



ಕರ್ನಾಟಕ ರಾಜ್ಯಪತ್ರ

ಅಧಿಕೃತವಾಗಿ ಪ್ರಕಟಿಸಲಾದುದು

ಸಂಪುಟ ೧೪೯ Volume 149	ಬೆಂಗಳೂರು, ಗುರುವಾರ, ನವೆಂಬರ್ ೨೭, ೨೦೧೪ (ಮಾರ್ಗಶಿರ ೬, ಶಕ ವರ್ಷ ೧೯೩೬) Bangalore, Thursday, November 27, 2014 (Margashira 6, Shaka Varsha 1936)	ಸಂಚಿಕೆ ೪೭ Issue 47
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ಭಾಗ ೪ಎ

ರಾಜ್ಯದ ವಿಧೇಯಕಗಳ ಮತ್ತು ಅವುಗಳ ಮೇಲೆ ಪರಿಶೀಲನಾ ಸಮಿತಿಯ ವರದಿಗಳು, ರಾಜ್ಯದ ಅಧಿನಿಯಮಗಳು ಮತ್ತು ಅಧ್ಯಾದೇಶಗಳು, ಕೇಂದ್ರದ ಮತ್ತು ರಾಜ್ಯದ ಶಾಸನಗಳ ಮೇರೆಗೆ ರಾಜ್ಯ ಸರ್ಕಾರವು ಹೊರಡಿಸಿದ ಸಾಮಾನ್ಯ ಶಾಸನಬದ್ಧ ನಿಯಮಗಳು ಮತ್ತು ರಾಜ್ಯಾಂಗದ ಮೇರೆಗೆ ರಾಜ್ಯಪಾಲರು ಮಾಡಿದ ನಿಯಮಗಳು ಹಾಗೂ ಕರ್ನಾಟಕ ಉಚ್ಚ ನ್ಯಾಯಾಲಯವು ಮಾಡಿದ ನಿಯಮಗಳು

ಕಾನೂನು ಸಚಿವಾಲಯ

ಅಧಿಸೂಚನೆ

ಸಂಖ್ಯೆ: ಲಾ 151 ಎಲ್‌ಎಡಿ 2014, ಬೆಂಗಳೂರು, ದಿನಾಂಕ: 09ನೇ ಅಕ್ಟೋಬರ್, 2014

ಮಾನ್ಯ ಉಚ್ಚ ನ್ಯಾಯಾಲಯ ಬೆಂಗಳೂರು - ಇಲ್ಲಿನ ಅಧಿಸೂಚನೆ ಸಂಖ್ಯೆ GOB(1)2/2014 ದಿನಾಂಕ 17-09-2014ರ ಅನ್ವಯ ಶ್ರೀ ರಮಾಕಾಂತ ಚವಾಣ್, 24ನೇ ಅಡಿಷನಲ್ ಚೀಫ್ ಮೆಟ್ರೋಪಾಲಿಟನ್ ಮ್ಯಾಜಿಸ್ಟ್ರೇಟ್, ಬೆಂಗಳೂರು ನಗರ - ಇವರ ಸೇವೆಯನ್ನು ಕಾನೂನು ಇಲಾಖೆಗೆ ನೀಡಲಾಗಿರುತ್ತದೆ. ಸದರಿ ನ್ಯಾಯಾಧೀಶರು ಹುದ್ದೆಯ ಅಧಿಕಾರವನ್ನು ವಹಿಸಿಕೊಳ್ಳುವ ದಿನಾಂಕದಿಂದ ಜಾರಿಗೆ ಬರುವಂತೆ, ಜಿಲ್ಲಾ ಕಾನೂನು ಸೇವೆಗಳ ಪ್ರಾಧಿಕಾರ, ಬೆಂಗಳೂರು ನಗರ ಇಲ್ಲಿನ ಸದಸ್ಯ ಕಾರ್ಯದರ್ಶಿ ಹುದ್ದೆಗೆ ಮರುಸ್ಥಳನಿಯುಕ್ತಿ ಮಾಡಲಾಗಿದೆ.

ಕರ್ನಾಟಕ ರಾಜ್ಯಪಾಲರ ಆದೇಶಾನುಸಾರ ಮತ್ತು ಅವರ ಹೆಸರಿನಲ್ಲಿ,

ಜಿ.ಲಕ್ಷ್ಮಣ,

ಸರ್ಕಾರದ ಅಧೀನ ಕಾರ್ಯದರ್ಶಿ (ಪ್ರ),

ಕಾನೂನು ಇಲಾಖೆ (ಆಡಳಿತ-2).

P.R. 855

S.C. 25

ಕಾನೂನು ಸಚಿವಾಲಯ

ಅಧಿಸೂಚನೆ

ಸಂಖ್ಯೆ: ಲಾ 109 ಎಲ್‌ಎಡಿ 2014, ಬೆಂಗಳೂರು, ದಿನಾಂಕ: 02ನೇ ಸೆಪ್ಟೆಂಬರ್, 2014

ಶ್ರೀ ಉಮೇಶ್ ಬೂದಪ್ಪ ಜೋಗೀಹಳ್ಳಿ, ಅಪರ ಸರ್ಕಾರಿ ವಕೀಲರು, ಹಿರೇಕೆರೂರು ತಾಲ್ಲೂಕು ಹಾವೇರಿ ಜಿಲ್ಲೆ ಇವರನ್ನು ತಕ್ಷಣದಿಂದ ಜಾರಿಗೆ ಬರುವಂತೆ ಮುಂದಿನ ಆದೇಶದವರೆಗೆ ರಾಣಿಬೆನ್ನೂರು ತಾಲ್ಲೂಕಿನ ಹಿರಿಯ ಶ್ರೇಣಿ ನ್ಯಾಯಾಲಯದ ಅಪರ ಸರ್ಕಾರಿ ವಕೀಲರ ಹುದ್ದೆಯ ಹೆಚ್ಚುವರಿ ಪ್ರಭಾರದಲ್ಲಿರಿಸಲಾಗಿದೆ. ಸದರಿ ವಕೀಲರು ಹೆಚ್ಚುವರಿಯಾಗಿ ಕಾರ್ಯನಿರ್ವಹಿಸುವ ಅವಧಿಯಲ್ಲಿ ಕರ್ನಾಟಕ ಕಾನೂನು ಅಧಿಕಾರಿಗಳ (ನೇಮಕಾತಿ ಮತ್ತು ಸೇವಾ ಷರತ್ತುಗಳು) ನಿಯಮಗಳು 1977ರ ನಿಯಮ 15(1)(II)ರ ಅನ್ವಯ ಪ್ರಯಾಣ ಭತ್ಯೆ ಪಡೆಯಲು ಅರ್ಹರಾಗಿರುತ್ತಾರೆ.

ಕರ್ನಾಟಕ ರಾಜ್ಯಪಾಲರ ಆದೇಶಾನುಸಾರ ಮತ್ತು ಅವರ ಹೆಸರಿನಲ್ಲಿ,

ಸಯೀದಾ ಬಾನು,

ಸರ್ಕಾರದ ಅಧೀನ ಕಾರ್ಯದರ್ಶಿ,

ಕಾನೂನು ಇಲಾಖೆ (ಆಡಳಿತ-2).

P.R. 856

S.C. 25

(೩೯೭೩)

ENERGY SECRETARIAT

NOTIFICATION

NO. EN41VSC2013, Date.05.09.2014

In exercise of the powers conferred by section 18 of the Energy Conservation Act 2001 (52 of 2001)

Section 18

THE GAZETTE OF INDIA

MINISTRY OF LAW, JUSTICE AND COMPANY AFFAIRS

(Legislative Department)

New Delhi, the 1st October, 2001/ Asvina 9, 1923 (Saka)

THE ENERGY CONSERVATION ACT, 2001

No 52 OF 2001 [29th September 2001]

Power of Central Government or State Government to issue directions

18. The Central Government or the State Government may, in the exercise of its powers and performance of its functions under this Act and for efficient use of energy and its conservation, issue such directions in writing as it deems fit for the purposes of this Act to any person, officer, authority or any designated consumer and such person, officer or authority or any designated consumer shall be bound to comply with such directions.

Explanation – For the avoidance of doubts, it is hereby declared that the power to issue directions under this section includes the power to direct –

(a) regulation of norms for process and energy consumption standards in any industry or building or building complex; or

(b) regulation of the energy consumption standards for equipment and appliances.

The State Government in consultation with the Bureau of Energy Efficiency do hereby adopts the following code and issues directives for efficient use of energy and its conservation in the buildings or building complexes namely:-

- This code may be called the Karnataka Energy Conservation Building Code (ECBC) 2014.
- Urban Local bodies as the enforcing authority for implementation of the ECBC in respect of Private buildings.
- Public Works Department (PWD) and Architecture Department, Government of Karnataka as the enforcing authority for implementation of the ECBC in respect of Government buildings.
- Department of Electrical Inspectorate, Government of Karnataka to inspect the electrical installations in the building which are ECBC compliant.
- Karnataka Renewable Energy Development Limited, as the nodal agency to monitor the implementation of the Code at the State level and also to create the awareness of the ECBC.
- It shall come into force from the date of its publication in the Official Gazette.

1. Scope

The code is applicable to all buildings or building complexes in the urban area that have a connected load of 100 kW or greater or a contract demand of 120 kVA or greater, or having conditioned area of 500 m² or more and used for commercial purposes.

1.1 Applicable Building Systems

The provisions of this code apply to:

- Building envelopes, except for unconditioned storage spaces or warehouses
- Mechanical systems and equipment, including heating, ventilating, and air conditioning
- Service hot water heating
- Interior and exterior lighting
- Electrical power and motors

1.2 Exemptions

The provisions of this code do not apply to:

- Buildings that do not use either electricity or fossil fuel
- Equipment and portions of building systems that use energy primarily for manufacturing processes

1.3 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.

1.4 Reference Standards

National Building Code 2005 is the reference document/ standard for lighting levels, HVAC, comfort levels, natural ventilation, pump and motor efficiencies, transformer efficiencies and any other building materials and system performance criteria.

2. Administration and Enforcement

2.1. Compliance Requirements

2.1.1 Mandatory Requirements

(A) Compliance of this code shall be mandatory for all applicable buildings specified in § 1.

(B) All Government notifications related to energy conservation or mandatory use of any product/process or equipment shall be complied with.

2.1.2 New Buildings

New buildings shall comply with either the provisions of § 3 through §7 of this code or the Whole Building Performance Method of Appendix B.

In case of mixed use buildings if the connected load of the commercial part qualifies for the applicability of this code then the commercial part of the building need to comply with this code.

2.1.3 Additions to Existing Buildings

Where the addition plus the existing building exceeds the conditioned floor area threshold of § 1, additions shall comply with the provisions of §3 through §7. 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 §2.1.3: 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.

2.1.4 Alterations to Existing Buildings

Where the existing building exceeds the conditioned floor area threshold in §1, portions of a building and its systems that are being altered shall meet the provisions of § 3 through §7. The specific requirements for alterations are described in § 2.1.4.1 to § 2.1.4.5.

Exception to § 2.1.4: When the entire building complies with all of the provisions of § 3 through §7 as if it were a new building.

2.1.4.1 Building Envelope

Alterations to the building envelope shall comply with the requirements of § 3 for fenestration, insulation, and air leakage applicable to the portions of the buildings and its systems being altered.

Exception to §2.1.4.1: 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

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

2.1.4.2 Heating, Ventilation and Air Conditioning

Alterations to building heating, ventilating, and air-conditioning equipment or systems shall comply with the requirements of § 4 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.

2.1.4.3 Service Water Heating

Alterations to building service water heating 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.

2.1.4.4 Lighting

Alterations to building lighting equipment or systems shall comply with the requirements of § 6 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 6.1 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 §2.1.4.4: 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.

2.1.4.5 Electric Power and Motors

Alterations to building electric power systems and motor shall comply with the requirements of § 7 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.

2.1.4.6 Star Labeling and Minimum star rating

All equipments and materials of type and specification coming under the purview of the star-labeling program as notified by BEE shall have minimum star rating as notified by the State Government. Refer to appendix-H for further details.

2.2 Compliance Approaches

The building shall comply with the mandatory provisions (§3.2, §4.2, §5.2, §6.2, and §7.2) and either of the following:

- (a) Prescriptive Method (§ 3.3, §4.3 and §6.3) Exception to § 2.2 (a): The envelope trade-off option of § 3.4 may be used in place of the prescriptive criteria of § 3.3
- (b) Whole Building Performance Method (Appendix B.)

2.3 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.

2.4 Compliance Documents

2.4.1 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

2.4.2. 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.

3. Envelope

3.1 General

The building envelope shall comply with the mandatory provisions of § 3.2 and either the prescriptive criteria of § 3.3 or the trade –off option of § 3.4.

3.2 Mandatory Requirements

3.2.1 Fenestration

3.2.1.1 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 C, 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 C.

