10.1.5 Documentation Requirements

Compliance shall be documented and submitted to the authority having jurisdiction. The information submitted shall include the following:

(a) The annual energy use for the proposed design and the standard design.

(b) A list of the energy-related building features in the proposed design that are different from the standard design.

(c) The input and output report(s) from the simulation program including a breakdown of energy usage by at least the following components: lights, internal equipment loads, service water heating equipment, space heating equipment, space cooling and heat rejection equipment, fans, and other HVAC equipment (such as pumps). The output reports shall also show the amount of time any loads are not met by the HVAC system for both the proposed design and standard design.

(d) An explanation of any error messages noted in the simulation program output.

10.2 Simulation General Requirements

10.2.1 Energy Simulation Program

The simulation program shall be a computer-based program for the analysis of energy consumption in buildings and be approved by the authority having jurisdiction. The simulation program and shall model the following:

(a) Energy flows on an hourly basis for all 8,760 hours in the year,

(b) Hourly variations in occupancy, lighting power, miscellaneous equipment power, thermostat setpoints, and HVAC system operation, defined separately for each day of the week and holidays,

(c) Thermal mass effects,

(d) Ten or more thermal zones,

(e) Part-load and temperature dependent performance of heating and cooling equipment,

(f) Air-side and water-side economizers with integrated control, and

(g) All of the standard design characteristics specified in this chapter.

10.2.2 Climatic Data

The simulation program shall use hourly values of climatic data, such as temperature and humidity from representative climatic data, for the city in which the proposed design is to be located. For cities or urban regions with several climatic data entries, and for locations where weather data are not available, the designer shall select available weather data that best represent the climate at the construction site.

10.2.3 Compliance Calculations

The proposed design and standard design shall be calculated using the following:

(a) Same simulation program,

(b) Same weather data, and

(c) Same building operation assumptions (thermostat setpoints, schedules, internal gains, occupant loads, etc.).

10.3 Calculating the Energy Consumption of the Proposed Design and the Standard Design

10.3.1 The simulation model for calculating the proposed design and the standard design shall be developed in accordance with the requirements in Table 10.3.1.

10.3.2 HVAC Systems

The HVAC system type and related performance parameters for the standard design shall be determined from Table 10.3.2 and the following rules:

10.3.3 Other Components

Components and parameters not listed in Table 10.3.2 or otherwise specifically addressed in this subsection shall be identical to those in the proposed design.

Exception to § 10.3.2(a): Where there are specific requirements in § 0, the component efficiency in the standard design shall be adjusted to the lowest efficiency level allowed by the requirement for that component type.

(a) All HVAC and service water heating equipment in the standard design shall be modeled at the minimum efficiency levels, both part load and full load, in accordance with § 0.

(b) Where efficiency ratings, such as EER and COP, include fan energy, the descriptor shall be broken down into its components so that supply fan energy can be modeled separately.

(c) Minimum outdoor air ventilation rates shall be the same for both the standard design and the proposed design.

(d) The equipment capacities for the standard design shall be sized proportionally to the capacities in the proposed design based on sizing runs; i.e., the ratio between the capacities used in the annual simulations and the capacities determined by the sizing runs shall be the same for both the proposed design and standard design. Unmet load hours for the proposed design shall not differ from unmet load hours for the standard design by more than 50 hours.

Table 10.3.1 Modeling Requirements for Calculating Proposed and Standard Design

Case	Proposed Building	Standard Design
1. Design Model	(a) The simulation model of the proposed design shall be consistent with the design documents, including proper accounting of fenestration and opaque envelope types and area; interior lighting power and controls; HVAC system types, sizes, and controls; and service water heating systems and controls. (b) When the whole building performance method is applied to buildings in which energy-related features have not yet been designed (e.g., a lighting system), those yet-to-be-designed features shall be described in the proposed design so that they minimally comply with applicable mandatory and prescriptive requirements from § 1 through § 1.	The standard design shall be developed by modifying the proposed design as described in this table. Except as specifically instructed in this table, all building systems and equipment shall be modeled identically in the standard design and proposed design.
2. Space Use Classification	The building type or space type classifications shall be chosen in accordance with § 7.3.1 or § 7.3.2. More than one building type category may be used in a building if it is a mixed-use facility.	Same as proposed design.
3. Schedules	The schedules shall be typical of the proposed building type as determined by the designer and approved by the authority having jurisdiction.	Same as proposed design.
4. Building Envelope	All components of the building envelope in the proposed design shall be modeled as shown on architectural drawings or as installed for existing building envelopes. Exceptions: The following building elements are permitted to differ from architectural drawings. (a) Any envelope assembly that covers less than 5% of the total area of that assembly type (e.g., exterior walls) need not be separately described. If not separately described, the area of an envelope assembly must be added to the area of the adjacent assembly of that same type. (b) Exterior surfaces whose azimuth orientation and tilt differ by no more than 45 degrees and are otherwise the same may be described as either a single surface or by using multipliers. (c) For exterior roofs other than roofs with ventilated attics, the reflectance and emittance of the roof surface shall be modeled. The reflectance and emittance shall be tested in accordance with § 4.3.1.1. (d) Manually operated fenestration shading devices such as blinds or shades shall not be modeled. Permanent shading devices such as fins, overhangs, and lightshelves shall be modeled.	The standard design shall have identical conditioned floor area and identical exterior dimensions and orientations as the proposed design, except as noted in (a), (b), (c), and (d) below. (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 such as roof, floors, doors, and walls shall be modeled as having the same heat capacity as the proposed design but with the minimum U-factor required in § 4.3.1 and § 4.3.2. (c) Fenestration— Fenestration areas shall equal that in the proposed design or 40% of gross above grade wall area, whichever is smaller, and shall be distributed uniformly in horizontal bands across the four orientations. No shading projections are to be modeled; fenestration shall be assumed to be flush with the exterior wall or roof. Manually operated fenestration shading devices such as blinds or shades shall not be modeled. Fenestration U-factor shall be the minimum required for the climate, and the solar heat gain coefficient shall be the maximum allowed for the climate and orientation. (d) Roof albedo. All roof surfaces shall be modeled with a reflectivity of 0.30
5. Lighting	Lighting power in the proposed design shall be determined as follows: (a) Where a complete lighting system	Lighting power in the standard design shall be determined using the same categorization procedure (building area or space function) and categories as the proposed design with

