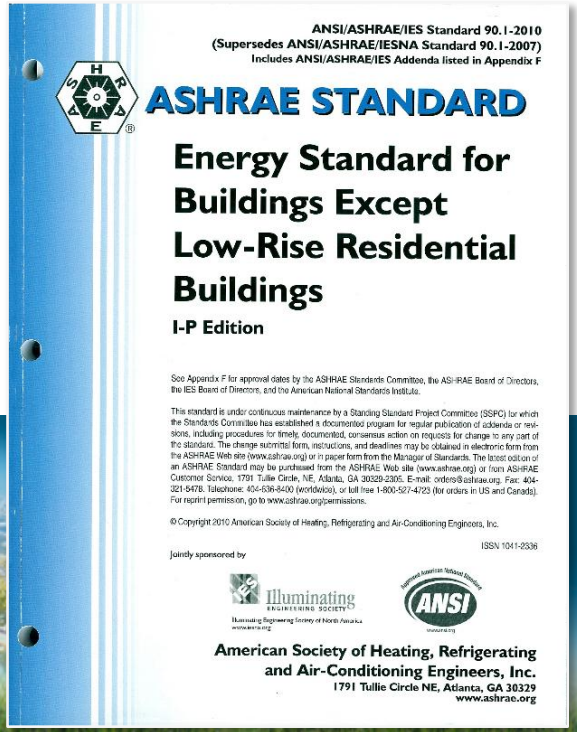
ANSI / ASHRAE / IESNA Standard 90.1 – 2010

Part 2 - Envelope Provisions (Section 5)



ANSI/ASHRAE/IES Standard 90.1-2010
(Supersedes ANSI/ASHRAE/IESNA Standard 90.1-2007)
Includes ANSI/ASHRAE/IES Addenda listed in Appendix F

ASHRAE STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

I-P Edition

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

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- Texas State Energy Conservation Office (SECO)