3.2.1.2 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 C by an accredited independent laboratory, and labeled and certified by the manufacturer or other responsible party.

Exceptions to §3.2.1.2:

- (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

3.2.1.3 Air Leakage

Air leakage for glazed swinging entrance doors and revolving doors shall not exceed 5.0 l/s-m². Air leakage for other fenestration and doors shall not exceed 2.0 l/s-m².

3.2.2 Opaque Construction

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

3.2.3 Building Envelope Sealing

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

- Joints around fenestration and door frames
- Openings between walls and foundations and between walls and roof and wall panels
- Openings at penetrations of utility services through, roofs, walls, and floors
- Site- built fenestration and doors
- Building assemblies used as ducts or plenums
- All other openings in the building envelope

3.3 Prescriptive Requirements**3.3.1 Roofs**

Roofs shall comply with either the maximum assembly U- factor or the minimum insulation R- value in Table 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 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

3.3.1.1 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).

3.3.2 Opaque Walls

Opaque walls shall comply with either the maximum assembly U- factor or the minimum insulation R-value in Table 3.2. R-value is for the insulation alone and does not include building materials or air films.

Table 3.2: Opaque Wall Assembly U-factor and Insulation R-value Requirements

Climate Zone	Hospitals, Hotels, Call Centers etc., (24- Hour)		Other Buildings 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-0.440	R-2.10	U-0.440	R-2.10
Hot and Dry	U-0.440	R-2.10	U-0.440	R-2.10
Warm and Humid	U-0.440	R-2.10	U-0.440	R-2.10
Moderate	U-0.440	R-2.10	U-0.440	R-2.10
Cold	U-0.369	R-2.20	U-0.352	R-2.35

3.3.3 Vertical Fenestration

Vertical fenestration shall comply with the maximum area weighted U-factor and maximum area weighted SHGC requirements of Table 3.3. Vertical fenestration area is limited to a maximum of 60% of the gross wall area for the prescriptive requirement.

Table 3.3: Vertical Fenestration U-factor and SHGC Requirements (U-factor in W/m²- °C)

Climate	Maximum U-factor	WWR ≤ 40%	40% < WWR ≤ 60%
		Maximum SHGC	Maximum SHGC
Composite	3.30	0.25	0.20
Hot and Dry	3.30	0.25	0.20
Warm and Humid	3.30	0.25	0.20
Moderate	6.90	0.40	0.30
Cold	3.30	0.51	0.51

See Appendix C §10.2.1 for Default values of Unrated Fenestration

Exception to § 3.3.3. 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 by Equation 11-2 and the overhang and side fins coefficients are available in table 11.6 § 11

Table 3.4 : SHGC “M” Factor Adjustments for Overhangs and Fins

Project Location	Orientation	Overhang “M” Factors for 4 Projection Factors				Vertical Fin “M” Factors for 4 Projection Factors				Overhang +Fin “M” Factors for 4 Projection Factors			
		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 §3.3.3: Vertical Fenestration areas located more than 2.2 m (7ft) above the level of the floor are exempt from the SHGC requirement in Table 3.3 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 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.

3.3.3.1 Minimum Visible Transmission of Glazing for Vertical Fenestration Vertical fenestration product shall have the minimum *Visual Light Transmittance* (VLT), defined as function of Window Wall Ratio (WWR), where Effective Aperture > 0.1, equal to or greater than the Minimum VLT requirements of Table 3.5.

Table 3.5: Minimum VLT Requirements:

Window Wall Ratio	Minimum VLT
0-0.3	0.27
0.31-0.4	0.20
0.41-0.5	0.16
0.51-0.6	0.13

3.3.4 Skylights

Skylights shall comply with the maximum U-factor and maximum SHGC requirements of Table 3.6. Skylight area is limited to a maximum of 5% of the gross roof area for the prescriptive requirement.

Table 3.6: Skylight U- factor and SHGC Requirements (U-factor W/m²-°C)

Climate	Maximum U – factor		Maximum SHGC	
	With Curb	w/o Curb	0-2% SRR	2.1-5% SRR
Composite	11.24	7.71	0.40	0.25
Hot and Dry	11.24	7.71	0.40	0.25
Warm and Humid	11.24	7.71	0.40	0.25
Moderate	11.24	7.71	0.61	0.4
Cold	11.24	7.71	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 § 10.2.2 for typical complying skylight constructions.

3.4 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 § 3.3 The envelope trade-off equation is found in Appendix D.

4. Heating, Ventilation and Air Conditioning

4.1 General

All heating, ventilation, and air conditioning equipment and systems shall comply with the mandatory provisions of §4.2 and the prescriptive criteria of §4.3.

4.2 Mandatory Requirements

4.2.1 Natural Ventilation

Natural ventilation shall comply with the design guidelines provided for natural ventilation in the National Building Code of India 2005 Part 8 Section 1, 5.4.3 and 5.7.1

4.2.2 Minimum Equipment Efficiencies

Cooling equipment shall meet or exceed the minimum efficiency requirements presented in Table 4.1. Heating & cooling equipment not listed here shall comply with ASHRAE 90.1- 2004 § 6.4.1.

Unitary Air Conditioner shall meet IS 1391 (Part 1), Split air conditioner shall meet IS 1391 (Part 2), Packaged air conditioner shall meet IS 8148 and Boilers shall meet IS 13980 with above 75% thermal efficiency.

Table 4.1: Chillers

Equipment Class	Minimum COP	Minimum IPLV	Test Standard
Air Cooled Chiller <530 kW (<150tons)	2.90	3.16	ARI 550/590 - 1998
Air Cooled Chiller ≥530 kW (≥150tons)	3.05	3.32	ARI 550/590 - 1998
Centrifugal Water Cooled Chiller <530kW (<150 tons)	5.0	5.25	ARI 550/590 - 1998
Centrifugal Water Cooled Chiller ≥530 and <1050 kW (≥150 and < 300 tons)	5.55	5.9	ARI 550/590 - 1998
Centrifugal Water Cooled Chiller ≥1050 kW (≥300tons)	6.1	6.4	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 <530kW (<150tons)	4.70	5.49	ARI 550/590 - 1998
Rotary Screw and Scroll Compressor, Water Cooled Chiller ≥530 and <1050 kW (≥150and <300 tons)	5.40	6.17	ARI 550/590 - 1998
Rotary Screw and Scroll Compressor, Water Cooled Chiller ≥1050kW (≥300tons)	5.75	6.43	ARI 550/590 - 1998

4.2.3 Controls

4.2.3.1 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 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 §4.2.3.1:

- a) Cooling systems < 28kW (8tons)
- b) Heating systems < 7 kW (2tons).

4.2.3.2 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.

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

4.2.3.4 The automatic door closure and door gaps sealing arrangement shall be provided in all air conditioned rooms.

4.2.4 Piping and Ductwork

4.2.4.1 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.

4.2.4.2 Ductwork shall be insulated in accordance with Table 4.2

Table 4.2 : Ductwork Insulation (m² - ° C/ W)

Duct Location	Required Insulation ^a	
	Supply Ducts	Return Ducts
Exterior	R-1.4	R-0.6
Ventilated Attic	R-1.4	R-0.6
Unventilated Attic without Roof Insulation	R-1.4	R-0.6
Unventilated Attic with Roof Insulation	R-0.6	No Requirement
Unconditioned Space ^b	R-0.6	No Requirement
Indirectly Conditioned Space ^c	No Requirement	No Requirement
Buried	R-0.6	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 Include return air plenums with or without exposed roofs above.

4.2.5 System Balancing

4.2.5.1 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 250 m² (2,500 ft²).

4.2.5.1.1 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.

4.2.5.1.2 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 §4.2.5.1.2:

- (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 is no greater than 5% of the nameplate horsepower draw, or 2.2 kW (3hp), whichever is greater.

4.2.6 Condensers**4.2.6.1 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.

The condensers (outdoor units) especially of single unit room split air conditioners shall be located in shaded and well ventilated area closest to the evaporator (indoor unit). In case of unavailability of shaded area, and the condensers shall be provided with artificial shading to prevent direct heating of the unit during day time by the sun light. The unitary air conditioners shall also be installed at suitable locations to avoid direct sunlight and shading may be provided for improved performance. The piping system connecting the outdoor and indoor units shall be insulated as per § 4.2.4.1 and the length of such pipes shall not exceed the length as specified by the manufacturer.

4.2.6.2 Treated Water for Condensers

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

4.3 Prescriptive Requirements

Compliance shall be demonstrated with the requirements in § 4.3.1 through § 4.3.2 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
- (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 system shall comply with ASHRAE 90.1-2004 § 6.5.

4.3.1 Economizers**4.3.1.1 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 22kW (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
- (c) 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 §4.3.1.1:

- (a) Projects in the Hot-Dry and Warm- Humid climate zones are exempt
- (b) Individual ceiling mounted fan systems < 3,200 l/s (6,500cfm) are exempt

4.3.1.2 Where required by § 4.3.1.1 economizers shall be capable of providing partial cooling even when additional mechanical cooling is required to meet the cooling load.

4.3.1.3 Air–side economizers shall be tested in the field following the requirements in Appendix F to ensure proper operation.

Exception to §4.3.1.3: 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 F.

4.3.2 Variable Flow Hydronic Systems

4.3.2.1 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.

4.3.2.2 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.

4.3.2.3 Chilled water or condenser water systems that must comply with either §4.3.2.1 or § 4.3.2.2 and that have pump motors greater than or equal to 3.7 kW (5 hp) shall be controlled by variable speed drives.

5. Service Hot Water and Pumping**5.1 General**

All service water heating equipment and systems shall comply with the mandatory provisions of § 5.2.

5.2 Mandatory Requirements

5.2.1 Solar Water Heating

Commercial establishments like hotels, hospitals, guesthouses with a centralized system shall have solar water heating for at least 1/5 of the design capacity.

Exception to §5.2.1: Systems that use heat recovery for at least 1/5 of the design capacity.

5.2.2 Equipment Efficiency

Service water heating equipment shall meet or exceed the performance and minimum efficiency requirements presented in available Indian Standards

- Solar water heater shall meet the performance /minimum efficiency level mentioned in IS 13129 Part (1&2)
- Gas Instantaneous Water heaters shall meet the performance /minimum efficiency level mentioned in IS 15558 with above 80% thermal efficiency.
- Electric water heater shall meet the performance /minimum efficiency level mentioned in IS 2082.

5.2.3 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:

- Maximum heat recovery from hot discharge system like condensers of air conditioning units
- Use of gas fired heaters wherever gas is available
- Electric heater as last resort

5.2.4 Piping Insulation

Piping insulation shall comply with § 4.2.4.1. The entire hot water system including the storage tanks, pipelines shall be insulated conforming to the relevant IS standards on materials and applications.

5.2.5 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.

5.2.6 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 §5.2.6: Pools deriving over 60% of their energy from site- recovered energy or solar energy source.

5.2.7 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.

6. Lighting

6.1 General

Lighting systems and equipment shall comply with the mandatory provisions of § 6.2 and the prescriptive criteria of § 6.3 and § 6.3.4. The lighting requirements in this section shall apply to:

- Interior spaces of buildings
- Exterior building features, including facades, illuminated roofs, architectural features, entrances, exits, loading docks, and illuminated canopies
- Exterior building grounds lighting that is provided through the building's electrical service

Exceptions to §6.1:

- Emergency lighting that is automatically off during normal building operation and is powered by battery, generator, or other alternate power source
- Lighting in dwelling units

6.2 Mandatory Requirements

6.2.1 Lighting Control

6.2.1.1 Automatic Lighting Shutoff

Interior lighting systems in buildings larger than 250 m² (2,500ft²) shall be equipped with an automatic control device. Within these buildings, all office areas less than 30 m² (300ft²) enclosed by walls or ceiling-height partitions, all meeting and conference rooms, all

toilets, all school classrooms, and all storage spaces shall be equipped with occupancy sensors. For others 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 m² (25,000 ft²) 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 §6.2.1.1: Lighting systems designed for 24-hour use.

6.2.1.2 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 m² (2,500ft²) for a space less than or equal to 1,000 m² (10,000ft²), and a maximum of 1,000 m² (10,000ft²) for a space greater than 1,000 m² (10,000ft²)
- (b) Be capable of overriding the shutoff control required in §6.2.1.1 for no more than 2 hours
- (c) Be readily accessible and located so the occupant can see the control

Exception to §6.2.1.2(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.

6.2.1.3 Control in Daylighted Areas

Luminaire in day lighted areas greater than 25m² (250 ft²) 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.

6.2.1.4 Exterior Lighting Control

Lighting for all exterior applications not exempted in § 6.3.4 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.