Case	Proposed Building	Standard Design
	exists, the actual lighting power shall be used in the model. (b) Where a lighting system has been designed, lighting power shall be determined in accordance with either § 7.3.1 or § 7.3.2. (c) Where no lighting exists or is specified, lighting power shall be determined in accordance with the § 7.3.1 for the appropriate building type. (d) Lighting system power shall include all lighting system components shown or provided for on plans (including lamps, ballasts, task fixtures, and furniture-mounted fixtures).	lighting power set equal to the maximum allowed for the corresponding method and category in either § 7.3.1 or § 7.3.2. Power for fixtures not included in the lighting power density calculation shall be modeled identically in the proposed design and standard design. Lighting controls shall be the minimum required.
6. HVAC Systems	The HVAC system type and all related performance parameters, such as equipment capacities and efficiencies, in the proposed design shall be determined as follows: (a) Where a complete HVAC system exists, the model shall reflect the actual system type using actual component capacities and efficiencies. (b) Where an HVAC system has been designed, the HVAC model shall be consistent with design documents. Mechanical equipment efficiencies shall be adjusted from actual design conditions to the standard rating conditions specified in § 0, if required by the simulation model. (c) Where no heating system exists or no heating system has been specified, the heating system shall be modeled as electric resistance. The system characteristics shall be identical to the system modeled in the standard design. (d) Where no cooling system exists or no cooling system has been specified, the cooling system shall be modeled as an air-cooled single-zone system, one unit per thermal block. The system characteristics shall be identical to the system modeled in the standard design.	The HVAC system type and related performance parameters for the standard design shall be determined from Table § 10.3.2. Equipment performance shall meet the requirements of § 0.
7. Service Hot Water	The service hot water system type and all related performance parameters, such as equipment capacities and efficiencies, in the proposed design shall be determined as follows: (a) Where a complete service hot water system exists, the model shall reflect the actual system type using actual component capacities and efficiencies. (b) Where a service hot water system has been designed, the service hot water model shall be consistent with design documents. (c) Where no service hot water system exists or is specified, no service hot water heating shall be modeled.	The water heating system shall be of the same type of the proposed design. For residential facilities, hotels and hospitals the standard design shall have a solar system capable of meeting 20% of the design load. Systems shall meet the efficiency requirements of § 6.2.2, the pipe insulation requirements of § 6.2.4 and incorporate heat traps in accordance with § 6.2.5.
8. Miscellaneous Loads	Receptacle, motor, and process loads shall be modeled and estimated based on the building type or space type category. These loads shall be included in simulations of the building and shall be	Receptacle, motor and process loads shall be modeled the same as the proposed design. The water heating system shall be of the same type of the proposed design.

Case	Proposed Building	Standard Design
	included when calculating the standard design and proposed design. All end-use load components within and associated with the building shall be modeled, unless specifically excluded by Sections 13 and 14 of this table (see below), but not limited to, exhaust fans, parking garage ventilation fans, exterior building lighting, swimming pool heaters and pumps, elevators and escalators, refrigeration equipment, and cooking equipment.	
9. Modeling Limitations to the Simulation Program	If the simulation program cannot model a component or system included in the proposed design, one of the following methods shall be used with the approval of the authority having jurisdiction: (a) Ignore the component if the energy impact on the trade-offs being considered is not significant. (b) Model the component substituting a thermodynamically similar component model. (c) Model the HVAC system components or systems using the standard design's HVAC system in accordance with Section 6 of this table. Whichever method is selected, the component shall be modeled identically for both the proposed design and standard design models.	Same as proposed design.

Table 10.3.2-2 HVAC Systems Map

		Nonresidential		
	Residential More than 3 stories	Less than 3 floors or less than 7,500 m²	4 or 5 floors or less than 7,500 m² or 5 floors or less and 7,500–15,000 m²	More than 5 floors or more than 15,000 mt²
Code	PTAC	PSZ	RHFS	RHFS
System type	Packaged terminal air conditioner	Packaged rooftop air conditioner	Central cooling plant with constant volume AHU for each zone	Central cooling plant with constant volume AHU for each zone
Fan control	Constant Volume	Constant volume	Constant volume air handler for each zone	Constant volume air handler for each zone
Cooling type	Direct expansion	Direct expansion	Air cooled reciprocating chiller	Water cooled centrifugal chiller
Heating type	Electric resistance	Electric resistance	Electric resistance	Electric resistance

11. Appendix C - IP Table Conversions

Table 4.3.1 Roof U-factor Requirements (U-factor in Btu/h-ft^2-^{o}F)

Climate Zone	24-Hour	Daytime
Composite	0.046	0.072
Hot and Dry	0.046	0.072
Warm and Humid	0.046	0.072
Moderate	0.072	0.072
Cold	0.046	0.072

Table 4.3.2 Wall U-factor Requirements (U-factor in Btu/h-ft^2-^{o}F)

Climate Zone	24-Hour	Daytime
Composite	0.062	0.062
Hot and Dry	0.065	0.062
Warm and Humid	0.062	0.062
Moderate	0.076	0.070
Cold	0.065	0.062

Table 4.3.3 Fenestration U-factor Requirements (U-factor in Btu/h-ft^2-^{o}F)

Climate	U-factor	SHGC
Composite	0.56	0.25
Hot and Dry	0.56	0.25
Warm and Humid	0.56	0.25
Moderate	1.22	0.40
Cold	0.72	0.51

Table 5.2.2-3 Heat Pumps Heating Mode

Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Performance Required[a]	Test Procedure[b]
Air Cooled (Heating Mode)	<65,000 Btu/h (Cooling Capacity)	Split System	6.8 HSPF (before 1/23/2006) 7.4 HSPF (as of 1/23/2006)	ARI 210/240
		Single Package	6.6 HSPF (before 1/23/2006) 7.4 HSPF (as of 1/23/2006)	
Air Cooled (Heating Mode)	≥65,000 Btu/h and <135,000 Btu/h (Cooling Capacity)	47°F db/43°F wb Outdoor air	3.2 COP	ARI 340/360
		17°F db/15°F wb Outdoor Air	2.2 COP	
	≥135,000 Btu/h (Cooling Capacity)	47°F db/43°F wb Outdoor air	3.1 COP	
		17°F db/15°F wb Outdoor Air	2.0 COP	

[a] IPLVs and Part load rating conditions are only applicable to equipment with capacity modulation.

[b] Section 12 of ASHRAE 90.1-2004 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

Table 5.2.2-4 Furnaces

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

[a] E_t = thermal efficiency. See test procedure for detailed discussion.

[b] Section 12 of ASHRAE 90.1-2004 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

[c] E_c = combustion efficiency. Units must also include an interrupted or intermittent ignition device (IID), have jacket losses not exceeding 0.75% of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.

[d] Combination units not covered by NAECA (3-phase power or cooling capacity greater than or equal to 65,000 Btu/h may comply with either rating.

[e] Minimum and maximum ratings as provided for and allowed by the unit's controls.

[f] E_t = thermal efficiency. Units must also include and interrupted or intermittent ignition device (IDD), have jacket losses not exceeding 0.75% of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternativ3 to a flue damper for those furnaces where combustion air is drawn form the conditioned space.

[g] E_c = combustion efficiency (100% less flue losses). See test procedure for detailed discussion.