Walls, Roofs & Fenestration Provisions

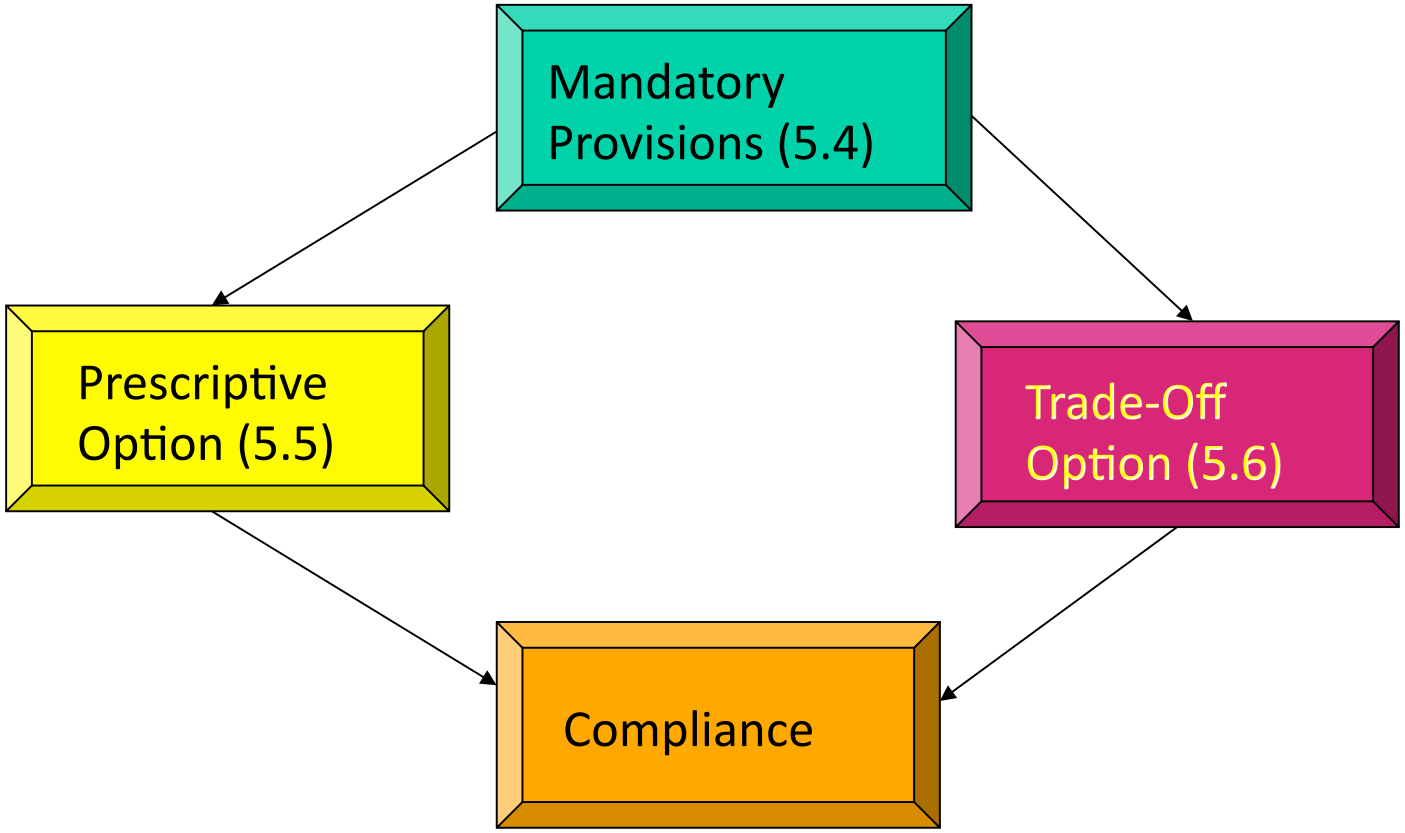
Space-Conditioning Categories

Section 5.1.2

- Each space to be included in a category:
  - Nonresidential conditioned space, or
  - Residential conditioned space, or
  - Semiheated space
- Spaces are assumed to be *conditioned spaces* at time of construction regardless of presence of HVAC in the building permit application or installed.
- Spaces in climate zones 3-8 may be designated as ***semiheated or unconditioned*** only if approved as such by the ***building official***. (Only climate zones 2 through 4 apply to Texas locations.)

Envelope Compliance Paths

Section 5.2



Space Definitions

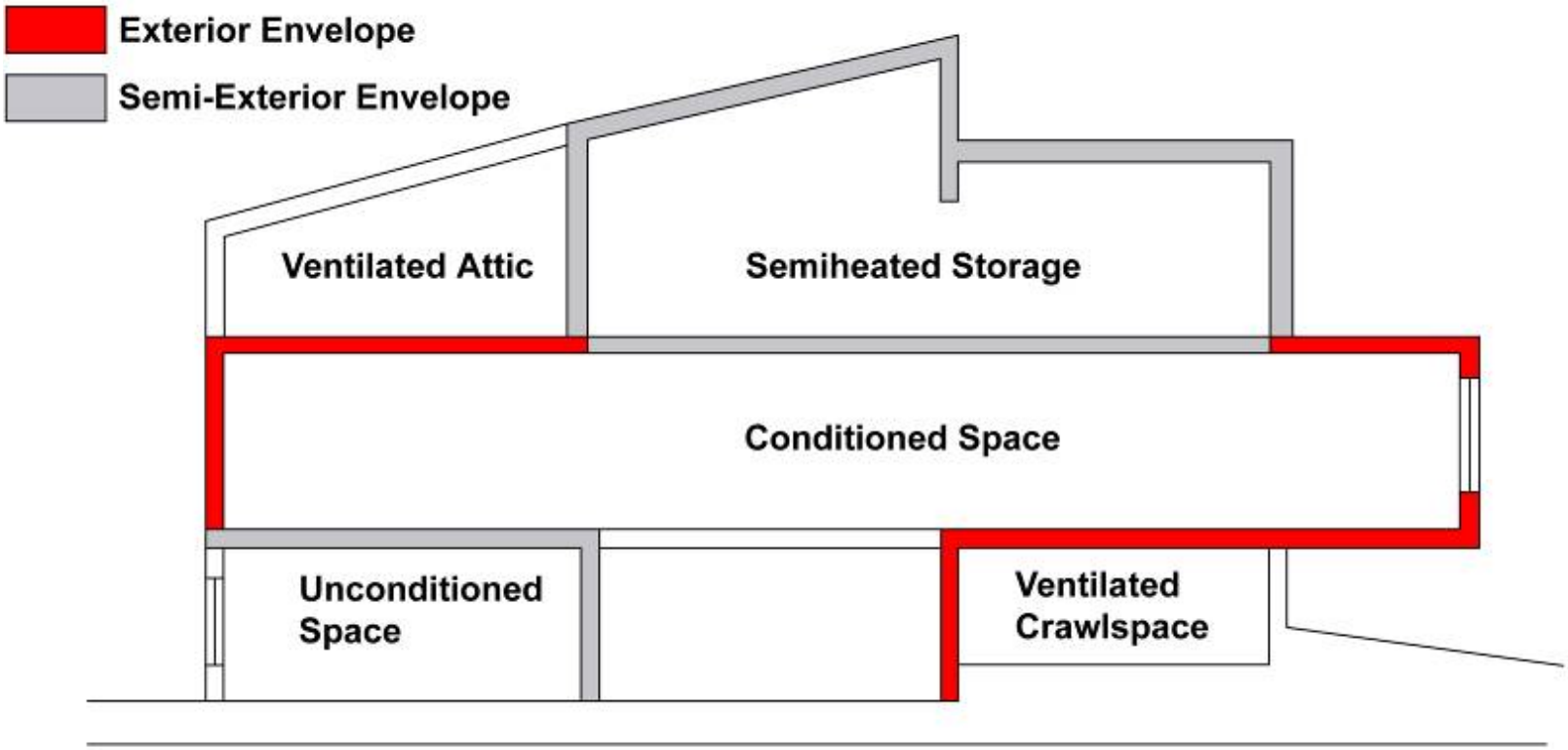


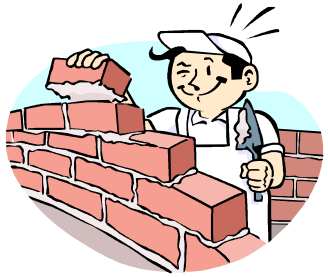
Figure 5-5 Space Definitions

Continuous Air Barriers

Section 5.4.3.1

Mandatory Provisions

- Entire building envelope to be designed and constructed with a continuous air barrier.
- Using **individual materials** that have an air permeance of ≤ 0.004 cfm/sq.ft. under 0.3 " w.g. pressure (1.57 psf.) The 90.1 Standard lists 13 examples like plywood, insulation board, metal, etc.
- Using **assemblies of materials** and components that have an average air leakage ≤ 0.04 cfm/sq.ft. Concrete masonry o.k. but needs to be fully grouted or painted.