6.2.1.5 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 m² (3,000ft²) area shall have a separate control device
- (b) Case Lighting: Lighting in cases used for display purposes greater than 300 m² (3,000ft²) 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 §6.2.1.2(c)
- (e) Non-visual Lighting: Lighting for non-visual 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

6.2.2. Signage/Advertising Signage

Internally – illuminated exit signs shall not exceed 5 W per face. The lighting power density in case of signage/advertisement signage should not exceed 5 Watts/ Sq feet for internally illuminated signage and 2.5 Watt/sq feet for externally illuminated signage.

6.2.3 Exterior Building Grounds Lighting

Lighting for exterior building grounds luminaires which operate at greater than 100 W shall contain lamps having minimum efficacy of 60 lm/W unless the luminaire is controlled by a motion sensor or exempt under § 6.1.

6.3 Prescriptive Requirements

6.3.1 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 §6.3.4 and shall not exceed the interior lighting power allowance determined in accordance with either §6.3.2 or § 6.3.3. 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 §6.3: 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
- (m) Athletic playing areas with permanent facilities for television broadcasting

6.3.2 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 6.1 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 6.1: 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 Residential	7.5
Convention Center	12.9	Museum	11.8
Dining : Bar Lounge/ Leisure	14.0	Office	10.8
Dining: Cafeteria /Fast Food	15.1	Parking Garage	3.2
Dining : Family	17.2	Performing Arts Theater	17.2
Dormitory./Hostel	10.8	Police/Fire Station	10.8
Gymnasium	11.8	Post Office/Town Hall/	11.8
Healthcare – clinic	10.8	Religious Building	14.0
Hospital/Health Care	12.9	Retail/Mall	16.1
Hotel	10.8	School/University	12.9
Library	14.0	Sports Arena	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.

6.3.3 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 6.2 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 6.2: Interior Lighting Power – Space Function Method

Space Function	LPD (W/m ²)	Space Function	LPD (W/m ²)
Office – enclosed	11.8	• For Reading area	12.9
Office –open plan	11.8	Hospital	
Conference/Meeting/Multipurpose	14.0	• For Emergency	29.1
Classroom/Lecture/Training	15.1	• For Recovery	8.6
Lobby *	14.0	• For Nurse Station	10.8
• For Hotel	11.8	• For Exam Treatment	16.1
• For Performing Arts Theater	35.5	• For Pharmacy	12.9
• For Motion Picture Theater	11.8	• For Patient Room	7.5
Audience/Seating Area *	9.7	• For Operating Room	23.7
• For Gymnasium	4.3	• For Nursery	6.5
• For Convention Center	7.5	• For Medical Supply	15.1
• For Religious Buildings	18.3	• For Physical Therapy	9.7
• For Sports Arena	4.3	• For Radiology	4.3
• For Performing Arts Theater	28.0	• For Laundry- Washing	6.5
• For Motion Picture Theater	12.9	Automotive–Service Repair	7.5
• For Transportation	5.4	Manufacturing Facility	
Atrium-first three floors	6.5	• For low bay(<8m ceiling)	12.9
Atrium- each additional floor	2.2	For High bay (>8m ceiling)	18.3
Lounge/Recreation*	12.9	• For Detailed Manufacturing	22.6
• For Hospital	8.6	• For Equipment Room	12.9
Dining Area*	9.7	• For Control Room	5.4
• For Hotel	14.0	Hotel/Motel Guest Rooms	11.8
• For Motel	12.9	Dormitory-Living Quarters	11.8
• For Bar Lounge/Leisure Dining	15.1	Museum	
• For Family Dining	22.6	• For General Exhibition	10.8
• Food Preparation	12.9	• For Restoration	18.3
Laboratory	15.1	Bank office- Banking Activity Area	16.1
Restrooms	9.7	Retail	
Dressing/ Locker/Fitting Room	6.5	• For Sales Area	18.3
Corridor/ Transition*	5.4	• For Mall Concourse	18.3
• For Hospital	10.8	Sports Arena	
• For Manufacturing Facility	5.4	• For Ring Sports Area	29.1
Stairs – active	6.5	• For Court Sports Area	24.8
Active Storage*	8.6	• For Indoor Field Area	15.1
• For Hospital	9.7	Warehouse	
Inactive Storage*	3.2	• For Fine material Storage	15.1
• For Museum	8.6	• For Medium/Bulky Material Storage	9.7
Electrical /Mechanical Facility	16.1	Parking Garage- Garage Area	2.2
Workshop	20.5	Transportation	
Convention Centre –Exhibit Space	14.0	• For Airport- Concourse	6.5
Library		• For Air/. Train/ Bus- Baggage Area	10.8

Space Function	LPD (W/m ²)	Space Function	LPD (W/m ²)
• For card File & Cataloging	11.8	• For Ticket Counter Terminal	16.1
• For Stacks	18.3		

* For all facilities except the following

6.3.4 Installed Interior Lighting Power

The installed interior lighting power calculated for compliance with § 6.3 shall include all power used by the luminaires, including lamps, ballasts, current regulators, and control devices except as specifically exempted in § 6.1.

Exception to §6.3.4: 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.

6.3.4.1 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 (45W/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.

6.3.5 Exterior Lighting Power

For building exterior lighting applications specified in Table 6.3 the connected lighting power shall not exceed the specified lighting power limits specified for each of these applications. Trade-offs between applications is not permitted. Exterior lighting for all other applications (except those included in the Exceptions to § 6.3.4) shall comply with the requirements of § 6.2.3

Table 6.3: Exterior Building Lighting Power

Exterior Lighting Applications	Power Limits
Building entrance (with canopy)	13 W/m ² (1.3W/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 (0.2W/ft ²)of vertical façade area

Exceptions to §6.3.5: 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 specifically designated as required by a health or life safety statute, ordinance, or regulation

7. Electrical Power

7.1 General

Electrical equipment and systems shall comply with the mandatory requirements of § 7.2.

7.2 Mandatory Requirements

7.2.1 Transformers

7.2.1.1 Maximum Allowable Power Transformer Losses

Power transformers of the proper ratings and design must be selected to satisfy the minimum acceptable efficiency at 50 % and 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.

Table 7.1: Dry Type Transformers – total losses for dry type transformers should conform as per the draft standard of Indian Standard IS 2026: Part 11 2007

Rating kVA	Max. Losses at 50 % loading kW*	Max. Losses at 100 % loading kW*	Total losses at 50 % loading kW*	Total losses at rated load kW*
	Up to 22 kV class		33 kV class	
100	0.94	2.4	1.12	2.4
160	1.29	3.3	1.42	3.3
200	1.5	3.8	1.75	4
250	1.7	4.32	1.97	4.6
315	2	5.04	2.4	5.4
400	2.38	6.04	2.9	6.8
500	2.8	7.25	3.3	7.8
630	3.34	8.82	3.95	9.2
800	3.88	10.24	4.65	11.4
1000	4.5	12	5.3	12.8
1250	5.19	13.87	6.25	14.5
1600	6.32	16.8	7.5	18
2000	7.5	20	8.88	21.4
2500	9.25	24.75	10.75	26.5

Table 7.2: Oil Filled Transformers- Total losses for oil filled transformers should conform as per the following table as specified in Central Electricity Authority norms.

Rating kVA	Max. Losses at 50 % loading kW*	Max. Losses at 100 % loading kW*	Total losses at 50 % loading kW*	Total losses at rated load kW*
	Up to 11 kV class		33 kV class	
100	0.52	1.80	0.56	1.82
160	0.77	2.20	0.78	2.58
200	0.89	2.70	0.90	3.00
250	1.05	3.32	--	--
315	1.10	3.63	1.30	4.30
400	1.45	4.63	1.52	5.10
500	1.60	5.50	1.95	6.45
630	2.00	6.64	2.30	7.60
1000	3.00	9.80	3.45	11.35
1250	3.60	12.00	4.00	13.25
1600	4.50	15.00	4.85	16.00
2000	5.40	18.40	5.70	18.50
2500	6.50	22.50	7.05	23.00

For Tables 7.1, 7.2: *Total loss values given in above table are applicable for thermal classes E, B & F and have component of load loss at reference temperature according to clause 17 of IS 2026: Part 11. i.e., average winding temperature rise as given in column 2 of Table 7.2 plus 30°C. An increase of 7% on total for thermal class H is allowed.

7.2.1.2 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 500kVA 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.

7.2.2 Energy Efficient Motors

Motors shall comply with the following:

- All permanently wired polyphase motors of 0.375kW 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 IS 12615 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 20 % 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

7.2.3 Power Factor Correction

All electricity supplies exceeding 100 A, 3 phases shall maintain their power factor between 0.95 lag and unity at the point of connection.

7.2.4 Check- Metering and Monitoring

- (a) 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.
- (b) 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)
- (c) Services not exceeding 65 kVA shall have permanently installed electrical metering to record energy (kWh).

7.2.5 Building Power Distribution Systems

7.2.5.1 Building Power Distribution Losses

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

BY ORDER AND IN THE NAME OF GOVERNOR OF KARNATAKA,

K.L. RAMACHANDRA

DEPUTY SECRETARY TO GOVERNMENT,
ENERGY DEPARTMENT.

8. Appendix A : Definitions, Abbreviations & Acronyms

8.1 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.

8.2 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) 10 CFR 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 conditions 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 to open and close a circuit by non automatic 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 like Commercial Complexes, Shopping malls, Hotels, Hospitals, Office buildings, Banks, Educational buildings, Cyber parks etc., 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

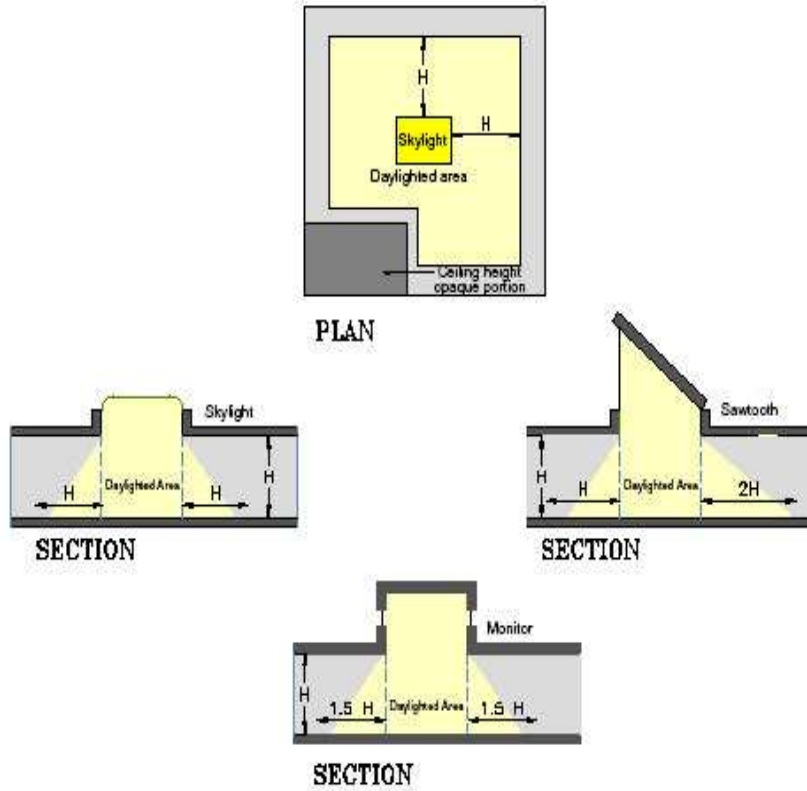
Control device: a specialized device used to regulate the operation of equipment

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

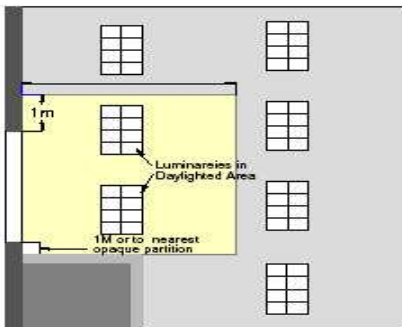
Daylighted area: the daylight illuminated floor area under horizontal fenestration (skylight) or adjacent to vertical fenestration (window), described as follows

- (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 2 H for the sawtooth configuration, or the distance to the nearest 1000mm (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, sleeping, eating, cooking, and sanitation

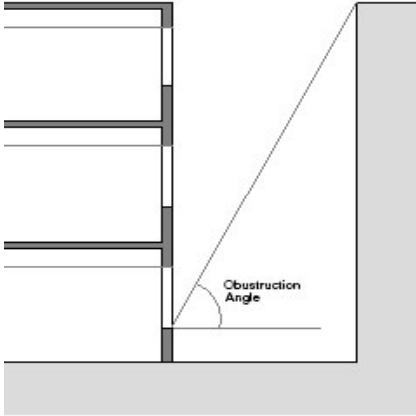
Economizer, air: a duct and damper arrangement and automatic control system that together allow a cooling system to supply outdoor air to reduce or eliminate the need for mechanical cooling during mild or cold weather

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. ($EA = VLT \times WWR$)

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° , 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 D. 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

Façade area: the 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 300mm (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 semi-heated 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 the 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 field 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 ($\text{W}/\text{m}^2\text{C}$ [$\text{Btu}/\text{ft}^2\text{F}$]) 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 luminaries.

