

(This foreword is provided for information only and is not part of the draft addendum.)

FOREWORD

Draft Addendum 90.1ao – Publication Draft. The purpose is to make Section 5 easier to understand and to use, especially for the first-time reader.

The changes are:

1. ***Move Table 5-3 as close to the beginning of the section as possible.***
 - Table 5-3 presents a summary of the prescriptive requirements in an easy-to-comprehend table.
 - In the standard it is now on the last page of the envelope section.
 - We have moved it as far forward as possible without violating 90.1 format.
2. ***Move “Semi-heated spaces” into exceptions.***
 - Currently, all readers need to understand this complexity before using the section, and it is not that easy.
 - With the revision, only those readers who want the flexibility of using semi-heated spaces need to deal with the complexity.
3. ***Move Details of Mandatory Provisions to end of Section***
 - Mandatory section is still 5.2, consistent with other sections.
 - Details are in new section 5.5.
4. ***Outline “Map” Added at beginning to Opaque Surfaces***
 - Reader can go directly to relevant sections for his/her building.
 - Reader no longer has to read through 3 pages to find relevant sections.
 - Does not have to Mandatory section is still 5.2, consistent with other sections.

THESE ARE EDITORIAL CHANGES. NO CHANGES TO THE REQUIREMENTS. THE REVISION IS SIMPLY A RE-STRUCTURING TO MAKE IT EASIER TO READ AND USE.

Addendum 90.1ao (I-P and SI Editions)

5 BUILDING ENVELOPE

5.1 General

5.1.1 Building Envelope Scope. Section 5 specifies requirements for the *exterior building envelope*, which separates *conditioned space* from the exterior.

Exceptions to 5.1.1:

For buildings that contain *spaces* that will be only *semi-heated or unconditioned*, and if alternate compliance is sought for such spaces, then Section 5 also specifies requirements for the *semi-exterior building envelope*, which separates:

- a) *conditioned space* from either *semi-heated space or unconditioned space*,

- b) *semi-heated space* from either *unconditioned space* or from the exterior.

Section 5 does not address moisture control or provide design guidelines to prevent moisture migration that leads to condensation, mold and mildew, or deterioration to insulation or equipment performance.

5.1.2 Compliance. For the appropriate climate, *space-conditioning category*, and *class of construction*, the *building envelope* shall comply with:

- (a) 5.1, General,
- (b) 5.2, Mandatory Provisions, and
- (c) either
 - 1. 5.3, Prescriptive Building Envelope Option, provided that:
 - a. the *vertical fenestration area* does not exceed 50% of the *gross wall area* for each *space-conditioning category*, and
 - b. the *skylight fenestration area* does not exceed 5% of the *gross roof area* for each *space-conditioning category*;or
 - 2. 5.4, Building Envelope Trade-off Option.

5.1.3 Climate. The climate shall be determined based on the *cooling degree-days base 50°F (10°C)*, *CDD50 (CDD10)*, and *heating degree-days base 65°F (18°C) HDD65 (HDD18)*.

5.1.3.1 Locations Listed. For those locations listed in Normative Appendix D, use the published climatic data to determine compliance. In the case of cities or urban regions with several climatic data entries, the designer shall select the location within the region or city that best represents the climate of the construction site.

5.1.3.2 Locations Not Listed. For locations not listed in Normative Appendix D, designers shall select the location that best represents the climatic conditions of the construction site being analyzed to determine compliance. If there are recorded historical climatic data available for a construction site they may be used to determine compliance if approved by the building official.

5.1.4 Envelope Requirements Are Specified by Space-Conditioning Categories.

Separate *exterior building envelope* requirements are specified for each of two categories of conditioned space:

- (a) *nonresidential conditioned space*
- b) *residential conditioned space*.

Spaces shall be assumed to be *conditioned space* and shall comply with the requirements for *conditioned space* at the time of construction, regardless of whether mechanical or electrical equipment is included in the building permit application or installed at that time.

Exceptions to 5.1.4: For buildings that contain *spaces* that will be only *semi-heated or unconditioned*, and if alternate compliance is sought for such spaces, then all *semi-heated or unconditioned* spaces shall be clearly indicated on the floor plan as such, and the following *semi-exterior building envelope* requirements apply:

- a) If a *space* will be only *semi-heated*, the *space* shall be considered *semi-heated*.
- b) If a *space* will remain *unconditioned*, the *space* shall be considered *unconditioned*.