Table 5.2.2-5 Boilers

Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Performance Required[b]	Test Procedure[c]
Boilers, Gas-Fired	<300,000 Btu/h	Hot Water	80% AFUE	DOE 10 CFR Part 430
		Steam	75% AFUE	
	≥300,000 Btu/h and ≤2,500,00 Btu/h	Maximum Capacity[d]	75% E_t[b]	H.I. Htg Boiler Std.
	>2,500,000 Btu/h[a]	Hot Water	80% E_c	
	>2,500,000 Btu/h[a]	Steam	80% E_c	
Boilers, Oil-Fired	<300,000 Btu/h		80% AFUE	DOE 10 CFR Part 430
	≥300,000 Btu/h and ≤2,500,00 Btu/h	Maximum Capacity[d]	78% E_t[b]	H.I. Htg Boiler Std.
	>2,500,000 Btu/h[a]	Hot Water	83% E_c	
	>2,500,000 Btu/h[a]	Steam	83% E_c	
Oil-Fired (Residual)	≥300,000 Btu/h and ≤2,500,00 Btu/h	Maximum Capacity[d]	78% E_t[b]	H.I. Htg Boiler Std.
	>2,500,000 Btu/h[a]	Hot Water	83% E_c	
	>2,500,000 Btu/h[a]	Steam	83% E_c	

[a] These requirements apply to boilers with rated input of 8,000,000 Btu/h or less that are not packaged boilers, and to all packaged boilers. Minimum efficiency requirements for boilers cover all capacities of packaged boilers.

[b] E_t = thermal efficiency. See reference document for detailed information.

[c] Section 12 of ASHRAE 90.1-2004 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

[d] Minimum and maximum ratings as provided for and allowed by the unit's controls.

Table 6.2.2 Minimum Efficiencies for Service Water Heating Equipment

Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Performance Required[a]	Test Procedure[b]
Electric Water Heaters	≤12 kW	Resistance ≥ 20 gal	0.93-0.00132V EF	DOE 10 CFR Part 430
	>12 kW	Resistance ≥20 gal	20 + 35 √V SL, Btu/h	ANSI Z21.10.3
	≤24 Amps and ≤250 Volts	Heat Pump	0.93-0.00132V EF	DOE 10 CFR Part 430
Gas Storage Water Heaters	≤75,000 Btu/h	≥20 gal	0.62-0.0019V EF	DOE 10 CFR Part 430
	>75,000 Btu/h	<4000 (Btu/h)/gal	80% E_t (Q/800 + 110 √V) SL, Btu/h	ANSI Z21.10.3
Gas Instantaneous Water Heaters	>50,000 Btu/h and <200,000 Btu/h	≥4000 (Btu/h)/gal and <2 gal	0.62-0.0019V EF	DOE 10 CFR Part 430
	≥200,000 Btu/h[c]	≥4000 (Btu/h)/gal and <10 gal	80% E_t	ANSI Z21.10.3
	≥200,000 Btu/h	≥4000 (Btu/h)/gal and ≥10 gal	80% E_t (Q/800 + 110 √V) SL, Btu/h	
Oil Storage Water Heaters	≤105,000 Btu/h	≥20 gal	0.59-0.0019V EF	DOE 10 CFR Part 430

	>105,000 Btu/h	<4000 (Btu/h)/gal	78% E_t (Q/800 + 110 √V) SL, Btu/h	ANSI Z21.10.3
Oil Instantaneous Water Heaters	≤210,000 Btu/h	≥4000 (Btu/h)/gal and <2 gal	0.59-0.0019V EF	DOE 10 CFR Part 430
	>210,000 Btu/h	≥4000 (Btu/h)/gal and <10 gal	80% E_t	ANSI Z21.10.3
	>210,000 Btu/h	≥4000 (Btu/h)/gal and ≥10 gal	78% E_t (Q/800 + 110 √V) SL, Btu/h	
Hot Water Supply Boilers, Gas and Oil	≥300,000 Btu/h and <12,500,000 Btu/h	≥4000 (Btu/h)/gal and <10 gal	80% E_t	ANSI Z21.10.3
Hot Water Supply Boilers, Gas		≥4000 (Btu/h)/gal and ≥10 gal	80% E_t (Q/800 + 110 √V) SL, Btu/h	
Hot Water Supply Boilers, Oil		≥4000 (Btu/h)/gal and ≥10 gal	78% E_t (Q/800 + 110 √V) SL, Btu/h	
Pool Heaters Oil and Gas	All		78% E_t	ASHRAE 146
Heat Pump Pool Heaters	All		4.0 COP	ASHRAE 146
Unfired Storage Tanks	All		R-12.5	(none)

[a] Energy factor (EF) and thermal efficiency (E_t) are minimum requirements, while standby loss (SL) is maximum Btu/h based on a 70°F temperature difference between stored water and ambient requirements. In the EF equation, *V* is the rated volume in gallons. In the SL equation, V is the rated volume in gallons and *Q* is the nameplate input rate in Btu/h.

[b] Section 12 of ASHRAE 09.1-2004 contains a complete specification, including the year version, of the referenced test procedure.

[c] Instantaneous water heaters with input rates below 200,000 Btu/h must comply with these requirements if the water heater is designed to heat water to temperatures 180°F or higher.

Table 7.3.1 Interior Lighting Power - Building Area Method

Building Area Type	LPD (W/ft^2)	Building Area Type	LPD (W/ft^2)
Automotive Facility	0.9	Multifamily	0.7
Convention Center	1.2	Museum	1.1
Court House	1.2	Office	1.0
Dining: Bar Lounge/Leisure	1.3	Parking Garage	0.3
Dining: Cafeteria/Fast Food	1.4	Penitentiary	1.0
Dining: Family	1.6	Performing Arts Theater	1.6
Dormitory	1.0	Police/Fire Station	1.0
Exercise Center	1.0	Post Office	1.1
Gymnasium	1.1	Religious Building	1.3
Healthcare-Clinic	1.0	Retail	1.5
Hospital/Health Care	1.2	School/University	1.2
Hotel	1.0	Sports Arena	1.1
Library	1.3	Town Hall	1.1
Manufacturing Facility	1.3	Transportation	1.0
Motel	1.0	Warehouse	0.8
Motion Picture Theater	1.2	Workshop	1.4