Air Barrier Design

Section 5.4.3.1.1

Section 5.4.3.1.1 Air Barrier Design. The air barrier shall be designed and noted in the following manner:

- All air barrier components of each building envelope assembly shall be clearly identified or otherwise noted on construction documents.
- The joints, interconnections, and penetrations of the air barrier components including lighting fixtures shall be detailed or otherwise noted.
- The continuous air barrier shall extend over all surfaces of the building envelope (at the lowest floor, exterior walls, and ceiling or roof).
- The continuous air barrier shall be designed to resist positive and negative pressures from wind, stack effect, and mechanical ventilation.

Air Barrier Installation

Section 5.4.3.1.2

Sealed, caulked, gasketed, or weather-stripped:

- Joints around windows and doors
- Junctions between walls & foundations or roofs
- Openings at penetrations of walls, roofs, and floors
- Site-built fenestration and doors
- Building assemblies used as air ducts or plenums
- Any penetrations through vapor retarders
- All other openings in building envelope

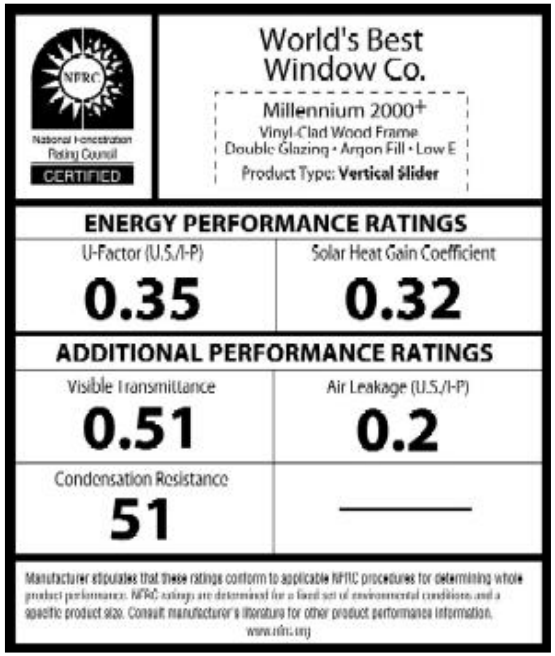
** Exceptions:

a. Semiheated spaces in climate zones 1 through 6.
b. Single wythe concrete masonry buildings in climate zone 2B.

Air Leakage - Fenestration and Doors

Section 5.4.3.2

- NFRC 400
- Labeled and certified by manufacturer
  - Glazed swinging entrance doors and revolving doors – not to exceed 1.0 cfm/ft^2
  - Curtain wall: 0.06 cfm/ft^2
  - Skylights: 0.3 cfm/ft^2
  - Non-swinging doors: 0.4 cfm/ft^2
  - Other products: 0.2 cfm/ft^2
- Exceptions:
  - Field-fabricated fenestration and doors
  - Metal garage roller doors – semiheated spaces in climate zones 1 through 6.



Air Leakage - Loading Dock Weatherseals

Section 5.4.3.3

In climate zones 4-8 (Texas Panhandle & north)

- Cargo doors and loading dock doors equipped with weatherseals
- To restrict infiltration when vehicles are parked in the doorway

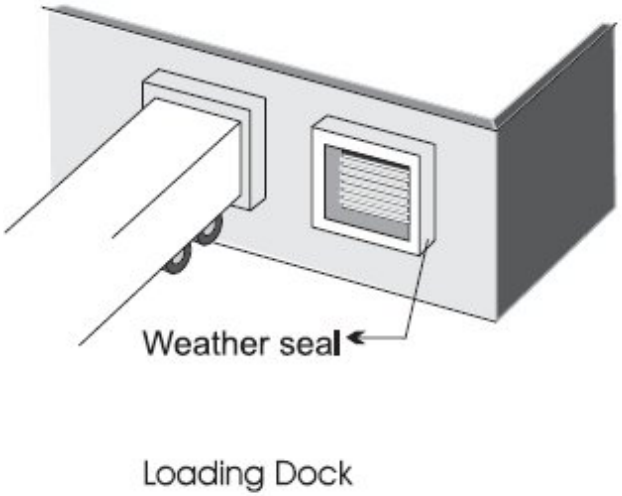
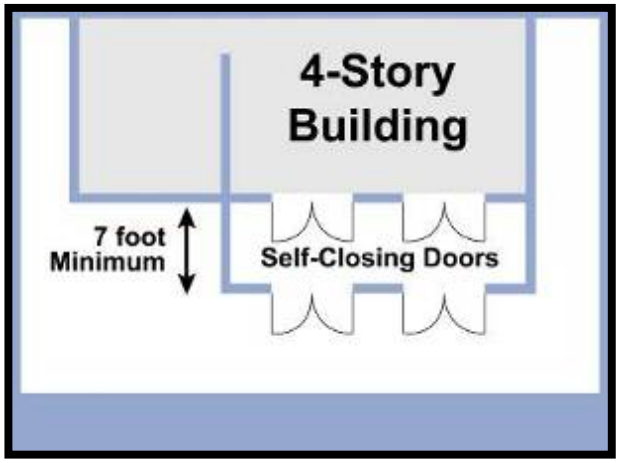