In climates that exceed 1800 *HDD65* (1000 *HDD18*), a space may be designated as either *semi-heated* or *unconditioned* only if approved by the *building official*.

5.2 Mandatory Provisions

5.2.1 Insulation General. Where insulation is required in 5.3 or 5.4, it shall also comply with 5.5.1.1 through 5.5.1.5.

5.2.2 ~~Fenestration and Doors.~~ Fenestration and doors shall comply with 5.5.2.

5.2.3 Air Leakage

5.2.3.1 Building Envelope Sealing. Building envelope sealing shall comply with 5.5.3.1, air leakage for *fenestration* and *doors* shall comply with 5.5.3.2, loading dock weather_seals shall comply with 5.5.3.3, and vestibules shall comply with 5.5.3.4.

5.3 Prescriptive Building Envelope Option

For *conditioned space*, the *exterior building envelope* shall comply with either the “nonresidential” or “residential” requirements in Table 5.3 (located in Normative Appendix B) for the appropriate climate.

[Table 5.3: When adopted, the appropriate tables are to be inserted here by the adopting jurisdiction (state, province, county, city, etc.) Only a limited number of tables in Normative Appendix B are applicable to any one particular jurisdiction. The remainder of Normative Appendix B need not be adopted. See Appendix B for the process to select the applicable tables. Then, select the actual tables from Normative Appendix B and insert them here. An example table is shown on the next page.]

Table 5.3-n Example Building Envelope Requirements

OPAQUE ELEMENTS	NONRESIDENTIAL		RESIDENTIAL		SEMI-HEATED	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
<u>Roofs</u>						
Insulation Entirely Above Deck	U-	R-	U-	R-	U-	R-
Metal Building	U-	R-	U-	R-	U-	R-
Attic and Other	U-	R-	U-	R-	U-	R-
<u>Walls, Above Grade</u>						
Mass	U-	R-	U-	R-	U-	R-
Metal Building	U-	R-	U-	R-	U-	R-
Steel Framed	U-	R-	U-	R-	U-	R-
Wood Framed and Other	U-	R-	U-	R-	U-	R-
<u>Walls, Below Grade</u>						
Below-Grade Wall	C-	R-	C-	R-	C-	R-
<u>Floors</u>						
Mass	U-	R-	U-	R-	U-	R-
Steel Joist	U-	R-	U-	R-	U-	R-
Wood Framed and Other	U-	R-	U-	R-	U-	R-
<u>Slab-On-Grade Floors</u>						
Unheated	F-	R-	F-	R-	F-	R-
Heated	F-	R-	F-	R-	F-	R-
<u>Opaque Doors</u>						
Swinging	U-		U-		U-	
Non-Swinging	U-		U-		U-	
FENESTRATION	Assembly Max. U (Fixed/Operable)	Assembly Max. SHGC (All Orientations/North-Oriented)	Assembly Max. U (Fixed/Operable)	Assembly Max. SHGC (All Orientations/North-Oriented)	Assembly Max. U (Fixed/Operable)	Assembly Max. SHGC (All Orientations/North-Oriented)
<u>Vertical Glazing, % of Wall</u>						
0-10.0%	U _{fixed} - U _{oper} -	SHGC _{all} - SHGC _{north} -	U _{fixed} - U _{oper} -	SHGC _{all} - SHGC _{north} -	U _{fixed} - U _{oper} -	SHGC _{all} - SHGC _{north} -
10.1-20.0%	U _{fixed} - U _{oper} -	SHGC _{all} - SHGC _{north} -	U _{fixed} - U _{oper} -	SHGC _{all} - SHGC _{north} -	U _{fixed} - U _{oper} -	SHGC _{all} - SHGC _{north} -
20.1-30.0%	U _{fixed} - U _{oper} -	SHGC _{all} - SHGC _{north} -	U _{fixed} - U _{oper} -	SHGC _{all} - SHGC _{north} -	U _{fixed} - U _{oper} -	SHGC _{all} - SHGC _{north} -
30.1-40.0%	U _{fixed} - U _{oper} -	SHGC _{all} - SHGC _{north} -	U _{fixed} - U _{oper} -	SHGC _{all} - SHGC _{north} -	U _{fixed} - U _{oper} -	SHGC _{all} - SHGC _{north} -
40.1-50.0%	U _{fixed} - U _{oper} -	SHGC _{all} - SHGC _{north} -	U _{fixed} - U _{oper} -	SHGC _{all} - SHGC _{north} -	U _{fixed} - U _{oper} -	SHGC _{all} - SHGC _{north} -
<u>Skylight with Curb, Glass, % of Roof</u>						
0-2.0%	U _{all} -	SHGC _{all} -	U _{all} -	SHGC _{all} -	U _{all} -	SHGC _{all} -
2.1-5.0%	U _{all} -	SHGC _{all} -	U _{all} -	SHGC _{all} -	U _{all} -	SHGC _{all} -
<u>Skylight with Curb, Plastic, % of Roof</u>						
0-2.0%	U _{all} -	SHGC _{all} -	U _{all} -	SHGC _{all} -	U _{all} -	SHGC _{all} -
2.1-5.0%	U _{all} -	SHGC _{all} -	U _{all} -	SHGC _{all} -	U _{all} -	SHGC _{all} -
<u>Skylight without Curb, All, % of Roof</u>						
0-2.0%	U _{all} -	SHGC _{all} -	U _{all} -	SHGC _{all} -	U _{all} -	SHGC _{all} -
2.1-5.0%	U _{all} -	SHGC _{all} -	U _{all} -	SHGC _{all} -	U _{all} -	SHGC _{all} -