Table 7.3.2 Interior Lighting Power – Space Function Method

Common Space Types	LPD (W/ft^2)	Building Specific Space Types	LPD (W/ft^2)
Office-enclosed	1.1	Fire Stations	
Office-open plan	1.1	Fire Station Engine Room	0.8
Conference/Meeting/Multipurpose	1.3	Sleeping Quarters	0.3
Classroom/Lecture/Training	1.4	Post Office – Seating Area	1.2
Lobby	1.3	Convention Center – Exhibit Space	1.3
For Hotel	1.1	Library	
For Performing Arts Theater	3.3	Card File & Cataloging	1.1
For Motion Picture Theater	1.1	Stacks	1.7
Audience/Seating Area	0.9	Reading Area	1.2
For Gymnasium	0.4	Hospital	
For Exercise Center	0.3	Emergency	2.7
For Convention Center	0.7	Recovery	0.8
For Religious Buildings	1.7	Nurse Station	1.0
For Sports Arena	0.4	Exam Treatment	1.5
For Performing Arts Theater	2.6	Pharmacy	1.2
For Motion Picture Theater	1.2	Patient Room	0.7
For Transportation	0.5	Operating Room	2.2
Atrium-first three floors	0.6	Nursery	0.6
Atrium-each additional floor	0.2	Medical Supply	1.4
Lounge/Recreation	1.2	Physical Therapy	0.9
For Hospital	0.8	Radiology	0.4
Dining Area	0.9	Laundry – Washing	0.6
For Hotel	1.3	Automotive – Service Repair	0.7
For Motel	1.2	Manufacturing	
For Bar Lounge/Leisure Dining	1.4	Low Bay (<8m ceiling)	1.2
For Family Dining	2.1	High Bay (>8m ceiling)	1.7
Food Preparation	1.2	Detailed Manufacturing	2.1
Laboratory	1.4	Equipment Room	1.2
Restrooms	0.9	Control Room	0.5
Dressing/Locker/Fitting Room	0.6	Hotel/Motel Guest Rooms	1.1
Corridor/Transition	0.5	Dormitory – Living Quarters	1.1
For Hospital	1.0	Museum	
For Manufacturing Facility	0.5	General Exhibition	1.0
Stairs-active	0.6	Restoration	1.7
Active Storage	0.8	Bank Office – Banking Activity Area	1.5
For Hospital	0.9	Religions Buildings	
Inactive Storage	0.3	Worship-pulpit, choir	2.4
For Museum	0.8	Fellowship Hall	0.9
Electrical/Mechanical	1.5	Retail	
Workshop	1.9	Sales Area	1.7
		Mall Concourse	1.7

Table 7.3.2 Interior Lighting Power – Space Function Method

Common Space Types	LPD (W/ft^2)	Building Specific Space Types	LPD (W/ft^2)
		Sports Arena	
		Ring Sports Area	2.7
		Court Sports Area	2.3
		Indoor Field Area	1.4
		Warehouse	
		Fine Material Storage	1.4
		Medium/Bulky Material Storage	0.9
		Parking Garage – Garage Area	0.2
		Transportation	
		Airport – Concourse	0.6
		Air/Train/Bus – Baggage Area	1.0
		Terminal – Ticket Counter	1.5

12. Appendix D – Default Values for Typical Constructions

12.1 Procedure for Determining Fenestration Product U-Factor and Solar Heat Gain Coefficient

§ 4.2.1.1 and § 4.2.1.2 require that U-factors and solar heat gain coefficients (SHGC) be determined for the overall fenestration product (including the sash and frame) in accordance with ISO 15099. The building envelope trade-off option in § 4.4 requires the use of visible light transmittance (VLT).

In several cases, ISO 15099 suggests that individual national standards will need to be more specific and in other cases the ISO document gives users the choice of two options. This section clarifies these specific issues as they are to be implemented for this code:

(a) § 4.1: For calculating the overall U-factor, ISO 15099 offers a choice between the linear thermal transmittance (4.1.2) and the area weighted method (4.1.3). The area weighted method (4.1.3) shall be used.

(b) § 4.2.2: Frame and divider SHGC's shall be calculated in accordance with § 4.2.2. The alternate approach in § 8.6 shall not be used.

(c) § 6.4 refers the issue of material properties to national standards. Material conductivities and emissivities shall be determined in accordance with Indian standards.

(d) § 7 on shading systems is currently excluded.

(e) § 8.2 addresses environmental conditions. The following are defined for India:

For U-factor calculations:

T_{in} = 21 °C

T_{out} = -18 °C

V = 5.5 m/s

$T_{rm,out} = T_{out}$

$T_{rm,in} = T_{in}$

I_s=0 W/m^2

For SHGC calculations:

T_{in} = 24 °C

T_{out} = 32 °C

V = 2.75 m/s

$T_{rm,out} = T_{out}$

$T_{rm,in} = T_{in}$

I_s=783 W/m^2

(f) § 8.3 addresses convective film coefficients on the interior and exterior of the window product. In § 8.3.1, simulations shall use the heat transfer coefficient based on the center of glass temperature and the entire window height; this film coefficient shall be used on all indoor surfaces, including frame sections. In § 8.3.2, the formula from this section shall be applied to all outdoor exposed surfaces.

(g) § 8.4.2 presents two possible approaches for incorporating the impacts of self-viewing surfaces on interior radiative heat transfer calculations. Products shall use

the method in § 8.4.2.1 (Two-Dimensional Element To Element View Factor Based Radiation Heat Transfer Calculation). The alternate approach in § 8.4.3 shall not be used.

12.2 Default U-Factors and Solar Heat Gain Coefficients for Unrated Fenestration Products

All fenestration with U-factors, SHGC, or visible light transmittance determined, certified, and labeled in accordance ISO 15099 shall be assigned those values.

12.2.1 Unrated Vertical Fenestration. Unlabeled vertical fenestration, both operable and fixed, shall be assigned the U-factors, SHGCs, and visible light transmittances in Table 12.2.1.

Table 12.2.1Defaults for Unrated Vertical Fenestration (Overall Assembly including the Sash and Frame)

		Clear Glass			Tinted Glass		
Frame Type	**Glazing Type**	**U-Factor (W/m^2-^oC)**	**SHGC**	**VLT**	**U-Factor (W/m^2-^oC)**	**SHGC**	**VLT**
All frame types	Single Glazing	7.1	0.82	0.76	7.1	0.70	0.58
	Double Glazing	3.4	0.56	0.56	n/a	n/a	n/a
Wood, vinyl, or fiberglass frame	Double Glazing	3.4	0.59	0.64	3.4	0.42	0.39
	Triple Glazing	2.6	0.52	0.57	2.6	0.34	0.21
Metal and other frame type	Double Glazing	5.1	0.68	0.66	5.1	0.50	0.40
	Triple Glazing	4.0	0.60	0.59	4.0	0.42	0.22

Exception to § 12.2.1: Until 31 December 2006, the following expanded default table is allowed to be used. However, if the Bureau of Indian Standards has not adopted a fenestration U-factor and SHGC rating and certification procedure by 30 June 2006, then this expanded default table is allowed to be used for six months after the date that the Bureau of Indian Standards adopts a fenestration U-factor and SHGC rating and certification procedure.