Figure 5-H—Loading Dock Weatherseal

Air Leakage – Vestibules

Section 5.4.3.4

- Required for all ***building entrances*** in
  - **Climate Zone 3** for entrances in >3-story buildings or ≥ 10,000 ft^2
  - **Climate Zones 4-8** for entrances in buildings ≥ 1000 ft^2
- Vestibules must have:
  - Self-closing doors
  - Interior and exterior doors not open at the same time
  - Distance between interior and exterior doors not < 7 ft when in closed position (remember ADA!)



Exceptions:

1. Revolving doors.
2. Climate zones 1&2.
3. "Non-entrance" doors that enter a space < 3000 ft^2 in any climate zones.
4. Dwelling units.

Building Envelope Prescriptive Option

Section 5.5

Window Wall Ratio (WWR) ≤ 40% of gross wall area
Skylight-roof ratio ≤ 5% of roof area
Each envelope component must separately meet requirements of Table 5.5

- 8 criteria sets for different climate types:
  - Each set = single page that summarizes all prescriptive requirements
    - Insulation levels for roofs, walls and floors
    - Fenestration criteria

Or, alternatives are to use Trade-Off Option (Section 5.6) or the ECB Method (Section 11)

Roof UF Requirements in Texas

Section 5.5.3.1

[No changes from 2007, but significant changes since version 2004]

Sample Cities from the 90.1 documents.	Climate Zone 2010 (just 3 zones Total in Texas)	90.1-2004 roof UF attic / concrete deck			90.1-2010 roof UF attic / concrete deck		
		Non-res.	Resi-dential	Semi-heated	Non-res.	Resi-dential	Semi-heated
Brownsville, Harlingen, McAllen, Corpus Christi, Galveston, Victoria, Houston, Huntsville, Beaumont, Port Arthur, Austin, San Antonio	2A	.034 .063	.027 .063	.081 .218	.027 * .048 *	.027 .048 *	.081 .218
Del Rio, Laredo	2B						
Dallas, Fort Worth, Waco, San Angelo	3A	.034 .063	.027 .063	.081 .218	.027 * .048 *	.027 .048 *	.053 * .173 *
Abilene, Big Spring, El Paso, Midland, Wichita Falls, Lubbock	3B						
Amarillo	4B	.034 .063	.027 .063	.081 .218	.027 * .048 *	.027 .048 *	.053 * .173 *

*** Represents increased stringency between 2004 and 2010.**

Table 5.5-2, Opaque elements (one table per climate zone)

Requirements for Climate Zone 2 (A, B)

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

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.048	R-20.0 c.i.	U-0.048	R-20.0 c.i.	U-0.218	R-3.8 c.i.
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.167	R-6.0
Attic and Other	U-0.027	R-38.0	U-0.027	R-38.0	U-0.081	R-13.0
Walls, Above-Grade						
Mass	U-0.151[a]	R5.7 c.i.[a]	U-0.123	R-7.6 c.i.	U-0.580	NR
Metal Building	U-0.113	R-13.0	U-0.113	R-13.0	U-0.184	R-6.0
Steel-Framed	U-0.124	R-13.0	U-0.064	R-13.0 + R-7.5 c.i.	U-0.124	R-13.0
Wood-Framed and Other	U-0.089	R-13.0	U-0.089	R-13.0	U-0.089	R-13.0
Walls, Below-Grade						
Below-Grade Wall	C-1.140	NR	C-1.140	NR	C-1.140	NR
Floors						
Mass	U-0.107	R-6.3 c.i.	U-0.087	R-8.3 c.i.	U-0.322	NR
Steel-Joist	U-0.052	R-19.0	U-0.052	R-19.0	U-0.069	R-13.0
Wood-Framed and Other	U-0.051	R-19.0	U-0.033	R-30.0	U-0.066	R-13.0
Slab-On-Grade Floors						
Unheated	F-0.730	NR	F-0.730	NR	F-0.730	NR
Heated	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.700		U-0.700	
Nonswinging	U-1.450		U-0.500		U-1.450	

Table 5.5-2, Opaque elements

Definitions of Roof Construction Types

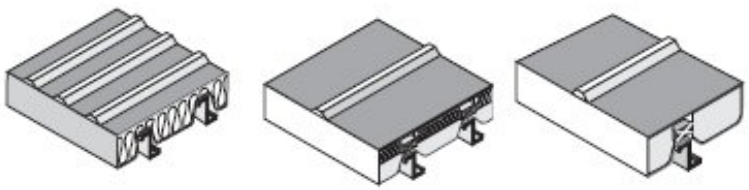
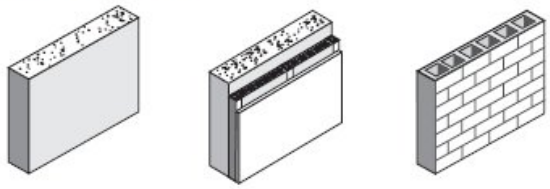
Roofs	
	Insulation Entirely above Deck
	Metal Building
	Attic and Other