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).

Luminaires: 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 and desiccant dehumidification combined with evaporative cooling, or another energy-driven thermodynamic cycle. Indirect or 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 from 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 from overload, short circuit, or ground fault.

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

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

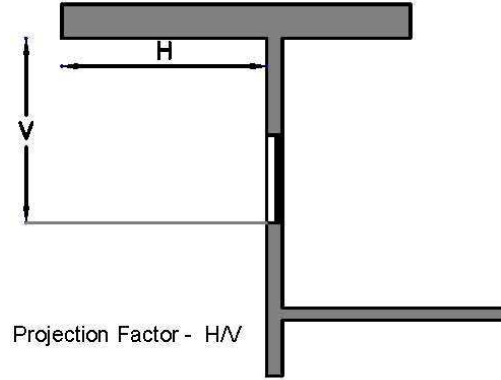
Permanently installed: equipment that is fixed in place and is not portable or movable.

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 not limited to, swimming pool, whirlpool, spa, hot tub.

Process load: the load on a building resulting from 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 $m^2 \cdot ^\circ C/W$ ($h \cdot ft^2 \cdot ^\circ F/Btu$). 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 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 ($^\circ F$) 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

Skylight roof ratio (SRR): is the ratio of the total skylight area of the roof, measured to the outside of the frame, to the gross exterior roof.

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: 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.

- Conditioned space:** a cooled space, heated space, or directly conditioned space.
- 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-ft^2) of floor area but is not a conditioned space.
- An enclosed space within a building that is not conditioned space or a semi-heated space. Crawlspace, attics, and parking garages with natural or mechanical ventilation are not considered enclosed spaces.

Standard Design: A computer representation of a hypothetical design based on the actual proposed design as per Appendix B- Whole Building Performance Method.

Storey: 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 storey.

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 from a system is finally delivered, e.g., registers, diffusers, lighting fixtures, faucets, etc.

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

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.

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 $\text{W/m}^2\text{-}^\circ\text{C}$ ($\text{Btu/h ft}^2\text{-}^\circ\text{F}$)

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

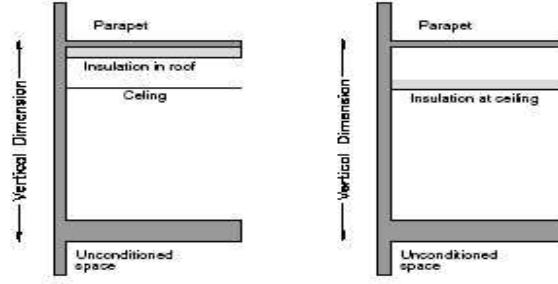
Vent damper: a device intended for installation in the venting system or an individual, automatically operated, fossil fuel- fired appliance in the outlet or downstream of the appliance draft control device, which is designed to automatically open the venting system when the appliance is in operation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

- Wall, above grade:** a wall that is not below grade.
- 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 area of the wall measured on the exterior face from the top of the floor to the bottom of the roof



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

Window Wall Ratio (WWR): is the ratio of vertical fenestration area to gross exterior wall area. Gross exterior wall area is measured horizontally from the exterior surface; it is measured vertically from the top of the floor to the bottom of the roof.

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).

8.3 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 unit 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
EC Act 2001	Energy Conservation Act 2001
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 degreeCelsius 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
ISHRAE	Indian Society of Heating, Refrigeration & Air-conditioning Engineers
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- ⁰ C	Watts per meter per degree Celsius
W/ m ² - ⁰ C	Watts per square meter per degree Celsius
Wh	Watt hour

9. Appendix. B Whole Building Performance Method

9.1 General

9.1.1 Scope

The whole building performance method is an alternative to the prescriptive requirements contained in § 1 through § 7 of this code . It applies for all building types covered by the code.

9.1.2 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 §7. The mandatory requirements of § 1 through §7 (§ 3.2, § 4.2, §5.2, §6.2 and § 7.2) shall be satisfied with the whole building performance method.

9.1.3 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 in the building shall be converted to kWh of electric energy at the rate of 0.75 kWh per mega Joule.

9.1.4 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.

9.1.5 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 is 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.

9.2 Simulation General Requirements

9.2.1 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 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 set points, and HVAC system operation, defined separately for each day of the week and holidays,
- (c) Thermal mass effects,
- (d) Ten or more thermal zones,
- (e) Part-load 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.

9.2.2 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.

9.2.3 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).

9.3 Calculating the Energy Consumption of the Proposed Design and the Standard design

9.3.1 The simulation model for calculating the proposed design and the standard design shall be developed in accordance with the requirements in Table 9.1.

9.3.2 HVAC Systems

The HVAC system type and related performance parameters for the standard design shall be determined from table 9.1 and the following rules:

- (a) Other Components: Components and parameters not listed in Table 9.2 or otherwise specifically addressed in this subsection shall be identical to those in the proposed design.(Exception to § 9.3.2(a) Where there are specific requirements in § 4.2.2, the component efficiency in the standard design shall be adjusted to the lowest efficiency level allowed by the requirement for that component type).
- (b) All HVAC and service water heating equipment in the standard design shall be modeled at the minimum efficiency levels, both part load and full load, in accordance with § 4.2.2.
- (c) Where efficiency ratings, such as EER and COP, include fan energy, the descriptor shall be broken down into its components so that supply fan energy can be modeled separately.
- (d) Minimum outdoor air ventilation rates shall be the same for both the standard design and the proposed design.
- (e) 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. The maximum number of unmet hours shall not exceed 300 for either case.

Table 9.1 Modeling Requirements for Calculating Proposed and Standard Design

Case	Proposed Building	Standard Design
1. Design Model	<p>(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 control; and service water heating systems and controls.</p> <p>(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 § 7</p>	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 § 6.3.2 or 6.3.3. 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	<p>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.</p> <p>Exceptions: The following building elements are permitted to differ from architectural drawings.</p> <p>(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.</p> <p>(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.</p> <p>(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 §3.3.1.1</p> <p>(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.</p>	<p>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.</p> <p>(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.</p> <p>(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 §3.3.1 and §3.3.2.</p> <p>(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.</p> <p>(d) Roof albedo. All roof surfaces shall be modeled with a reflectivity of 0.30.</p>

Case	Proposed Building	Standard Design
5. Lighting	<p>Lighting power in the proposed design shall be determined as follows:</p> <p>(a) Where a complete lighting system exists, the actual lighting power shall be used in the model.</p> <p>(b) Where a lighting system has been designed, lighting power shall be determined in accordance with either §6.3.2 or §6.3.3.</p> <p>(c) Where no lighting exists or is specified, lighting power shall be determined in accordance with the § 6.3.2 for the appropriate building type.</p> <p>(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).</p>	<p>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 lighting power set equal to the maximum allowed for the corresponding method and category in either §6.3.2 or §6.3.3. 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.</p>
6. HVAC Systems	<p>The HVAC system type and all related performance parameters, such as equipment capacities and efficiencies, in the proposed design shall be determined as follows:</p> <p>(a) Where a complete HVAC System exists, the model shall reflect the actual system type using actual component capacities and efficiencies.</p> <p>(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 §4, if required by the simulation model.</p> <p>(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.</p> <p>(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.</p>	<p>The HVAC system type and related performance parameters for the standard design shall be determined from Table 9.2: HVAC Systems Map. Equipment performance shall meet the requirements of § 4.</p>
7. Service Hot Water	<p>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:</p> <p>(a) Where a complete service hot water system exists, the model shall reflect the actual system type using actual component capacities and efficiencies.</p> <p>(b) Where a service hot water system has been designed , the service hot water model shall be consistent with design documents.</p> <p>(c) Where no service hot water system exists or is specified, no service hot water heating shall be modeled.</p>	<p>The water heating 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 §5.2.2, the pipe insulation requirements of §5.2.4 and incorporate heat traps in accordance with §5.2.5.</p>

Case	Proposed Building	Standard Design
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 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, 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.	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
9 Modeling Limitations to the Simulation program	<p>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:</p> <p>(a) Ignore the component if the energy impact on the trade-offs being considered is not significant.</p> <p>(b) Model the component substituting a thermodynamically similar component model.</p> <p>(c) Model the HVAC system components or systems using the standard design's HVAC system in accordance with Section 6 of this table.</p> <p>Whichever method is selected, the component shall be modeled identically for both the proposed design and standard design models.</p>	Same as proposed design.

Table 9.2: HVAC Systems Map

<i>Non Residential</i>				
	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 m²
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 variable air volume AHU for each zone
Fan control	Constant volume	Constant volume	Constant volume air handler for each zone	Variable volume air handler
Cooling type	Direct expansion	Direct expansion	Chilled water*	Chilled water*
Heating type	Electric resistance	Electric resistance	Electric resistance	Electric resistance

*If the proposed building has an air cooled chiller/system then the budget building shall have Air cooled chiller otherwise the budget case shall have water cooled centrifugal chillers. If the building has a mix of Air and Water cooled chillers then, the baseline building shall have the mix of air and water cooled chillers in the same proportion.

Chiller Efficiencies shall be as per Table 4.1.

10. Appendix C: Default Values for Typical Constructions

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

§3.2.1.1 and §3.2.1.2 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 §3.4 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 of ISO 15099: 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 of ISO 15099: Frame and divider SHGC's shall be calculated in accordance with § 4.2.2.
- (c) §6.4 of ISO 15099 refers the issue of material properties to national standards. Material conductivities and emissivities shall be determined in accordance with Indian standards.
- (d) §7 of ISO 15099 on shading systems is currently excluded.
- (e) §8.2 of ISO 15099 addresses environmental conditions. The following are defined for India:

For U-factor calculations:

$T_{in} = 24 \text{ }^\circ\text{C}$

$T_{out} = 32 \text{ }^\circ\text{C}$

$V = 3.35 \text{ m/s}$

$T /_{m,out} = T_{out}$

$T /m, in = T_{in}$

$I_s = 0 \text{ W/m}^2$

For SHGC calculations :

$T_{in} = 24 \text{ }^\circ\text{C}$

$T_{out} = 32 \text{ }^\circ\text{C}$

$V = 2.75 \text{ m/s}$

$T /_{m,out} = T_{out}$

$T /m, in = T_{in}$

$I_s = 783 \text{ W/m}^2$

- (f) §8.3 of ISO 15099 addresses convective film coefficients on the interior and exterior of the window product. In §8.3.1 of ISO 15099, 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 of ISO 15099, the formula from this section shall be applied to all outdoor exposed surfaces
- (g) §8.4.2 of ISO 15099 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 of ISO 15099 (Two-Dimensional Element to Element View Factor Based Radiation Heat Transfer Calculation). The alternate approach in §8.4.3 of ISO 15099 shall not be used

10.2 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.

10.2.1 Unrated vertical fenestration:

Unlabeled vertical fenestration, both operable and fixed, shall be assigned the U-factors, SHGC s, and visible light transmittances in Table 10.1.

Table 10.1 Defaults for Unrated Vertical Fenestration (Overall Assembly including the Sash and Frame)

Frame type	Glazing Type	Clear Glass			Tinted Glass		
		U factor (W/m ² .°C)	SHGC	VLT	U-Factor (W/m ² .°C)	SHGC	VLT
All frame types	Single Glazing	7.1	0.82	0.76	7.1	0.70	0.58
Wood, vinyl, or fiber, glass Frame	Double Glazing	3.3	0.59	0.64	3.4	0.42	0.39
Metal and Other frame type	Double Glazing	5.1	0.68	0.66	5.1	0.50	0.40

10.2.2 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 10.1. To determine the default U-factor for unrated sloped glazing and skylights without a curb, multiply the values in Table 10.1 by 1.2. To determine the default U-factor for unrated skylights on a curb, multiply the values in Table 10.1 by 1.6.