12.2.2 Unrated Sloped Glazing and Skylights

Unrated sloped glazing and skylights, both operable and fixed, shall be assigned the SHGCs and visible light transmittances in Table 12.2.1. To determine the default U-factor for unrated sloped glazing and skylights without a curb, multiply the values in Table 12.2.1 by 1.2. To determine the default U-factor for unrated skylights on a curb, multiply the values in Table 12.2.1 by 1.6.

12.3 Typical Roof Constructions

For calculating the overall U-factor of a typical roof construction, the U-factors from the typical wall construction type and effective U-factor for insulation shall be combined according to the following equation:

$$U_{TotalRoof} = \frac{1}{\frac{1}{U_{TypicalRoof}} + \frac{1}{U_{TyipcalInsulation}}}$$

where

$U_{TotalRoof}$ Total U-factor of the roof with insulation

$U_{Typical\ Roof}$ U-factor of the roof from Table 12.3-1

$U_{Typical\ Insulation}$ U-factor of the effective insulation from Table 12.3-2.

Table 12.3-1 Defaults for Typical Roof Construction Types

Type	U-factor (W/m²-°K)	U-factor (Btu/h-ft²-°F)
RCC slab with mud phuska and clay tiles	2.797	0.493
RCC slab with foam concrete or perlite	0.069	0.012
Inverted clay/pots with mud phuska	2.244	0.396

Table 12.3-2 Defaults for Effective U-factor for Exterior Insulation Layers

Thickness	R-value	U-factor (W/m²-°K)	U-factor (Btu/h-ft²-°F)
15 mm (0.5”)	0.70 (4)	1.420	0.250
20 mm (0.75”)	1.06 (6)	0.946	0.167
25 mm (1.0”)	1.41 (8)	0.710	0.125
40 mm (1.5”)	2.11 (12)	0.568	0.100
50 mm (2.0”)	2.82 (16)	0.406	0.071
65 mm (2.5”)	3.52 (20)	0.284	0.050
75 mm (3.0”)	3.70 (21)	0.270	0.048

12.4 Typical Wall Constructions

For calculating the overall U-factor of a typical wall construction, the U-factors from the typical wall construction type and effective U-factor for insulation shall be combined according to the following equation:

$$U_{TotalWall} = \frac{1}{\frac{1}{U_{TypicalWall}} + \frac{1}{U_{TyipcalInsulation}}}$$

where

$U_{TotalWall}$ Total U-factor of the wall with insulation

$U_{Typical\ Wall}$ U-factor of the wall from Table 12.4-1

$U_{Typical\ Insulation}$ U-factor of the effective insulation from Table 12.4-2 or Table 12.4-3

Table 12.4-1 Defaults for Typical Wall Construction Types

Type	Description	U-factor (W/m²-°K)	U-factor (Btu/h-ft²-°F)
Mass single wall	Single wall with no insulation, plaster on both sides	1.99	0.351
Mass double wall	Double brick wall with air gap	1.23	0.216
Curtain wall	Curtain wall	2.11	0.371

Table 12.4-2 Defaults for Effective U-factor for Exterior Insulation Layers

Thickness	R-value	U-factor (W/m²-°K)	U-factor (Btu/h-ft²-°F)
15 mm (0.5”)	0.70 (4)	1.262	0.222
20 mm (0.75”)	1.06 (6)	0.874	0.154
25 mm (1.0”)	1.41 (8)	0.668	0.118
40 mm (1.5”)	2.11 (12)	0.454	0.080
50 mm (2.0”)	2.82 (16)	0.344	0.061
65 mm (2.5”)	3.52 (20)	0.277	0.049
75 mm (3.0”)	3.70 (21)	0.264	0.047

Table 12.4-3 Defaults for Effective U-factor for Interior Insulation Layers

Thickness	R-value	U-factor (W/m²-°K)	U-factor (Btu/h-ft²-°F)
15 mm (0.5”)	0.70 (4)	4.732	0.833
20 mm (0.75”)	1.06 (6)	3.549	0.625
25 mm (1.0”)	1.41 (8)	2.988	0.526
40 mm (1.5”)	2.11 (12)	2.103	0.370
50 mm (2.0”)	2.82 (16)	1.670	0.294
65 mm (2.5”)	3.52 (20)	1.385	0.244
75 mm (3.0”)	3.70 (21)	1.183	0.208

13. Appendix E – Building Envelope Tradeoff Method

13.1.1 Equation 13.1

The envelope performance factor shall be calculated using the following equations.

$$EPF_{Total} = EPF_{Roof} + EPF_{Wall} + EPF_{Fenest}$$

where

$$EPF_{Roof} = c_{Roof} \sum_{s=1}^{n} U_s A_s$$

$$EPF_{Wall} = c_{Wall,Mass} \sum_{s=1}^{n} U_s A_s + c_{Wall,Other} \sum_{s=1}^{n} U_s A_s$$

$$EPF_{Fenest} = c_{1Fenest,North} \sum_{w=1}^{n} SHGC_w M_w A_w + c_{2Fenest,North} \sum_{w=1}^{n} U_w A_w +$$
$$c_{1Fenest,NonNorth} \sum_{w=1}^{n} SHGC_w M_w A_w + c_{2Fenest,NonNorth} \sum_{w=1}^{n} U_w A_w +$$
$$c_{1Fenest,Skylight} \sum_{s=1}^{n} SHGC_s A_s + c_{2Fenest,Skylight} \sum_{s=1}^{n} U_s A_s$$

where

EPF_{Roof}	Envelope performance factor for roofs. Other subscripts include walls and fenestration.
A_s, A_w	The area of a specific envelope component referenced by the subscript "s" or for windows the subscript "w".
$SHGC_w$	The solar heat gain coefficient for windows (w). $SHGC_s$ refers to skylights.
M_w	A multiplier for the window SHGC that depends on the projection factor of an overhang or sidefin.
U_s	The U-factor for the envelope component referenced by the subscript "s".
c_{Roof}	A coefficient for the "Roof" class of construction. Values of "c" are taken from Table 13-1 through Table 13-5 for each class of construction.