Note to adopting authority: Insert appropriate tables here from Appendix B.

If a building contains any semi-heated space or unconditioned¹ space, per the exceptions to 5.1.2, then the *semi-exterior building envelope* shall comply with the requirements for *semi-heated space* in Table 5.3 for the appropriate climate. (See Figure 5.3, Exterior and Semi-Exterior Building Envelope.)

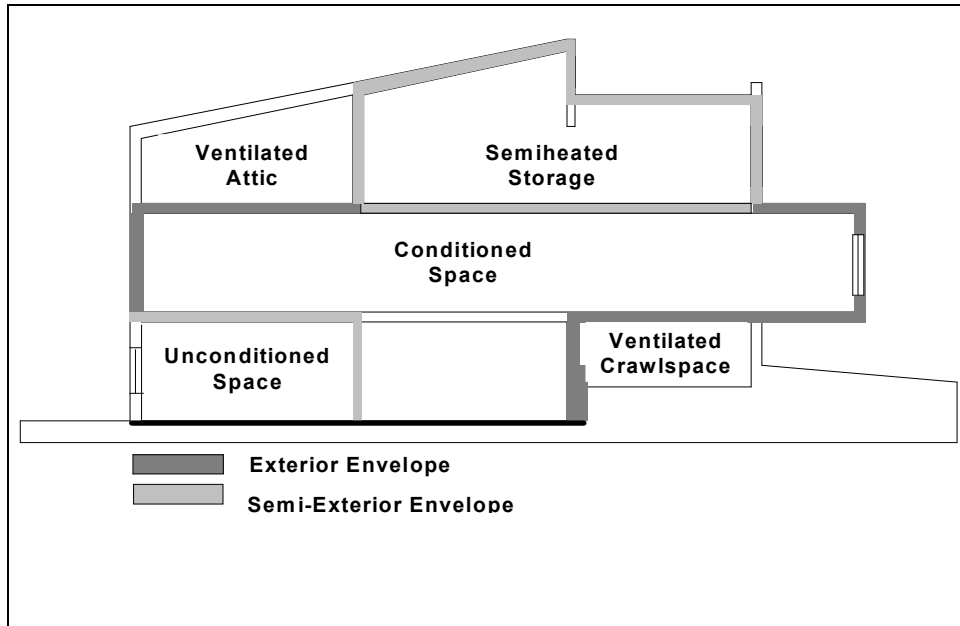


Figure 5.3 Building Envelope

5.3.1 Opaque Areas. Opaque surfaces shall comply with the following sections.

- (a) **Roof Insulation** shall comply with 5.3.1.1,
 - (b) **Above-Grade Wall Insulation** shall comply with 5.3.1.2,
 - (c) **Below-Grade Wall Insulation** shall comply with 5.3.1.3,
 - (d) **Floor Insulation** shall comply with 5.3.1.4, and,
 - (e) **Slab-On-Grade Floor Insulation** shall comply with 5.3.1.5.
 - (f) **Opaque doors** shall comply with 5.3.1.6.
- 1) For all opaque surfaces except doors, compliance shall be demonstrated by one of the following three methods: Compliance with the minimum *rated R-values of insulation* shall be demonstrated for the thermal resistance of the added insulation in framing cavities and *continuous insulation* only. *Rated R-values of insulation* shall not include the thermal transmittance of other *building materials* or air films. Insulation shall extend over the full component area to the intended *rated R-value of insulation* unless otherwise allowed in 5.2.1. If NR appears in a table, there are no insulation requirements for that *class of construction* and *space-conditioning category*. This option does not apply to *opaque doors*.