10.3 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:

$$U_{\text{Total Roof}} = \frac{1}{\frac{1}{U_{\text{Typical Roof}}} + \frac{1}{U_{\text{Typical Insulation}}}}$$

where

$U_{\text{Total Roof}}$ Total U-factor of the roof with insulation

$U_{\text{Typical Roof}}$ U-factor of the roof

$U_{\text{Typical Insulation}}$ U-factor of the effective insulation from Table 10.2

Table 10.2: Defaults for effective U-Factor for Exterior Insulation layers (under review)

Thickness	R- Value	U=Factor (W/m ² - °k)
15mm(0.5")	0.70 (4)	1.420
20 mm(0.75")	1.06 (6)	0.946
25 mm (1.0")	1.41 (8)	0.710
40 mm(1.5")	2.11 (12)	0.568
50 mm(2.0")	2.82 (16)	0.406
65 mm (2.5")	3.52 (20)	0.284
75 mm(3.0")	3.70 (21)	0.270

10.4 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:

$$U_{\text{Total Wall}} = \frac{1}{\frac{1}{U_{\text{Typical Wall}}} + \frac{1}{U_{\text{Typical Insulation}}}}$$

where

$U_{\text{Total Wall}}$ Total U-factor of the wall with insulation

$U_{\text{Typical Wall}}$ U-factor of the wall from

$U_{\text{Typical Insulation}}$ U-factor of the effective insulation from

Table 10.3 or Table 10.4

Table 10.3 : Defaults for effective U-Factor for Exterior Insulation Layers (under review)

Thickness	R- value	U-factor (W/m ² - °k)
15mm(0.5")	0.70 (4)	1.262
20 mm(0.75")	1.06 (6)	0.874
25 mm (1.0")	1.41 (8)	0.668
40 mm(1.5")	2.11 (12)	0.454
50 mm(2.0")	2.82 (16)	0.344
65 mm (2.5")	3.52 (20)	0.277
75 mm(3.0")	3.70 (21)	0.264

Table 10.4: Typical Thermal Properties of Common Building and Insulating Materials - Design Values^a (Source: ASHRAE Fundamentals Handbook, 2001)

Description	Density kg/m ³	Conductivity ^b (K), W/ (m. K)	Conductance (C), W/ (m ² K)	Resistance ^c (R)		Specific Heat, kJ/ (kg K)
				1/k, Km ² /W	For Thickness Listed (1/C), K m ² /W	
BUILDING BOARD						
Asbestos- cement board...	1900	0.58	--	1.73	--	1.00
Asbestos- cement board....3.2mm	1900	--	187.4	--	0.05	--
Asbestos- cement board.....6.4mm	1900	--	93.7	--	0.011	--
Gypsum or plaster board...9.5 mm	800	-	17.6	--	0.056	1.09
Gypsum or plaster board...12.7 mm	800	--	12.6	--	0.079	--
Gypsum or plaster board...15.9 mm	800	--	10.1	--	0.099	--
Plywood (Douglas fir) ^d	540	0.12	--	8.66	--	1.21
Plywood or wood panels....19.0mm	540	--	6.1	--	0.16	1.21
Vegetable fiber board						
Sheathing, regular density ^e						
..... 12.7mm	290	--	4.3	--	0.23	1.30
..... 19.8 mm	290	--	2.8	--	0.36	--
Sheathing intermediate density ^e						
.....12.7 mm...	350	--	5.2	--	0.19	1.30
Nail base sheathing ^e12.7mm	400	--	5.3	--	0.19	1.30
Shingle backer ... 9.5mm	290	--	6.0	--	0.17	1.30
Sound deadening board ...12.7mm	240	--	4.2	--	0.24	1.26
Tile and lay in panels, plain or acoustic						
.....12.7 mm	290	--	4.5	--	0.22	--
.....19.0 mm	290	--	3.0	--	0.33	--
Laminated paper board	480	0.072	--	13.9	--	1.38
Homogeneous board from repulped paper.....						
	480	0.072	--	13.9	--	1.17
Hardboard ^e						
Medium density	800	0.105	--	9.50	--	1.30
High density, Service-tempered grade & service grade	880	0.82	--	8.46	--	1.34
High density, standard-tempered grade.....	1010	0.144	--	6.93	--	1.34

Description	Density kg/m ³	Conductivity ^b (K), W/ (m. K)	Conductance (C), W/ (m ² K)	Resistance ^c (R)		Specific Heat, kJ/ (kg K)
				1/k, Km ² /W	For Thickness Listed (1/C), K m ² /W	
Particle board ^e -						
Low density.....	590	0.102	--	9.77	--	1.30

Medium density	800	0.135	--	7.35	--	1.30
High density.....	1000	0.170	--	5.90	--	1.30
Underlayment15.9mm	640	--	6.9	--	0.14	1.21
Wafer board	590	0.01	--	11.0	--	--
Wood sub floor..... 19.0mm	--	--	6.0	--	0.17	1.38

BUILDING MEMBRANE

Vapor- permeable felt	--	--	94.9	--	0.011	--
Vapor-seal, 2 layers of mopped 0.73kg/m ² felt....	--	--	47.4	--	0.21	--
Vapor seal, plastic film	--	--	--	--	Negl.	--

FINISH FLOORING MATERIALS

Carpet and fibrous pad.....	--	--	2.73	--	0.37	1.42
Carpet and rubber pad.....	--	--	4.60	--	0.22	1.38
Cork tile3.2mm	--	--	20.4	--	0.049	2.01
Terrazzo.....25mm	--	--	71.0	--	0.014	0.80
Tile – asphalt, linoleum, vinyl, rubber...	--	--	113.6	--	0.009	1.26
Vinyl asbestos.....	--	--	--	--	--	1.01
Ceramic.....	--	--	--	--	--	0.80
Wood, hardwood finish... 19mm	--	--	8.35	--	0.12	--

INSULATING MATERIALS

Blanket and batt ^{f9}						
Mineral fiber, fibrous form processed from rock, slag, or glass						
approx. 75-100mm.....	6.4-32	--	0.52	--	1.94	--
approx. 90mm.....	6.4-32	--	0.44	--	2.29	--
approx. 90mm.....	19-26	--	0.38	--	2.63	--
approx. 140-165.....	6.4-32	--	0.30	--	3.32	--
approx. 140mm.....	10-16	--	0.27	--	3.67	--
approx. 150-190mm.....	6.4-32	--	0.26	--	3.91	--

Description	Density kg/m ³	Conductivity ^b (K), W/(m. K)	Conductance (C), W/ (m ² K)	Resistance ^c (R)		Specific Heat, kJ/ (kg K)
				1/k, Km ² /W	For Thicknes s Listed (1/C), K m ² /W	
approx. 210-250mm.....	6.4-32	--	0.19	--	5.34	--
approx. 250-330mm.....	6.4-32	--	0.15	--	6.77	--
Board and slabs						
Cellular glass.....	136	0.050	--	19.8	--	0.75
Glass fiber, organic bonded.....	64-140	0.036	--	27.7	--	0.96
Expanded perlite, organic bonded	16	0.052	--	19.3	--	1.26
Expanded rubber (rigid).....	72	0.032	--	31.6	--	1.68
Expanded polystyrene, extruded (smooth skin surface) CFC -12 exp).....	29-56	--	--	--	--	--
Expanded polystyrene extruded (smooth skin surface)	--	--	--	--	--	--

Description	Density kg/m ³	Conductivity ^p (K), W/(m.K)	Conductance (C), W/ (m ² K)	Resistance ° (R)		Specific Heat, kJ/ (kg K)
				1/k, Km ² /W	For Thicknes s Listed (1/C), K m ² /W	
(HCFC-142 b exp.) ^h	29-56	0.029	--	34.7	--	1.21
Expanded polystyrene, molded beads	16	0.037	--	26.7	--	--
	20	0.036	--	27.7	--	--
	24	0.035	--	28.9	--	--
	28	0.035	--	28.9	--	--
	32	0.033	--	30.2	--	--
Cellular polyurethane/ polyisocyanurate ¹ (CFC-11exp.) (unfaced).....	24	0.023-0.026	--	43.3- 38.5	--	1.59
Cellular polyisocyanurate i... .. (CFC-11 exp.) (gas- permeable facers).....	24-40	0.023-0.026	--	43.3- 38.5	--	0.92
Cellular polyisocyanurate j (CFC-11 exp) (gas-impermeable facers).....	32	0.020	--	48.8	--	0.92
Cellular phenolic (closed cell). (CFC-11, CFC-113 exp.) ^k	32	0.017	--	56.8	--	--
Cellular phenolic (open cell).....	29-35	0.033	--	30.5	--	--
Mineral fiber with resin binder...	240	0.042	--	23.9	--	0.71
Mineral fiberboard, wet felted						
Core or roof insulation.....	260-270	0.049	--	20.4	--	--
Acoustical tile.....	290	0.050	--	19.8	--	0.80
Acoustical tile.....	340	0.053	--	18.7	--	--
Mineral fiberboard, wet molded						
Acoustical tile ¹	370	0.060	--	16.5	--	0.59
Wood or cane fiberboard						
Acoustic tile ¹ 12.7mm	--	--	4.5	--	0.22	1.30
Acoustical tile ¹19.0mm	--	--	3.0	--	0.33	--
Interior finish (plank, tile)	240	0.050	--	19.8	--	1.34
Cement fiber slabs (shredded wood with Portland cement binder).....	400-430	0.072-0.076	--	13.9- 13.1	--	--
Cement fiber slabs (shredded wood with magnesia oxysulfide binder).....	350	0.082	--	12.1	--	1.30
<i>LooseFill</i>						
Cellulosic insulation (milled paper or wood pulp .).....	37-51	0.039-0.046	--	25.6- 21.7	--	1.38
Perlite; expanded	32-66	0.039-0.045	--	25.6- 22.9	--	1.09
	66-120	0.045-0.052	--	22.9- 19.4	--	--
	120-180	0.052-0.060	--	19.4- 16.6	--	--
Mineral fiber (rock, slag or glass) ⁹ approx 95-130mm...	9.6-32	--	--	--	1.94	0.71

Description	Density kg/m ³	Conductivity ^p (K), W/(m.K)	Conductance (C), W/ (m ² K)	Resistance ° (R)		Specific Heat, kJ/ (kg K)
				1/k, Km ² /W	For Thicknes s Listed (1/C), K m ² /W	
approx 170-220mm...	9.6-32	--	--	--	3.35	--
approx 190-250mm...	9.6-32	--	--	--	3.87	--
approx 260-350mm...	9.6-32	--	--	--	5.28	--
Mineral fiber (rock, slag, or glass) ^q approx. 90mm (closed side wall application).....	32-56	--	--	--	2.1-2.5	--
Vermiculite, exfoliated.....	110-130	0.068	--	14.8	--	1.34
	64-96	0.063	--	15.7	--	--
Spray Applied Polyurethane foam....	24-40	0.023-0.026	--	43.3- 38.5	--	--
Urea formaldehyde foam...	11-26	0.032-0.040	--	31.5- 24.7	--	--
Cellulosic fiber	56-96	0.042-0.049	--	23.9- 20.4	--	--
Glass fiber	56-72	0.038-0.039	--	26.7- 25.6	--	--
<i>Reflective Insulation</i>						
Reflective material ($\epsilon < 0.5$) in center of 20mm cavity forms two 10mm vertical air spaces ^m	--	--	1.76	--	0.57	--
METALS						
(See Chapter 38, Table 3 of ASHRAE Fundamentals Handbook 2001)						
ROOFING						
Asbestos- cement shingles.....	1900	--	27.0	--	0.037	1.00
Asphalt roll roofing.....	1100	--	36.9	--	0.026	1.51
Asphalt shingles	1100	--	12.9	--	0.077	1.26
Built -up roofing10mm	1100	--	17.0	--	0.058	1.46
Slate13mm	--	--	114	-	0.009	1.26
Wood shingles. plain and plastic film faced	--	--	6.0	--	0.166	1.30
PLASTERING MATERIALS						
Cement plaster, sand aggregate...	1860	0.72	--	1.39	--	0.84
Sand aggregate10mm	--	--	75.5	--	0.013	0.84
Sand aggregate20mm	--	--	37.8	--	0.026	0.84
Gypsum plaster:						
Lightweight aggregate13mm	720	--	17.7	--	0.056	--
Lightweight aggregate.....16mm	720	--	15.2	--	0.066	--
Lightweight aggregate on metal lath19mm	--	--	12.1	--	0.083	--
Perlite aggregate	720	0.22	--	4.64	--	1.34
Sand aggregate	1680	0.81	--	1.25	--	0.84
Sand aggregate13mm	1680	--	63.0	--	0.016	--
Sand aggregate16mm	1680	--	51.7	--	0.019	--
Sand aggregate on metal lath19mm	--	--	43.7	--	0.023	--
Vermiculite aggregate.....	720	0.24	--	4.09	--	--