Table 5.5-2, Opaque elements

Definitions of Wall Constructions Types

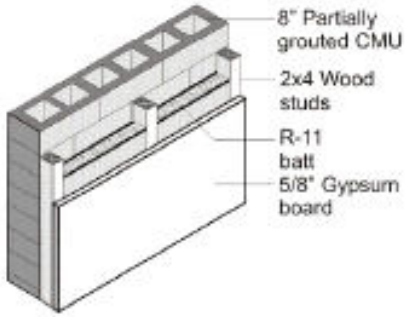
Walls, Above-Grade	
	Mass
	Metal Building
	Steel-Framed
	Wood-Framed and Other

Opaque Areas

Section 5.5.3, Mass Wall Criterion

HC CALCULATION
Above-grade Wall Example

The HC is the sum of the density times the specific heat times the thickness for each layer of the wall. The calculation can be structured in tabular form as shown below.

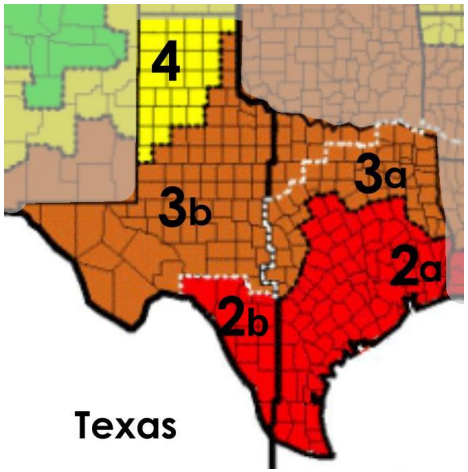


Item	Weight (lb/ft 2)	Fraction of Wall	Specific Heat (Btu/lb °F)	HC (Btu/ft ^{2}°F)
8" Partially Grouted CMU (105 lb/ft 3)	47.00	1.00	0.20	9.40
2X4 Wood Studs	9.30	0.22	0.33	0.46
R-11 Batt	0.25	0.78	0.30	0.06
5/8" gypsum board	2.60	1.00	0.26	0.68
Total				10.60

Mass Wall criterion is HC > 7 (high density) or 5 (light density)

Cool Roofs

Section 5.5.3.1.1



Required in climate zones 1 through 3 (most of Texas):

Requirements:

a. Three-yr-aged roof solar reflectance ≥ 0.55 and emittance ≥ 0.75, (certified by ASTM C1549/ E1918/ C1371/ E408), or

b. Three-yr-aged SRI (solar reflectance index) ≥ 64*, (certified by ASTM E1980), or

c. Increased insulation from Table 5.5.3.1.2

---

* SRI ≈ 100 x (R + 0.12E)… approx.

Cool Roofs – SRI value 64

Section 5.5.3.1.1

The second criterion for achieving the high albedo roof is to reach a Solar Reflective Index (SRI *) of 64. Approximate values of E and R to reach SRI=64 are shown in the table at the right.

* As tested by ASTM E1980.

Table to reach SRI=64 (Approx.)

To Reach SRI = 64, 3-yr age	
Emittance (E)	**Reflectance (R)**
0.30	0.604
0.35	0.598
0.40	0.592
0.45	0.586
0.50	0.580
0.55	0.574
0.60	0.568
0.65	0.562
0.70	0.556
0.75	0.550

Increased Roof Insulation

Section 5.5.3.1.1

The third criterion for the Cool Roof requirement is to have increased insulation. (CZ 1 through 3)

Table 5.5.3.1.2				
Roofs	**Non-residential**		**Residential**	
Opaque Elements	Assembly Maximum	Insul. Min. R-value	Assembly Maximum	Insul. Min. R-value
Insul. entirely above deck	U-0.030	R-33	U-0.029	R-34
Metal buildings	U-0.028	R-35		

Cool Roof Exceptions

Section 5.5.3.1.1

a. Stone Ballasted roof at ≥ 17 psf.
b. Vegetated roof w/ ≥ 2.5" soil that covers ≥ 75% of roof area with growing plants.
c. Roofs where ≥ 75% of roof area:
    1) Shaded on June 21 by permanent features, or
    2) Covered by solar collectors or solar PV arrays, or
    3) Combinations of 1 and 2 above.
d. Steep sloped roofs (**> 2:12 slope**).
e. Low sloped (**≤ 2:12 slope**) metal bldg. roofs in climate zones 2 and 3.
f. Roofs over ventilated attics or semi-heated spaces.
g. Asphaltic membranes in climate zones 2 and 3.