Table 13-1 – Envelope Performance Factor Coefficients – Composite Climate

	Daytime Occupancy		24-Hour Occupancy	
	U-factor	SHGC	U-factor	SHGC
Mass Walls	6.01	-	13.85	-
Curtain Walls, Other	15.72	-	20.48	-
Roofs	11.93	-	24.67	-
North Windows	-1.75	40.65	-4.56	58.15
Non-North Windows	-1.25	54.51	0.68	86.57
Skylights	-96.35	311.71	-294.66	918.77

Table 13-2 – Envelope Performance Factor Coefficients – Hot Dry Climate

	Daytime Occupancy		24-Hour Occupancy	
	U-factor	SHGC	U-factor	SHGC
Mass Walls	5.48	-	15.01	-
Curtain Walls, Other	6.38	-	22.06	-
Roofs	11.14	-	25.98	-
North Windows	-2.40	36.57	-1.49	56.09
Non-North Windows	-1.86	46.79	1.187	81.79
Skylights	-96.27	309.33	-295.81	923.01

Table 13-3 – Envelope Performance Factor Coefficients – Hot Humid Climate

	Daytime Occupancy		24-Hour Occupancy	
	U-factor	SHGC	U-factor	SHGC
Mass Walls	6.42	-	9.60	-
Curtain Walls, Other	14.77	-	19.71	-
Roofs	9.86	-	14.11	-
North Windows	-1.58	34.95	-7.29	64.19
Non-North Windows	-1.00	43.09	-6.48	76.83
Skylights	-96.11	305.45	-295.45	893.55

Table 13-4 – Envelope Performance Factor Coefficients – Moderate Climate

	Daytime Occupancy		24-Hour Occupancy	
	U-factor	SHGC	U-factor	SHGC
Mass Walls	2.017	-	3.11	-
Curtain Walls, Other	2.72	-	4.11	-
Roofs	5.46	-	5.86	-
North Windows	-3.10	29.66	-11.95	62.14
Non-North Windows	-2.98	34.86	-11.62	68.45
Skylights	-96.21	298.82	-294.12	876.70

Table 13-5 – Envelope Performance Factor Coefficients – Cold Climate

	Daytime Occupancy		24-Hour Occupancy	
	U-factor	SHGC	U-factor	SHGC
Mass Walls	5.19	-	5.19	-
Curtain Walls, Other	6.76	-	6.76	-
Roofs	5.69	-	5.67	-
North Windows	1.55	9.13	1.55	9.13
Non-North Windows	-1.13	16.32	-1.13	16.32
Skylights	-93.44	283.18	-93.44	283.18

13.1.2 Overhang and Side Fin Coefficients

The "M" multiplication factor can also be calculated using Equation 4.3.3. If the equation is used, a separate calculation shall be made for each orientation and unique shading condition.

Equation 13.1.2: $M = a \cdot PF^2 + b \cdot PF + 1$

Table 4.3.3-3 - Overhang and Side Fin Coefficients

Device	Coefficient	North	South	East/West
Overhangs	A	0.16	0.21	0.10
	B	-0.61	-0.83	-0.58
Side Fins	A	0.23	0.12	0.14
	B	-0.74	-0.59	-0.52

13.1.3 Budget Building Definition

The following rules shall be used to define the budget building.

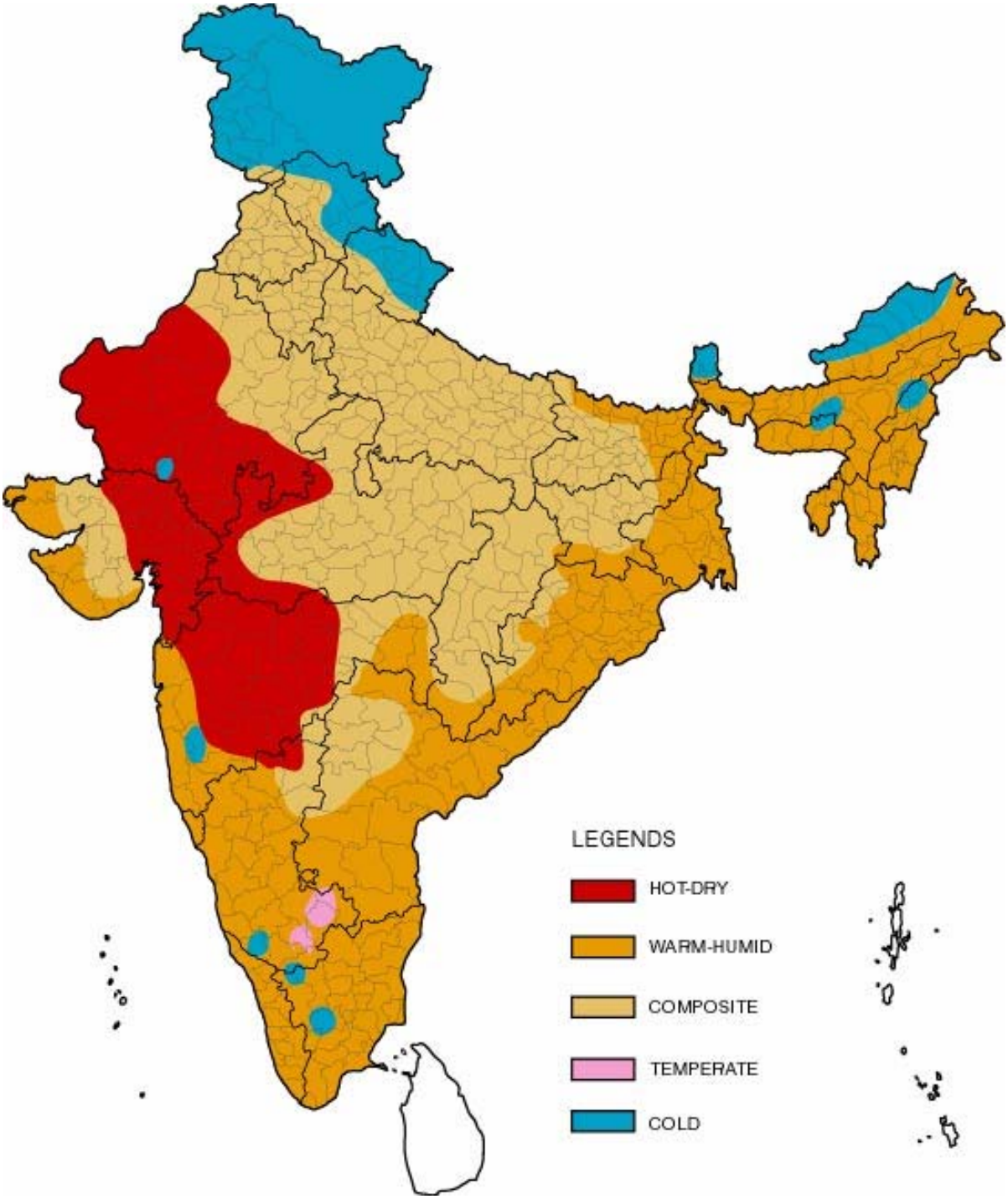
(a) The budget building shall have the same building floor area, gross wall area and gross roof area as the proposed design. If the building has both 24-hour and daytime occupancies, the distribution between these shall be the same as the proposed design.

(b) The U-factor of each envelope component shall be equal to the criteria from § 4.3 for each class of construction.

(c) The vertical fenestration area shall be equal to the proposed design or 40% of the gross exterior wall area, which ever is less. The skylight area shall be equal to the proposed design or 5% of the gross exterior roof area, which ever is less.

(d) The SHGC of each window or skylight component shall be equal to the criteria from § 4.3.