Description	Density kg/m ³	Conductivity ^b (K), W/(m. K)	Conductance (C), W/ (m ² K)	Resistance ° (R)		Specific Heat, kJ/ (kg K)
				1/k, Km ² /W	For Thicknes s Listed (1/C), K m ² /W	
MASONRY MATERIALS						
<i>Masonry Units</i>						
Brick, fired clay.....	2400	1.21-1.47	--	0.83- 0.68	--	--
	2240	1.07-1.30	--	0.94- 0.77	--	--
	2080	0.92-1.12	--	1.08- 0.89	--	--
	1920	0.81-0.98	--	1.24- 1.02	--	0.79
	1760	0.71-0.85	--	1.42- 1.18	--	--
	1600	0.61-0.74	--	1.65- 1.36	--	--
	1440	-0.52-0.62	--	1.93- 1.61	--	--
	1280	0.43-0.53	--	2.31- 1.87	--	--
	1120	0.36-0.45	--	2.77- 2.23	--	--
Clay tile, hollow						
1 cell deep..... 75mm	--	--	7.10	--	0.14	0.88
1 cell deep.....100mm	--	--	5.11	--	0.20	--
2 cells deep...150mm	--	--	3.75	--	0.27	--
2 cells deep...200mm	--	--	3.07	--	0.33	--
2 cells deep...250mm	--	--	2.56	--	0.39	--
3 cells deep...300mm	--	--	2.27	--	0.44	--
Concrete blocks ^{n,o}						
Limestone aggregate						
200mm, 16.3kg, 2210 kg/m ³ concrete, 2 cores...	--	--	--	--	--	--
same with perlite filled cores	--	--	2.73	--	0.37	--
300mm, 25kg, 2210kg/m ³ concrete, 2 cores.....	--	--	--	--	--	--
Same with perlite filled cores....	--	--	1.53	--	0.65	--
Normal mass aggregate (sand and gravel) 200mm						
15-16 kg, 2020-2180 kg/ m ³ concrete, 2 or 3 cores.....	--	--	5.1-5.8	--	0.20-0.17	0.92
Same with perlite filled cores...	--	--	2.84	--	0.35	--
Same with vermiculite filled cores	--	--	3.0-4.1	--	0.34-0.24	--
300mm, 22.7kg, 2000kg/ m ³ concrete, 2 cores	--	--	4.60	--	0.217	0.92
Medium mass aggregate (combi nations of normal and low mass aggregate) 200mm, 12-13 kg, 1550- 1790 kg/ m ³ concrete, 2 or 3 cores...	--	--	3.3-4.4	--	0.30-0.22	--

Description	Density kg/m ³	Conductivity ^b (K), W/(m.K)	Conductance (C), W/ (m ² K)	Resistance ° (R)		Specific Heat, kJ/ (kg K)
				1/k, Km ² /W	For Thicknes s Listed (1/C), K m ² /W	
Same with perlite filled cores.....	--	--	1.5-2.5	--	0.65-0.41	--
Same with vermiculite filled cores...	--	--	1.70	--	0.58	--
Same with molded EPS (beads) filled cores.....	--	--	1.82	--	0.56	--
Same with molded EPS inserts in cores.....	--	--	2.10	--	0.47	--
Low mass aggregate (expanded shale, clay, slate or slag, pumice) 150 mm 7.3- 7.7 kg, 1360-1390 kg/m ³ concrete, 2 or 3 cores.....	--	--	3.0-3.5	--	0.34-0.29	--
Same with perlite filled cores.....	--	--	1.36	--	0.74	--
Same with vermiculite filled cores	--	--	1.87	--	0.53	--
200mm, 8.6-10.0mm, 1150-1380 kg/ m ³ concrete	--	--	1.8-3.1	--	0.56-0.33	0.88
Same with perlite filled cores.....	--	--	0.9-1.3	--	1.20-0.77	--
Same with vermiculite filled cores	--	--	1.1-1.5	--	0.93-0.69	--
Same with molded EPS (beads) filled cores	--	--	1.19	--	0.85	--
Same with UF foam filled cores.....	--	--	1.25	--	0.79	--
Same with molded EPS inserts in cores.....	--	--	1.65	--	0.62	--
300mm, 14.5-16.3 kg, 1280-1440 kg/ m ³ concrete, 2 or 3 cores.....	--	--	2.2-2.5	--	0.46-0.40	--
Same with perlite filled cores.....	--	--	0.6-0.9	--	1.6-1.1	--
Same with vermiculite filled cores	--	--	0.97	--	1.0	--
Stone, lime, or sand						
Quartzitic and sandstone	2880	10.4	--	0.10	--	--
	2560	6.2	--	0.16	--	--
	2240	3.5	--	0.29	--	--
	1920	1.9	--	0.53	--	0.79
Calcitic, dolomitic, limestone, marble, and granite.....	2880	4.3	--	0.23	--	--
	2560	3.2	--	0.32	--	--
	2240	2.3	--	0.43	--	--
	1920	1.6	--	0.63	--	0.79
	1600	1.1	--	0.90	--	--
Gypsum partition tile						
75 by 300 by 760mm, solid.....	--	--	4.50	--	0.222	0.79
75 by 300 by 760mm, 4 cells.....	--	--	4.20	--	0.238	--
100 by 300 by 760mm, 3 cells ...	--	--	3.40	--	0.294	--
Concretes ^o						
Sand and gravel or stone	2400	1.4-2.9	--	0.69-	--	--

Description	Density kg/m ³	Conductivity ^b (K), W/(m.K)	Conductance (C), W/ (m ² K)	Resistance ° (R)		Specific Heat, kJ/ (kg K)
				1/k, Km ² /W	For Thicknes s Listed (1/C), K m ² /W	
aggregate concretes (concretes with more than				0.35		
50% quartz or quartzite sand have	2240	1.3-2.6	--	0.77- 0.39	--	0.8- 1.0
conductivities in the higher end of the range)	2080	1.0-1.9	--	0.99- 053	--	--
Limestone concretes.....	2240	1.60	--	0.62	--	--
	1920	1.14	--	0.88	--	--
	1600	0.79	--	1.26	--	--
Gypsum- fiber concrete (87.5% gypsum, 12.5% wood chips)	816	0.24	--	4.18	--	0.88
Cement/lime, mortar and stucco...	1920	1.40	--	0.71	--	--
	1600	0.97	--	1.04	--	--
	1280	0.65	--	1.54	--	--
Lightweight aggregate concretes						
Expanded shale, clay or slate; expanded slags;	1920	0.9-1.3	--	1.08- 0.76	--	
cinders; pumice (with density up to 1600 kg/m ³);	1600	0.68-0.89	--	1.48- 1.12	--	0.84
and scoria (sanded concretes have conductivities in	1280	0.48-0.59	--	2.10- 1.69	--	0.84
the higher end of the range).....	960	0.30-0.36	--	3.30- 2.77	--	--
	640	0.18	--	5.40	--	--
Perlite, vermiculite, and polystyrene beads.....	800	0.26-0.27	--	3.81-3.68	--	--
	640	0.20-0.22	--	4.92-4.65	--	0.63- 0.96
	480	0.16	--	6.31	--	--
	320	0.12	--	8.67	--	--
Foam concretes.....	1920	0.75	--	1.32	--	--
	1600	0.60	--	1.66	--	--
	1280	0.44	--	2.29	--	--
	1120	0.36	--	2.77	--	--
Foam concretes and cellular concretes.....	960	0.30	--	3.33	--	--
	640	0.20	--	4.92	--	--
	320	0.12	--	8.67	--	--
SIDING MATERIALS (on flat surface)						
<i>Shingles</i>						
Asbestos- cement	1900	--	27.0	--	0.037	--

Description	Density kg/m ³	Conductivity ^b (K), W/(m. K)	Conductance (C), W/ (m ² K)	Resistance ° (R)		Specific Heat, kJ/ (kg K)
				1/k, Km ² /W	For Thicknes s Listed (1/C), K m ² /W	
Wood, 400mm, 190mm exposure.....	--	--	6.53	--	0.15	1.30
Wood, double, 400mm, 300mm exposure.....	--	--	4.77	--	0.21	1.17
Wood, plus insul. backer board,8mm <i>Siding</i>	--	--	4.03	--	0.25	1.30
Asbestos –cement, 6.4mm, lapped	--	--	27.0	--	0.037	1.01
Asphalt roll siding.....	--	--	36.9	--	0.026	1.47
Asphalt insulating siding (12.7mm bed).....	--	--	3.92	--	0.26	1.47
Hardboard siding, 11mm.....	--	--	8.46	--	0.12	1.17
Wood, drop , 20 by 200mm.....	--	--	7.21	--	0.14	1.17
Wood, bevel, 13 by 200mm, lapped.....	--	--	6.98	--	0.14	1.17
Wood, bevel, 19 by 250mm, lapped.....	--	--	5.40	--	0.18	1.17
Wood, plywood, 9.5mm, lapped	--	--	9.60	--	0.10	1.22
Aluminum, steel, or vinyl ^{p,q} over sheathing						
Hollow-backed.....	--	--	9.31	--	0.11	1.22 ^d
Insulating-board backed.....						
9.5mm nominal.....	--	--	3.12	--	0.32	1.34
9.5mm nominal, foil backed	--	--	1.93	--	0.52	--
Architectural (soda-lime float) glass	--	--	56.8	--	0.018	0.84
WOODS (12% moisture content)^{e,f}						
Hardwoods	-	-	-	-	-	1.63 ^g
Oak.....	659-749	0.16-0.18	-	6.2-5.5	-	-
Birch	682-726	0.167-0.176	-	6.0-5.7	-	-
Maple	637-704	0.157-0.171	-	6.4-5.8	-	-
Ash.....	614-670	0.153-0.164	-	6.5-6.1	-	-
Softwoods						1.63 ^g
Southern pine.....	570-659	0.144-0.161	-	6.9-6.2	-	-
Douglas fir- Larch.....	536-581	0.137-0.145	-	7.3-6.9	-	-
Southern cypress.....	502-514	0.130-0.132	-	7.7-7.6	-	-
Hem –Fir, Spruce- Pine-Fir....	392-502	0.107-0.130	-	9.3-7.7	-	-
West coast woods, Cedars.....	347-502	0.098-0.130	-	10.3-7.7	-	-
California redwood.....	392-448	0.107-0.118	-	9.4-8.5	-	-

*For referencing a, b, c etc. of the above table, refer to the notes on next pages

❖ **NOTES OF TABLE 10.4**

^aValues are for a mean temperature of 24°C. Representative values for dry materials are intended as design (not specification) values for materials in normal use. Thermal values of insulating materials may differ from design values depending on their in-situ properties

(e.g., density and moisture content, orientation, etc.) and variability experienced during manufacture. For properties of a particular product, use the value supplied by the manufacturer or by unbiased tests.

^b The symbol λ is also used to represent thermal conductivity.

^c Resistance values are the reciprocals of C before rounding off C to two decimal places.

^d Lewis (1967).

^e U.S. Department of Agriculture (1974).

^f Does not include paper backing and facing, if any. Where insulation forms a boundary (reflective or otherwise) of an airspace, see Tables 2 and 3 for the insulating value of an airspace with the appropriate effective emittance and temperature conditions of the space.

^g Conductivity varies with fiber diameter. (See Chapter 23, Factors Affecting Thermal Performance). Batt, blanket, and loose-fill mineral fiber insulations are manufactured to achieve specified R-values, the most common of which are listed in the table. Due to differences in manufacturing processes and materials, the product thicknesses, densities, and thermal conductivities vary over considerable ranges for a specified R-value.

^h This material is relatively new and data are based on limited testing.

ⁱ For additional information, see Society of Plastics Engineers (SPI) Bulletin U108. Values are for aged, unfaced board stock. For change in conductivity with age of expanded polyurethane/ polyisocyanurate, see Chapter 23, Factors Affecting Thermal Performance.

^j Values are for aged products with gas-impermeable facers on the two major surfaces. An aluminum foil facer of 25 μm thickness or greater is generally considered impermeable to gases. For change in conductivity with age of expanded polyisocyanurate, see Chapter 23, Factors Affecting Thermal Performance, and SPI Bulletin U108.

^k Cellular phenolic insulation may no longer be manufactured. The thermal conductivity and resistance values do not represent aged insulation, which may have a higher thermal conductivity and lower thermal resistance.

^l Insulating values of acoustical tile vary, depending on density of the board and on type, size, and depth of perforations.

^m Cavity is framed with 20mm wood furring strips. Caution should be used in applying this value for other framing materials. The reported value was derived from tests and applies to the reflective path only. The effect of studs or furring strips must be included in determining the overall performance of the wall.

ⁿ Values for fully grouted block may be approximated using values for concrete with a similar unit density.

^o Values for concrete block and concrete are at moisture contents representative of normal use.

^p Values for metal or vinyl siding applied over flat surfaces vary widely, depending on amount of ventilation of airspace beneath the siding; whether airspace is reflective or non reflective; and on thickness, type, and application of insulating backing-board used. Values are averages for use as design guides, and were obtained from several guarded hot box tests (ASTM C 236) or calibrated hot box (ASTM C 976) on hollow-backed types and types made using backing of wood fiber, foamed plastic, and glass fiber. Departures of $\pm 50\%$ or more from these values may occur.

^q Vinyl specific heat = 1.0 kJ/(kg.K)

^r See Adams (1971), MacLean (1941), and Wilkes (1979). The conductivity values listed are for heat transfer across the grain. The thermal conductivity of wood varies linearly with the density, and the density ranges listed are those normally found for the wood species given. If the density of the wood species is not known, use the mean conductivity value. For extrapolation to other moisture contents, the following empirical equation developed by Wilkes (1979) may be used:

$$(4.895 \times 10^{-3} + 1.503 \times 10^{-4}M)p$$

$$k = 0.7494 + \frac{(4.895 \times 10^{-3} + 1.503 \times 10^{-4}M)p}{1 + 0.01M}$$

where p is density of the moist wood in kg/m³, and M is the moisture content in percent.