Table 5.5-2 (Fenestration: Windows & Skylights)

U.F. & SHGC Requirements in Climate Zone 2 (A, B)

UF and SHGC ** Requirements ≤ 40% glass

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

Fenestration	Nonresidential		Residential		Semiheated	
	Assembly Max. U	Assembly Max. SHGC	Assembly Max. U	Assembly Max. SHGC	Assembly Max. U	Assembly Max. SHGC
Vertical Glazing, 0%–40% of Wall						
Nonmetal framing (all)[b]	U-0.75	SHGC-0.25 all	U-0.75	SHGC-0.25 all	U-1.20	SHGC-NR all
Metal framing (curtainwall/storefront)[c]	U-0.70		U-0.70		U-1.20	
Metal framing (entrance door)[c]	U-1.10		U-1.10		U-1.20	
Metal framing (all other)[c]	U-0.75		U-0.75		U-1.20	
Skylight with Curb, Glass, % of Roof						
0%–2.0%	U_{all}–1.98	$SHGC_{all}$–0.36	U_{all}–1.98	$SHGC_{all}$–0.19	U_{all}–1.98	$SHGC_{all}$–NR
2.1%–5.0%	U_{all}–1.98	$SHGC_{all}$–0.19	U_{all}–1.98	$SHGC_{all}$–0.19	U_{all}–1.98	$SHGC_{all}$–NR
Skylight with Curb, Plastic, % of Roof						
0%–2.0%	U_{all}–1.90	$SHGC_{all}$–0.39	U_{all}–1.90	$SHGC_{all}$–0.27	U_{all}–1.90	$SHGC_{all}$–NR
2.1%–5.0%	U_{all}–1.90	$SHGC_{all}$–0.34	U_{all}–1.90	$SHGC_{all}$–0.27	U_{all}–1.90	$SHGC_{all}$–NR
Skylight without Curb, All, % of Roof						
0%–2.0%	U_{all}–1.36	$SHGC_{all}$–0.36	U_{all}–1.36	$SHGC_{all}$–0.19	U_{all}–1.36	$SHGC_{all}$–NR
2.1%–5.0%	U_{all}–1.36	$SHGC_{all}$–0.19	U_{all}–1.36	$SHGC_{all}$–0.19	U_{all}–1.36	$SHGC_{all}$–NR

**** SHGCs have a major change from 90.1-2004: These now apply to all orientations, including North**

Solar Heat Gain Coefficient (SHGC)

Section 5.8.2.5

"The SHGC for the overall fenestration area shall be determined in accordance with NFRC 200."

Exceptions – one of these alternatives:

- **SC (from NFRC 300) x 0.86 is acceptable for overall fenestration area.**
- **SHGC of center of glass (spectral data file per NFRC 300 certified by manufacturer) is acceptable for overall fenestration area.**
- **SHGC from Table A8.1 for unlabeled skylights.**
- **SHGC from Table A8.2 for other unlabeled vertical fenestration.**

Notes:

NFRC (National Fenestration Rating Council) test procedures:

100: U-Factors

200: Solar Heat Gain Coefficients (SHGC)

300: Solar Optical properties, incl. SC (Shading Coefficient)

400: Air leakage rates

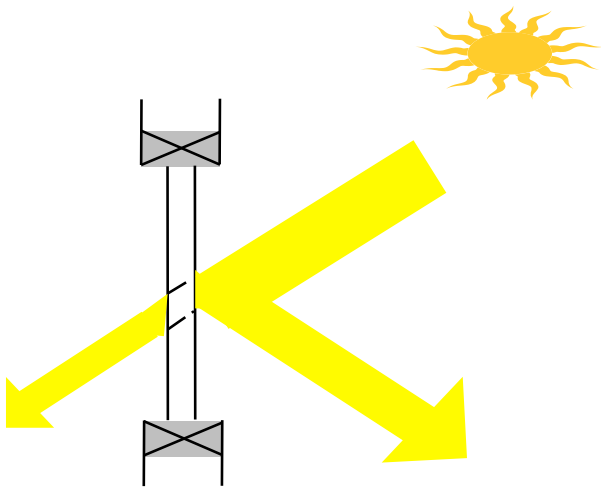
Fenestration SHGC Limits

Section 5.5.4.4

- SHGC of vertical fenestration and skylights to be ≤ maximum SHGC values in Table 5.5-z for "all" orientations.
- Exceptions:
  - **For overhangs, the SHGC is reduced by multiplier in Table 5.5.4.4.1**
  - **On street side, street level, if story ht. ≤20', and overhang >0.5PF, and WWR<0.75**

Observation:

There are no SHGC requirements for ***semiheated spaces in any*** climate zone nor for residential buildings in ***climate zones 7 and 8***.



Overhangs

Section 5.5.4.4.1.a

Credit for External Shading

- Credit is limited to overhangs
- Credit is not provided for other external shading devices such as:
  - Vertical fins, or
  - Non-permanent devices such as awnings
- Shading effects from geometry of some other devices, e.g., slatted louvers & screens, may be converted to equivalent overhang, with approval of building official.