14. Appendix F – Climate Zone Map Of India



Source: National Building Code 2005, Part 8, Fig. 2

15. Appendix G – Air-Side Economizer Acceptance Procedures

15.1 Construction Inspection

Prior to Performance Testing, verify and document the following:

- System controls are wired correctly to ensure economizer is fully integrated (i.e. economizer will operate when mechanical cooling is enabled).
- Economizer lockout control sensor location is adequate (open to air but not exposed to direct sunlight nor in an enclosure; away from sources of building exhaust; at least 8 m [25 ft] away from cooling towers).
- System is provided with barometric relief, relief fan or return fan to control building pressure.

15.2 Equipment Testing

Step 1: Simulate a cooling load and enable the economizer by adjusting the lockout control setpoint. Verify and document the following:

- Economizer damper modulates opens to 100% outside air.
- Return air damper modulates closed and is completely closed when economizer damper is 100% open.
- Economizer damper is 100% open before mechanical cooling is enabled.
- Relief fan or return fan (if applicable) is operating or barometric relief dampers freely swing open.

Step 2: Continue from Step 1 and disable the economizer by adjusting the lockout control setpoint. Verify and document the following:

- Economizer damper closes to minimum ventilation position.
- Return air damper opens to at or near 100%.
- Relief fan (if applicable) shuts off or barometric relief dampers close. Return fan (if applicable) may still operate even when economizer is disabled.

16. Appendix H – Compliance Forms

16.1Envelop Summary

Envelope Summary **ENVELOPE Summary**

2005 India Energy Conservation Building Code Compliance Forms — Draft 1, 27 March 2005

Project Info	Project Address	Date
		For Building Department Use
	Applicant Name:	
	Applicant Address:	
	Applicant Phone:	

Project Description	☐ New Building	☐ Addition	☐ Alteration	☐ Change of Use

Compliance Option	☐ Prescriptive	☐ Envelope Trade-Off (Appendix D)	☐ Systems Analysis

	◯ Hospital, hotel, call center (24 hour)		◯ Other building types (daytime)		
Vertical Fenestration Area Calculation Note: Vertical fenestration area can not exceed 40% of the gross wall area for prescriptive option.	Total Vertical Fenestration Area (rough opening)	divided by	Gross Exterior Wall Area	times 100 equals	**% Vertical Fenestration**
		÷		X 100 =	
Skylight Area Calculation Note: Skylight area can not exceed 5% of the gross roof area for prescriptive compliance.	Total Skylight Area (rough opening)	divided by	Gross Exterior Wall Area	times 100 equals	**% Skylight**
		÷		X 100 =	

Hospital, hotel, call center (24 hour)	
OPAQUE ASSEMBLY	
Roof *m Insulation R-value*	
Wall *m Insulation R-value*	
FENESTRATION	
Vertical	
Maximum U-factor	
Maximum SHGC (or SC)	
Overhang (yes or no)	
If yes, enter Projection Factor	
Side fins (yes or no)	
If yes, enter Projection Factor	
Skylight	
Maximum U-factor	
Maximum SHGC (or SC)	

Other building type (daytime)	
OPAQUE ASSEMBLY	
Roof *m Insulation R-value*	
Wall *m Insulation R-value*	
FENESTRATION	
Vertical	
Maximum U-factor	
Maximum SHGC (or SC)	
Overhang (yes or no)	
If yes, enter Projection Factor	
Side fins (yes or no)	
If yes, enter Projection Factor	
Skylight	
Maximum U-factor	
Maximum SHGC (or SC)	

16.2 Building Permit Plans Checklist

Building Permit Plans Checklist							ENVELOPE Checklist
2005 India Energy Conservation Building Code Compliance Forms							Draft 1, 27 March 2005
Project Address						Date	
The following information is necessary to check a building permit application for compliance with the building envelope requirements in the 2005 India Energy Conservation Building Code.							
Applicability (yes, no, n.a.)			Code Section	Component	Information Required	Location on Plans	Building Department Notes
MANDATORY PROVISIONS (Section 4.2)							
			4.2.1	Fenestration rating			
			4.2.1.1	U-factor	Specify whether per 4.2.1.1 or default in Appendix C		
			4.2.1.2	SHGC	Specify whether per 4.2.1.2 or default in Appendix C		
			4.2.1.3	Air leakage	Specify leakage rates		
			4.2.2	Opaque U-factors	Specify whether per default in Appendix C or ASHRAE		
			4.2.3	Bldg. env. sealing	Indicate sealing, caulking, gasketing, and weatherstripping		
PRESCRIPTIVE COMPLIANCE OPTION (Section 4.3)							
			4.3.1	Roof	Indicate R-values on roof sections		
			4.3.2	Cool roof	Indicate minimum reflectance and emittance on plans		
			4.3.3	Roof	Indicate R-values on wall sections		
			4.3.4	Vertical fenestration	(1) Indicate U-factors on fenestration schedule. Indicate if values are rated or default. If values are default, then specify frame type, glazing layers, gapwidth, low-e. (2) Indicate SHGC or SC on fenestration schedule. Indicate if values are rated or default. (3) Indicate if overhangs or side fins are used for compliance purposes. If so, provide projection factor calculation.		
			4.3.5	Skylights	(1) Indicate U-factors on fenestration schedule. Indicate if values are rated or default. If values are default, then specify frame type, glazing layers, gapwidth, low-e. (2) Indicate SHGC or SC on fenestration schedule. Indicate if values are rated or default.		
BUILDING ENVELOPE TRADE-OFF OPTION (Section 4.4)							
					Provide calculations		

16.3 Mechanical Summary

Mechanical Summary **MECHANICAL Summary**

2005 India Energy Conservation Building Code Compliance Forms Draft 1, 27 March 2005

Project Info	Project Address	Date
		For Building Dept. Use
	Applicant Name:	
	Applicant Address:	
	Applicant Phone:	

Project Description	
Briefly describe mechanical system type and features. ☐ Includes Plans	

Compliance Option	◉ Simple System ◯ Complex System ◯ Systems Analysis

Equipment Schedules	The following information is required to be incorporated with the mechanical equipment schedules on the plans. For projects without plans, fill in the required information below.