^s From Wilkes (1979), an empirical equation for the specific heat of moist wood at 24°C is as follows:

$$(0.299 + 0.01M)$$

$$C_p = 0.1442 \times \frac{(0.299 + 0.01M)}{(1 + 0.01M)} + \Delta C_p$$

where ΔC_p accounts for the heat of absorption and is denoted by $\Delta C_p = M (0.008037 - 1.325 \times 10^{-4}M)$

where M is the moisture content in percent by mass.

Assuming parallel heat flow only, the calculated resistance is higher than that calculated on the assumption of isothermal planes. The actual resistance generally is some value between the two calculated values. In the absence of test values, examination of the construction usually reveals whether a value closer to the higher or lower calculated R-value should be used. Generally, if the

construction contains a layer in which lateral conduction is high compared with transmittance through the construction, the calculation with isothermal planes should be used. If the construction has no layer of high lateral conductance, the parallel heat flow calculation should be used.

Hot box tests of insulated and uninsulated masonry walls constructed with block of conventional configuration show that thermal resistances calculated using the isothermal planes heat flow method agree well with measured values (Van Geem 1985, Valore 1980, Shu et al. 1979). Neglecting horizontal mortar joints in conventional block can result in thermal transmittance values up to 16% lower than actual, depending on the density and thermal properties of the masonry, and 1 to 6% lower, depending on the core insulation material (Van Geem 1985, McIntyre 1984). For aerated concrete block walls, other solid masonry, and multicore block walls with full mortar joints, neglecting mortar joints can cause errors in R-values up to 40% (Valore 1988). Horizontal mortar joints usually found in concrete block wall construction are neglected in Example 2.

Constructions Containing Metal

Curtain and metal stud-wall constructions often include metallic and other thermal bridges, which can significantly reduce the thermal resistance. However, the capacity of the adjacent facing materials to transmit heat transversely to the metal is limited, and some contact resistance between all materials in contact limits the reduction. Contact resistances in building structures are only 0.01 to 0.1 K.m²/W-too small to be of concern in many cases. However, the contact resistances of steel framing members may be important. Also, in many cases (as illustrated in Example 3), the area of metal in contact with the facing greatly exceeds the thickness of the metal, which mitigates the contact resistance effects.

Thermal characteristics for panels of sandwich construction can be computed by combining the thermal resistances of the various layers. R-values for the assembled sections should be determined on a representative sample by using a hot box method. If the sample is a wall section with air cavities on both sides of fibrous insulation, the sample must be of representative height since convective airflow can contribute significantly to heat flow through the test section. Computer modeling can also be useful, but all heat transfer mechanisms must be considered. In Example 3, the metal member is only 0.5 mm thick, but it is in contact with adjacent facings over a 32mm-wide area. The steel member is 90 mm deep, has a thermal resistance of approximately 0.0019 K.m²/W, and is virtually isothermal. The calculation involves careful selection of the appropriate thickness for the steel member. If the member is assumed to be 0.5 mm thick, the fact that the flange transmits heat to the adjacent facing is ignored, and the heat flow through the steel is underestimated. If the member is assumed to be 32 mm thick, the heat flow through the steel is overestimated. In Example 3, the steel member behaves in much the same way as a rectangular member 32 mm thick and 90 mm deep.

11. Appendix D: Building Envelope Tradeoff Method

11.1 The Envelope Performance Factor

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

$$\text{Equation 11-1: } EPF_{\text{Total}} = EPF_{\text{Roof}} + EPF_{\text{Wall}} + EPF_{\text{Fenest}}$$

Where

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

$$EPF_{\text{wall}} = C_{\text{Wall, Mass}} \sum_{s=1}^n U_s A_s + C_{\text{Wall, other}} \sum_{s=1}^n U_s A_s$$

$$EPF_{\text{Fenest}} = C_{1, \text{Fenest, North}} \sum_{w=1}^n SHGC_w M_w A_w + C_{2, \text{Fenest, North}} \sum_{w=1}^n U_w A_w +$$

$$C_{1, \text{Fenest, Non North}} \sum_{w=1}^n SHGC_w M_w A_w + C_{2, \text{Fenest, Non North}} \sum_{w=1}^n U_w A_w +$$

$$C_{1, \text{Fenest, Skylight}} \sum_{s=1}^n SHGC_s A_s + C_{2, \text{Fenest, Skylight}} \sum_{s=1}^n U_s A_s$$

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). SHGCs 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.

C_{wall} A coefficient for the "Wall"

C_{1 Fenest} A coefficient for the "Fenestration 1"

C_{2 Fenest} A coefficient for the "Fenestration 2"

Values of "C" are taken from table 11.1 through table 11.5 for each class of construction

Table 11.1 : Envelope Performance Factor Coefficients – Composite Climate (under review)

	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 11.2 : Envelope Performance Factor Coefficients – Hot Dry Climate (under review)

	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 11.3 : Envelope Performance Factor Coefficients – Hot Humid Climate (under review)

	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 11. 4: Envelope Performance Factor Coefficients -Moderate Climate (under review)

	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 11.5 : Envelope Performance Factor Coefficients – Cold Climate (under review)

	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

11.1.2 Overhang and Side Fin Coefficients

The “M” multiplication factor can also be calculated using Equation 11-2. If the equation is used, a separate calculation shall be made for each orientation and unique shading condition.

Equation 11-2: $M = a \cdot PF^2 + b \cdot PF + 1$

Table 11.6 : 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

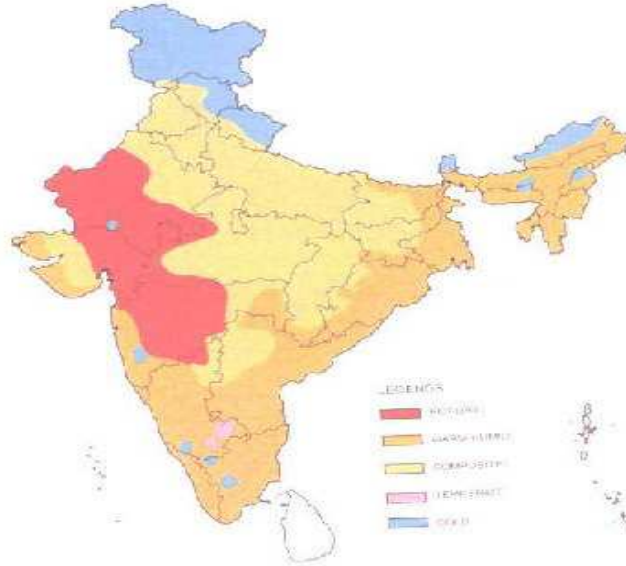
11.1.3 Baseline Building Definition:

The following rules shall be used to define the Baseline Building for Envelope Trade Off

- The Baseline 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 he proposed design
- The U-factor of each envelope component shall be equal to the criteria from §3.3 for each class of construction
- 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
- The SHGC of each window or skylight component shall be equal to the criteria from §3.3

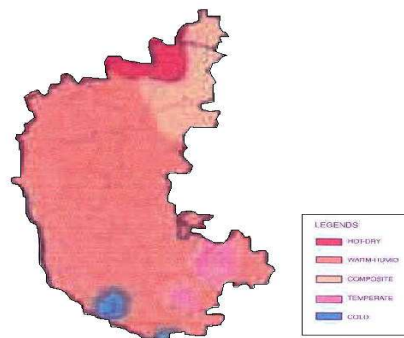
12.Appendix E: Climate Zone Map of India

Appendix E: Climate Zone Map of India



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

12.1 Climate Zone Map of Karnataka



12.2 District wise details of latitudes and longitudes of Karnataka

District wise details of latitudes and longitudes of karnataka:

The Indian State of Karnataka is located within 11°30' North and 18°30' North latitudes and 74° East and 78°30' East longitude. The following are the districts of Karnataka with latitudes and longitude.

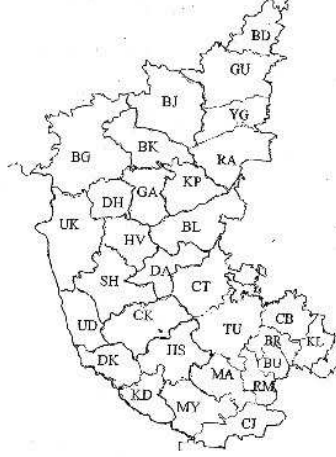


Table 12.1 showing details of District wise latitude and longitude

Sl.No.	Code	District	Headquarters	Latitudes	Longitudes
1	BK	Bagalkot	Bagalkot	16° 12' N	75° 45' E
2	BN	Bangalore Urban	Bangalore	12° 58' N	77° 38' E
3	BR	Bangalore Rural	Bangalore	12° 58' N	77° 38' E
4	BG	Belgaum	Belgaum	15° 52' N	74° 34' E
5	BL	Bellary	Bellary	15° 09' N	76° 55' E
6	BD	Bidar	Bidar	17° 55' N	77° 39' E
7	BJ	Bijapur	Bijapur	16° 50' N	75° 47' E
8	CJ	Chamarajanagar	Chamarajanagar	11° 56' N	77° 00' E
9	CB	Chikballapur	Chikballapur	13° 26' N	77° 46' E
10	CK	Chikmagalur	Chikmagalur	13° 18' N	75° 49' E
11	CT	Chitradurga	Chitradurga	14° 14' N	76° 26' E
12	DK	Dakshina Kannada	Mangalore	12° 52' N	74° 53' E
13	DA	Davanagere	Davanagere	14° 31' N	75° 58' E
14	DH	Dharwad	Dharwad	15° 27' N	75° 05' E
15	GA	Gadag	Gadag	15° 25' N	75° 42' E
16	GU	Gulbarga	Gulbarga	17° 19' N	76° 54' E
17	HS	Hassan	Hassan	13° 01' N	76° 10' E
18	HV	Haveri	Haveri	14° 48' N	75° 24' E
19	KD	Kodagu	Madikeri	12° 26' N	75° 47' E
20	KL	Kolar	Kolar	13° 09' N	78° 11' E
21	KP	Koppal	Koppal	15° 20' N	76° 13' E
22	MA	Mandya	Mandya	12° 31' N	76° 53' E
23	MY	Mysore	Mysore	12° 18' N	76° 42' E
24	RA	Raichur	Raichur	16° 12' N	77° 22' E

SI.No.	Code	District	Headquarters	Latitudes	Longitudes
25	RM	Ramanagara	Ramanagara	12° 54' N	78° 02' E
26	SH	Shimoga	Shimoga	13° 56' N	75° 38' E
27	TU	Tumkur	Tumkur	13° 20' N	77° 08' E
28	UD	Udupi	Udupi	13° 20' N	74° 45' E
29	UK	Uttara kannada	Karwar	14° 48' N	74° 11' E
30	YG	Yadgir	Yadgir	16° 46' N	77° 8' E

Table 12.2 showing Longitude and Latitude of Important locations in Karnataka

Location	Latitude	Longitude	Location	Latitude	Longitude
Aland	17° 36' N	76° 35' E	Jog Falls	14° 18' N	74° 55' E
Anagundi	15° 21' N	76° 33' E	Kadur	13° 33' N	76° 03' E
Athani	16° 44' N	75° 06' E	Kallur	16° 12' N	77° 08' E
Bagalkot	16° 12' N	75° 45' E	Kalyani	17° 53' N	76° 59' E
Bagevadi	16° 33' N	76° 05' E	Karkala	13° 12' N	75° 00' E
Bangalore	12° 58' N	77° 38' E	Karwar	14° 48' N	74° 11' E
Bantwal	12° 53' N	75° 05' E	Khanapur	15° 42' N	74° 35' E
Belgaum	15° 52' N	74° 34' E	Kolar	13° 09' N	78° 11' E
Bellary	15° 09' N	76° 55' E	Kollegal	12° 09' N	77° 09' E
Bhadravati	13° 52' N	75° 40' E	Kollur	13° 53' N	74° 53' E
Bhalki	18° 04' N	77° 10' E	Koppal	15° 20' N	76° 13' E
Bidar	17° 55' N	77° 39' E	Kotturu	14° 49' N	76° 16' E
Bijapur	16° 50' N	75° 47' E	Krishnaraj Res.	12° 20' N	76° 32' E
Chamrajnagar	11° 56' N	77° 00' E	Kudremukh, Peak	13° 10' N	75° 15' E
Channapatna	12° 38' N	77° 13' E	Kumta	14° 26' N	74° 27' E
Chickballapur	13° 26' N	77° 46' E	Lingsugur	16° 07' N	76° 34' E
Chikmagalur	13° 18' N	75° 49' E	Londa	15° 60' N	74° 50' E
Chiknayakanhalli	13° 25' N	76° 40' E	Mangalore	12° 52' N	74° 53' E
Chitradurga	14° 14' N	76° 26' E	Manvi	19° 18' N	76° 30' E
Coondapur	13° 38' N	74° 42' E	Mercara	12° 26' N	75° 47' E
Davangere	14° 31' N	75° 58' E	Muddebihal	16° 20' N	76° 10' E
Deodurug	16° 25' N	77° 00' E	Mudhol	16° 20' N	75° 20' E
Dharwar	15° 27' N	75° 05' E	Mulbagal	13° 11' N	78° 14' E
Dodballapur	13° 14' N	77° 23' E	Mysore	12° 18' N	76° 42' E
Gadag	15° 25' N	75° 42' E	Nanjangud	12° 07' N	76° 44' E
Gangawati	15° 30' N	76° 36' E	Puttur	12° 45' N	75° 1' E
Gersoppa (Jog) Falls	14° 18' N	74° 55' E	Ramanagaram	12° 54' N	78° 02' E
Gokak	16° 11' N	74° 52' E	Ramdurg	15° 58' N	75° 22' E
Gulbarga	17° 19' N	76° 54' E	Ranibennur	14° 33' N	75° 41' E
Hampi (Vijayanagar)	15° 20' N	76° 30' E	Robertsonpet	12° 58' N	78° 16' E
Hangal	14° 46' N	75° 12' E	Sagar	16° 37' N	76° 51' E
Harihar	14° 31' N	75° 52' E	Sandur	15° 02' N	76° 36' E
Harnahalli	13° 15' N	76° 12' E	Savanur	14° 58' N	75° 19' E
Harapanahalli	14° 47' N	75° 58' E	Shahabad	17° 1' N	78° 11' E
Hassan	13° 01' N	76° 10' E	Shahapur	15° 5' N	74° 34' E
Hiriyur	13° 57' N	76° 40' E	Shikaripur	14° 16' N	75° 24' E