Overhangs

Section 5.5.4.4.1.a

- Credit is given for permanent overhangs by adjustment to SHGC (Table 5.5.4.4.1)
- Size of credit is determined by projection factor

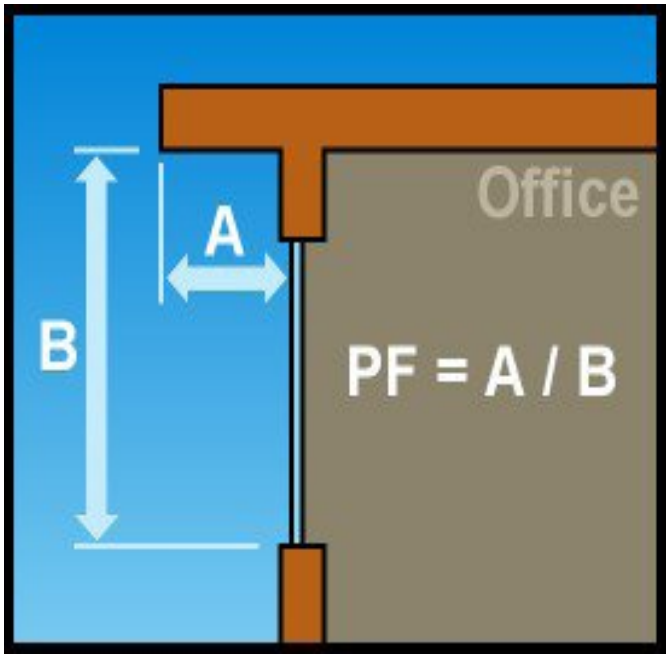


TABLE 5.5.4.4.1
SHGC Multipliers for Permanent Projections

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

Fenestration SHGC Limits

Section 5.5.4.4.1.c -- Street Side Exceptions

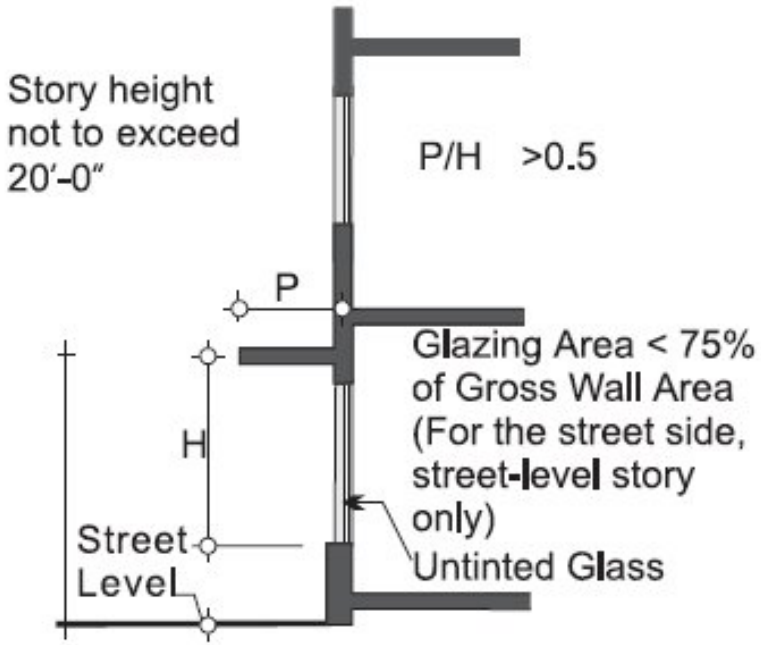
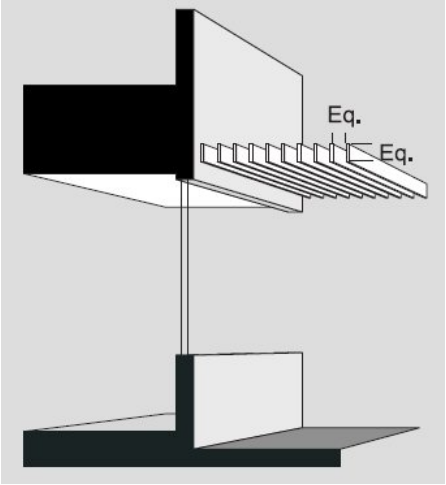


Figure 5-M—Vertical Fenestration at Street Level

Overhangs

Section 5.5.4.4.1

- Open slotted sun shades will also qualify as a shade if the sun is blocked out totally on June 21.



A few useful formulae for sun angle at noon (use for south-facing windows):

- Sun altitude angle on June 21 = 90 – Latitude + 23.5
- Sun altitude angle on Mar 21 & Sept 21 = 90 – Latitude
- Sun altitude angle on Dec 21 = 90 – Latitude – 23.5

Fenestration Orientation

Section 5.5.4.5

5.5.4.5 Fenestration Orientation. The *vertical fenestration area* shall meet the following requirement:

$$A_S \geq A_W \text{ and } A_S \geq A_e$$

where:

A_s = south oriented *vertical fenestration area* (oriented ≤ 45 degrees of true south)

A_n = north oriented *vertical fenestration area* (oriented ≤ 45 degrees of true north)

A_w = west oriented *vertical fenestration area* (oriented < 30 degrees of true west)

A_e = east oriented *vertical fenestration area* (oriented < 30 degrees of true east)

In the southern hemisphere, replace A_S with A_n in the formulae above. W

Skylights are Required (in certain cases)

Section 5.5.4.2.3

Required in any enclosed space that is four stories or less that is:

a. ≥ 5000 ft^2 and,
b. Directly under a roof with ceiling height ≥ 15 ft., and
c. Any of these: office, lobby, atrium, concourse, corridor, warehouse, storage, gym, convention ctr., auto service, manufacturing, retail, distribution center, transportation, or workshop.