Cooling Equipment Schedule

Equip. ID	Brand Name	Model No.	Capacity kW	Total L/s	OSA CFM or Econo?	SEER or EER	IPLV	Location

Heating Equipment Schedule

Equip. ID	Brand Name	Model No.	Capacity kW	Total L/s	OSA cfm or Econo?	Input kW	Output kW	Efficiency

Fan Equipment Schedule

Equip. ID	Brand Name	Model No.	Total L/s	SP	kW	Flow Control	Location of Service

16.4 Mechanical Checklist

Mechanical Permit Checklist						MECHANICAL Checklist	
2005 India Energy Conservation Building Code Compliance Forms							Draft 1, 27 March 2005
Project Address						Date	
The following information is necessary to check a building permit application for compliance with the mechanical requirements in the 2005 India Energy Conservation Building Code.							
Applicability (yes, no, n.a.)			Code Section	Component	Information Required	Location on Plans	Building Department Notes
HEATING, VENTILATING, AND AIR CONDITIONING (Chapter 5)							
MANDATORY PROVISIONS (Section 5.2)							
			5.2.1	Equipment effficiency	Provide equipment schedule with type, capacity, efficiency		
			5.2.2	Controls			
			5.2.2.1	Timeclocks	Indicate thermostat with night setback, 3 different day types, and 2-hour manual override		
			5.2.2.2	Temp. & deadband	Indicate temperature control with 3 degree C deadband minimum		
			5.2.2.3	Clg.tower, fluid cooler	Indicate two-speed motor, pony motor, or variable speed drive to control the fans		
			5.2.3	Piping & ductwork	Indicate sealing, caulking, gasketing, and weatherstripping		
			5.2.3.1	Piping insulation	Indicate R-value of insulation		
			5.2.3.2	Ductwork insulation	Indicate R-value of insulation		
			5.2.3.3	Ductwork sealing	Specify sealing types and locations		
			5.2.4	System balancing	Specify system balancing		
PRESCRIPTIVE COMPLIANCE OPTION (Section 5.3)							
			5.3		Indicate whether project is complying with ECBC Prescriptive Option OR with ASHRAE Standard 90.1-2004		
			5.3.1	Economizer			
			5.3.3.1	Air economizer	Indicate 100% capability on schedule		
			5.3.3.2	Integrated operation	Indicate capability for partial cooling		
			5.3.3.3	Field testing	Specify tests		
			5.3.2	Variable flow hydronic			
			5.3.3.1	Pump flow rates	Indicate variable flow capacity on schedules		
			5.3.3.2	Isolation valves	Indicate two-way automatic isolation valves		
			5.3.3.3	Variable speed drive	Indicate variable speed drive		
SERVICE WATER HEATING AND PUMPING (Chapter 6)							
MANDATORY PROVISIONS (Section 6.2)							
			6.2.1	Solar water heating	Provide calculations to justify capacity to meet 20% threshold		
			6.2.2	Equipment effficiency	Provide equipment schedule with type, capacity, efficiency		
			6.2.3	Piping insulation	Indicate R-value of insulation		
			6.2.4	Heat traps	Indicate heat trap on drawings or provide manufacturers specifications to show that equipment has internal heat trap		
			6.2.5	Pool covers	Provide vapor retardant cover for pools		
			6.2.5	Pools over 32 C	Provide R-2.1 insulation		

16.5 Lighting Summary

Lighting Summary LIGHTING Summary

2005 India Energy Conservation Building Code Compliance Forms Draft 1, 27 March 2005

Project Info	Project Address	Date
		For Building Department Use
	Applicant Name:	
	Applicant Address:	0
	Applicant Phone:	

Project Description	☐ New Building ☐ Addition ☐ Alteration ☐ Change of Use	

Compliance Option	☐ Prescriptive ☐ Systems Analysis

Alteration Exceptions (check box, if appropriate)	☐ Less than 50% of the fixtures are new and installed lighting wattage is not being increased

Maximum Allowed Lighting Wattage (Interior, Section 7.3)

Location (floor/room no.)	Occupancy Description	Allowed Watts per m^2 **	Area in m^2	Allowed x Area
				0.0
				0.0
				0.0
	** Document all exceptions		Total Allowed Watts	0.0

Proposed Lighting Wattage (Interior)

Location (floor/room no.)	Fixture Description	Number of Fixtures	Watts/ Fixture	Watts Proposed
				0.0
				0.0
				0.0
	Total Proposed Watts may not exceed Total Allowed Watts for Interior		Total Proposed Watts	0.0

Maximum Allowed Lighting Wattage (Exterior, Section 7.4)

Location	Description	Allowed Watts per m^2 or per lm	Area in m^2 (or lm for perimeter)	Allowed Watts x m^2 (or x lm)
				0.0
				0.0
				0.0
				0.0
				0.0
			Total Allowed Watts	0.0

Proposed Lighting Wattage (Exterior)

Location	Fixture Description	Number of Fixtures	Watts/ Fixture	Watts Proposed
				0.0
				0.0
				0.0
	Total Proposed Watts may not exceed Total Allowed Watts for Exterior		Total Proposed Watts	0.0

16.6 Lighting Permit Checklist

Lighting Permit Checklist						LIGHTING Checklist
2005 India Energy Conservation Building Code Compliance Forms						Draft 1, 27 March 2005
Project Address					Date	
The following information is necessary to check a building permit application for compliance with the lighting requirements in the 2005 India Energy Conservation Building Code.						
Applicability (yes, no, n.a.)			Code Section	Component	Information Required	Location on Plans	Building Department Notes
LIGHTING (Chapter 7)							
MANDATORY PROVISIONS (Section 7.2)							
			7.2.1	Controls			
			7.2.1.1	Automatic shutoff	Indicate automatic shutoff locations or occupancy sensors		
			7.2.1.2	Space control	Provide schedule with type, indicate locations		
			7.2.1.3	Daylight zones	Provide schedule with type and features, indicate locations		
			7.2.1.4	Ext. lighting control	Indicate photosensor or astronomical time switch		
			7.2.1.5	Additional control	Provide schedule with type, indicate locations		
			7.2.2	Tandem wiring	Show wiring on schedule		
			7.2.3	Exit signs	Indicate 5 watts maximum		
			7.2.4	Ext. bldg.grounds ltg.	Indicate minimum efficacy of 60 lumens/Watt		
PRESCRIPTIVE INTERIOR LIGHTING POWER COMPLIANCE OPTION (Section 7.3)							
			7.3		Indicate whether project is complying with the Building Area Method (7.3.1) or the Space Function Method (7.3.2)		
			7.3.1	Building area method	Provide lighting schedule with wattage of lamp and ballast and number of fixtures. Document all exceptions.		
			7.3.2	Space function method	Provide lighting schedule with wattage of lamp and ballast and number of fixtures. Document all exceptions.		
			7.3.3	Luminaire wattage	Indicate on plans		
PRESCRIPTIVE EXTERIOR LIGHTING POWER COMPLIANCE OPTION (Section 7.4)							
			7.4	Building area method	Provide lighting schedule with wattage of lamp and ballast and number of fixtures. Document all exceptions.		
ELECTRICAL POWER (Chapter 8)							
MANDATORY PROVISIONS (Section 8.2)							
			8.2.1	Transformers	Provide schedule with transformer losses		
			8.2.2	Motor efficiency	Provide equipment schedule with motor capacity, efficiency		
			8.2.3	Power factor correction	Provide schedule with power factor correction		
			8.2.4	Check metering	Provide check metering and monitoring		

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