Location	Latitude	Longitude	Location	Latitude	Longitude
Hole Narsipur	12° 47' N	76° 17' E	Shimoga	13° 56' N	75° 38'
Humnabad	17° 43' N	77° 12' E	Talguppa	14° 10' N	74° 52' E
Honnavar	14° 17' N	74° 29' E	Tarikere	13° 42' N	75° 51' E
Honnali	14° 15' N	75° 41' W	Tumkur	13° 20' N	77° 08' E
Hosadurga	13° 48' N	76° 20' E	Udipi	13° 20' N	74° 45' E
Hospet	15° 16' N	76° 26' E	Vanivilas Sagar	13° 50' N	76° 25' E
Hubli	15° 20' N	75° 12' E	Vijayanagar (Hampi)	15° 20' N	76° 30' E
Hunsur	12° 18' N	76° 19' E	Wadi	17° 00' N	76° 57' E
Jamkhandi	16° 30' N	75° 20' E	Yelandur	12° 05' N	77° 00' E

13. Appendix F: Air-Side Economizer Acceptance Procedures Envelope Summary

13.1 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

13.2 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

14. Appendix G: – Compliance Forms*

14.1 Envelope Summary

Envelope Summary	
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Energy Conservation Building Code Compliance Forms

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

Project Description	New	Addition	Alteration	Change of use
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Compliance Option	Prescriptive	Envelope Trade-off (Appendix D)	Whole building performance
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

	<input type="radio"/> Hospital, hotel, call center (24hour)		<input type="radio"/> Other building types (daytime)		
Vertical Fenestration Area Calculation Note:Vertical fenest ration area can not exceed 60% of the gross wall area for prescriptive compliance	Total Vertical Fenestration Area (rough opening)	divided by	Gross Exterior Wall Area	times 100 equals	% Vertical Fenestration
		÷		X100 =	
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
		÷		X100 =	

Hospital, hotel, call center(24 hour)	
OPAQUE ASSEMBLY	
Roof	Minimum Insulation R- value
Wall	Minimum Insulation R- value
FENESTRATION	
Vertical	
	Maximum U- factor
	Maximum SHGC
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

Other building type (daytime)	
OPAQUE ASSEMBLY	
Roof	Minimum Insulation R- value
Wall	Minimum Insulation R- value
FENESTRATION	
Vertical	
	Maximum U- factor
	Maximum SHGC
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

*ECBC implementing agencies may adapt the compliance form to suit their requirement

14. 2 Building Permit Plans Checklist

Building Permit Plans Checklist	ENVELOPE Checklist
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Energy Conservation Building Code Compliance Forms

Project Address	Date
The following information is necessary to check a building permit application for compliance with the building envelope requirements in the Energy Conservation Building Code .	

Applicability (yes, no, n.a.)	Code Section	Component	Information Required	Location on Plans	Building Depart ment Notes
MANDATORY PROVISIONS (Section 3.2)					
	3.2.1	Fenestration rating			
	3.2.1.1	U-factor	Specify whether per 3.2.1.1 or default in Appendix C		
	3.2.1.2	SHGC	Specify whether per 3.2.1.2 or default in Appendix C		
	3.2.1.3	Air leakage	Specify leakage rates		
	3.2.2	Opaque U-factors	Specify whether per default in Appendix C or ASHRAE		
	3.2.3	Bldg. env.sealing	Indicate sealing, caulking, gasketing, and weather stripping		
PRESCRIPTIVE COMPLIANCE OPTION (section 3.3)					
	3.3.1	Roof	Indicate R-values on roof sections		
	3.3.1.1	Cool roof	Indicate minimum reflectance and emittance on plans		
	3.3.3	Opaque Walls	Indicate R-values on wall sections		
	3.3.3	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, gap width, 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 .		
	3.3.4	Skylight	(1) Indicate U-factors on fenestration schedule. Indicate if values are rated or default. If values are default, then specify frame type, glazing layers, gap width , low-e (2) Indicate SHGC or SC on fenestration schedule. Indicate if values are rated or default.		
BUILDING ENVELOPE TRADE- OFF OPTION (Section 3.4)					
			Provide calculations		

14.4 Mechanical Checklist

Mechanical Permit Checklist	MECHANICAL Checklist
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Energy conservation Building Code Compliance Forms

Project Address	Date
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The following information is necessary to check a building permit application for compliance with the mechanical requirements in the 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 4)					
MANDATORY PROVISIONS (Section 4.2)					
	4.2.2	Equipment efficiency	Provide equipment schedule with type, capacity, efficiency		
	4.2.3	Controls			
	4.2.3.1	Time clocks	Indicate thermostat with night setback, 3 different day types, and 2- hour manual override		
	4.2.3.2	Temp. & dead band	Indicate temperature control with 3 degree C dead band minimum		
	4.2.3.3	Cooling, tower, fluid cooler	Indicate two-speed motor, pony motor, or variable speed drive to control the fans		
	4.2.4.1	Piping & ductwork			
	4.2.4.1	Piping insulation	Indicate R-value of insulation		
	4.2.4.1	Ductwork insulation	Indicate R-value of insulation		
	4.2.4.1	Ductwork sealing	Specify sealing types and locations		
	4.2.5	System balancing	Specify system balancing		
PRESCRIPTIVE COMPLIANCE OPTION (Section 4.3)					
	4.3		Indicate whether project is complying with ECBC Prescriptive Option OR with ASHRAE Standard 90.1 – 2004		
	4.3.1	Economizer			
	4.3.1.1	Air economizer	Indicate 100% capability on schedule		
	4.3.1.2	Integrated operation	Indicate capability for partial cooling		
	4.3.1.3	Field testing	Specify tests		
	4.3.2	Variable flow hydronic			
	4.3.2.1	Pump flow rates	Indicate variable flow capacity on schedules		
	4.3.2.2	Isolation values	Indicate two-way automatic isolation valves		
	4.3.2.3	Variable speed drive	Indicate variable speed drive		

SERVICE WATER HEATING AND PUMPING (Chapter 5)					
MANDATORY PROVISIONS (Section 5.2)					
	5.2.1	Solar water heating	Provide calculations to justify capacity to meet 20% threshold		
	5.2.2	Equipment efficiency	Provide equipment schedule with type, capacity, efficiency		
	5.2.4	Piping insulation	Indicate R- value of insulation		

		5.2.5	Heat traps	Indicate heat trap on drawings or provide manufacturers specifications to show that equipment has internal heat trap		
		5.2.6	Pool covers	Provide vapor retardant cover for pools		
		5.2.6	Pools over 32°C	Provide R- 2.1 insulation		

14.5 Lighting Summary

Lighting Summary

Energy Conservation Building Code Compliance Forms

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

Project Description	<input type="checkbox"/> New building	<input type="checkbox"/> Addition	<input type="checkbox"/> Alteration	<input type="checkbox"/> Change of use
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Compliance Option	<input type="checkbox"/> Prescriptive	<input type="checkbox"/> Systems Analysis
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Alteration Exceptions (Check box, if appropriate)	<input type="checkbox"/> Less than 50% of the fixtures are new and installed lighting wattage is not being increased
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Maximum Allowed Lighting Wattage (Interior, Section 6.3)

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

Proposed Lighting Wattage (Interior)

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

Maximum Allowed Lighting Wattage (Exterior, Section 6.4)

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)
Total Allowed Watts				

Proposed Lighting Wattage (Exterior)

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

14. 6 Lighting Permit Checklist

Lighting Permit Checklist	LIGHTING Checklist
Energy Conservation Building Code Compliance Forms	
Project Address	Date
The following information is necessary to check a building permit application for compliance with the lighting requirements in the Energy Conservation Building Code .	

Applicability (yes, no, n.a)	Code section	Component	Information Required	Location on Plans	Building Department Notes
LIGHTING (Chapter 6)					
MANDATORY PROVISIONS (Section 6.2)					
	6.2.1	Lighting controls			
	6.2.1.1	Automatic shutoff	Indicate automatic shutoff locations or occupancy sensors		
	6.2.1.2	Space control	Provide schedule with type, indicate locations,		
	6.2.1.3	Daylight zones	Provide schedule with type and features, indicate locations		
	6.2.1.4	Exterior lighting control	Indicate photosensor or astronomical time switch		
	6.2.1.5	Additional control	Provide schedule with type, indicate locations		
	6.2.2	Exit signs	Indicate 5 watts maximum		
	6.2.3	Exterior building grounds lighting	Indicate minimum efficacy of 60 lumens/Watt		

PRESCRIPTIVE INTERIOR LIGHTING POWER COMPLIANCE OPTION (section 6.3)					
			6.3		Indicate whether project is complying with the Building Area method (6.3.2) or the Space Function Method (6.3.3)
			6.3.2	Building area method	Provide lighting schedule with wattage of lamp and ballast and number of fixtures. Document all exceptions
			6.3.3	Space function method	Provide lighting schedule with wattage of lamp and ballast and number of fixtures. Document all exceptions
			6.3.4.1	Luminaire wattage	Indicate on plans
PRESCRIPTIVE EXTERIOR LIGHTING POWER COMPLIANCE OPTION (section 6.3.5)					
			6.3.5	Exterior Lighting Power	Provide lighting schedule with wattage of lamp and ballast and number of fixtures. Document all exceptions

ELECTRICAL POWER (Chapter 7)					
MANDATORY PROVISIONS (Section 7.2)					
			7.2.1	Transformers	Provide schedule with transformer losses
			7.2.2	Motor efficiency	Provide equipment schedule with motor capacity, efficiency
			7.2.3	Power factor correction	Provide schedule with power factor correction
			7.2.4	Check metering	Provide check metering and monitoring

15 APPENDIX – H

Equipments, materials and minimum Star labeling (*)

Equipment	Details	Minimum Star labeling
Air Conditioning	Single-phase split and unitary air conditioners of vapor compression type up to a rated cooling capacity of 11 kW or as amended from time to time	Three Star & above
Ceiling fans	All ceiling fans of sweep 1200mm or as amended from time to time shall be BEE star labeled.	Three Star & above
Electric Water Heaters	Electric water heaters of capacity up to 200 litres or as amended from time to time	Three Star & above
Distribution Transformers	Distribution transformers of rating 16kVA to 200 kVA or as amended from time to time.	Three Star & above
Squirrel cage induction motors	Three phase squirrel cage induction motors in 2 Pole and 4 Pole for continuous duty (S1) operation suitable for voltage and frequency variation as per IS 12615:2004 with the following output rating 0.75kW, 1.1kW, 1.5kW, 2.2kW, 3.7kW, 5.5kW, 7.5kW, 9.3kW, 11kW and 15 kW or as amended from time.	BEE Star labeled or as notified
Electric Pump sets	Pump Sets covering Electric mono set pumps, submersible pumps sets and open well submersible pump sets used for clear, cold water and water supply purposes of ratings 1.1kW to 15 kW or as amended from time to time.	Three Star & above

(*) The list of equipments and materials shall be governed by appropriate notifications under the star labeling or appropriate clause of EA Act 2001 by BEE and as amended from time to time.

K.L. RAMACHANDRA

DEPUTY SECRETARY TO GOVERNMENT,
ENERGY DEPARTMENT.

PR. 674

SC. 50