Specification requirements:

Daylight area under skylights ≥ ½ the floor area and either:

a. Skylight area-to-daylit area ratio ≥ 3% w/ VT ≥ 0.40, or
b. Skylight effective aperture area ≥ 1%

_____

Effective aperature area = 0.85 x skylight area x VT x WF / daylit area

- VT = Visible Transmittance
- WF = Well Factor = 0.9 for well depth < 2' or 0.7 for well depth ≥ 2'

Skylight Exemptions

(Section 5.5.4.2.3)

a. In spaces in climate zones 6 through 8.
b. In spaces with general LPD < 0.5 W/ft^2.
c. In spaces that are blocked from receiving direct beam sunlight on ≥ 50% of roof area for > 1500 daylight hrs/yr.
a. In spaces where the daylight area under roof-top monitors is > 50% of the floor area.
b. In spaces where 90% of the skylight area is shaded on June 21 in Northern Hemisphere.

The required daylight area under skylights may be reduced by the amount of:

a. primary sidelighted area with a sidelighting aperture > 15%, given appropriate general lighting control, or
b. secondary sidelighted area with a sidelighting aperture > 30% and with general lighting controlled by continuous daylight dimmers.

SHGC of Skylights

Section 5.5.4.4.2

Skylights shall have a SHGC ≤ that specified for "all orientations" in Table 5.5-x.

Exception: Skylights are exempt from SHGC req'mts if they:

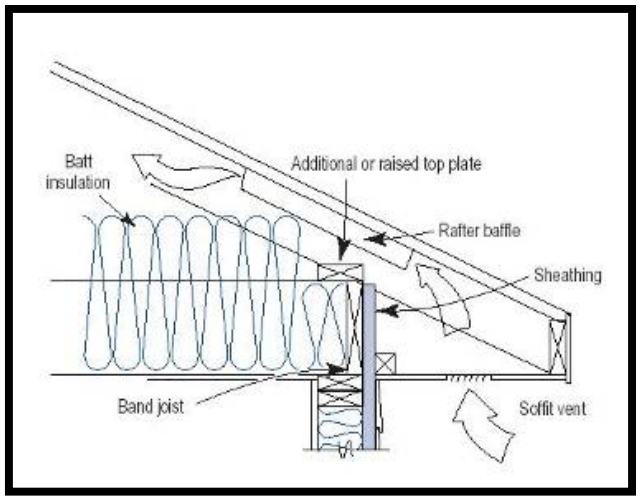
a. Have a glazing material or diffuser w/ a haze value > 90% when tested by ASTM D1003, or

b. Have a skylight VT > 0.40 and have all general lighting in the daylit area under the skylights controlled by multi-level photocontrols in accordance with Section 9.4.1.5.

Insulation Installation

Section 5.8.1

- Per manufacturer's instructions, so as to achieve the rated R-value
  - Exception: Metal buildings – if roof and wall insulation is compressed between roof or wall skin and the structure.
- No open-blown or poured loose-fill insulation when ceiling slope is > 3/12.
- If eave vents installed, provide baffling of air vents to deflect incoming air above the surface of the insulation.
- Recessed fixtures shall not affect the insulation thickness unless:
  a. Area affected < 1% of the opaque area, or
  b. Entire roof, wall, or floor is covered with insulation to full depth required, or
  c. Reduced effects are included in calculations for the area-weighted method in Table A9.4C



Envelope Alteration Exceptions

Section 5.1.3

The following need not comply:

- Storm windows over existing windows
- Glazing replacement only (≤ U/SHGC)
- Window replacement (≤ 25% and ≤ U/SHGC)
- Insulation cavity already filled (R=3/inch) or unexposed (inaccessible)
- Roof membrane only or below deck insulation
- Vestibule requirement not imposed on door replacement, but existing vestibule shall not be removed.

Building Envelope Trade-Off Option

Section 5.6.1

- This section explains the ***Envelope Trade-Off Option*** that will allow for trade-offs among roof and wall elements.
- This procedure involves the calculation of an ***"Envelope Performance Factor"*** (EPF), which must be calculated by the Appendix C procedures or by the ECB methodology (explained in Section 11 of the Standard.)
- Building complies if:
  - It satisfies the provisions of 5.1, 5.4, 5.7 and 5.8, and
  - Envelope performance factor (EPF) of proposed building is $\leq$ EPF of a budget building design that would meet the prescriptive provisions.
    - ➢ The EPF considers only the building envelope components – not HVAC and lighting systems.
    - ➢ Schedules of operation, lighting power, equipment power, occupant density, and mechanical systems to be the same for both the proposed building and the budget building.

Assembly U.F., C-Factor & F-Factor Determination

Normative Appendix A

- For any unlabeled building products, use this appendix for pre-calculated U-factors, C-factors, and F-factors
  - Above-grade walls
  - Below-grade walls
  - Floors
  - Slab-on-grade floors
  - Opaque doors
  - Fenestration

This Concludes:
ANSI / ASHRAE / IESNA Standard 90.1 – 2010
Part 2 - Envelope Provisions

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