- 2) Compliance shall be shown with the maximum *U-factor*, *C-factor*, or *F-factor* for the entire assembly in Table 5.3 for the component in lieu of complying with the minimum *rated R-value of insulation* for the insulation alone. *U-factors*, *C-factors*, and *F-factors* for typical construction assemblies are included in Normative Appendix A, and these values shall be used to determine compliance. For assemblies significantly different from those in Normative Appendix A, calculations shall be performed in accordance with the procedures required in Normative Appendix A. If NR appears in a table in the minimum insulation column, there are also no maximum *U-factor*, *C-factor*, or *F-factor* requirements for the entire assembly for that *class of construction* and *space-conditioning category* for the prescriptive option in 5.3. However, the *U-factor*, *C-factor*, or *F-factor* specified is the basis for the trade-off option in 5.4.
- 3) If there are multiple assemblies within a single *class of construction* for a single *space-conditioning category*, compliance shall be shown for an area-weighted average *U-factor*, *C-factor*, or *F-factor*. It is not acceptable to do an area-weighted average for the *rated R-value of insulation* or to do an area-weighted average across multiple *classes of construction* or multiple *space-conditioning categories*.

5.3.1.1 Roof Insulation. All *roofs*, including *roofs with insulation entirely above deck*, *metal building roofs*, and *attics and other roofs*, shall have a *rated R-value of insulation* not less than that specified in Table 5.3. *Skylight curbs* shall be insulated to the level of *roofs with insulation entirely above the deck* or R-5 (R-0.85), whichever is less.

- a) For *roofs with insulation entirely above deck*, the *rated R-value of insulation* is for *continuous insulation*. Interruptions presented by framing and pads for mechanical equipment with the combined total area no greater than one percent of the opaque assembly area shall be permitted.
- b) For *metal building roofs*, the first *rated R-value of insulation* is for insulation draped over purlins and then compressed when the metal spanning members are attached, or for insulation hung between the purlins, provided there is a minimum 1 in. (25 mm) thermal break between the purlins and the metal spanning members. For double-layer installations, the second *rated R-value of insulation* is for insulation installed parallel to the purlins. For continuous insulation (e.g., insulation boards), it is assumed that the insulation boards are installed below the purlins and are uninterrupted by framing members. Insulation exposed to the *conditioned space* or *semi-heated space* shall have a facing, and all insulation seams shall be continuously sealed to provide a continuous air barrier.
- c) For *attics and other roofs*, the *rated R-value of insulation* is for insulation installed both inside and outside the roof, or entirely inside the roof cavity, and allows occasional interruption by framing members, but requires that the framing members be covered with insulation when the depth of the insulation exceeds the depth of the framing cavity. Insulation in attics and other roofs shall be permitted to be tapered at the eaves where the building structure does not allow full depth. For *single-rafter roofs*, the requirement is the lesser of the values for *attics and other roofs* and those listed in Table 5.3.1.1A.

**Table 5.3.1.1A
Single Rafter Roofs**

	Minimum Insulation R-Value or Maximum Assembly U-Factor		
	Wood Rafter Depth, d (actual)		
<i>HDD65</i> (<i>HDD18</i>)	d ≤ 8 in. (d ≤ 200 mm)	8 < d ≤ 10 in. (200 < d ≤ 250 mm)	10 < d ≤ 12 in. (250 < d ≤ 300 mm)
0 - 12600 (0 - 7000)	R-19 (3.3) U-0.055 (0.31)	R-30 (5.3) U-0.036 (0.20)	R-38 (6.7) U-0.028 (0.16)
> 12600 (> 7000)	R-21 (3.7) U-0.052 (0.29)	R-30 (5.3) U-0.036 (0.20)	R-38 (6.7) U-0.028 (0.16)

Exception to 5.3.1.1: This exception applies to exterior roofs other than roofs with ventilated attics and does not apply to semi-heated spaces. For demonstrating compliance, the U-factor of the proposed roof is allowed to be decreased by the multipliers in Table 5.3.1.1B provided the exterior roof surface:

1. has a minimum total solar reflectance of 0.70 when tested in accordance with ASTM E903, and
2. has a minimum thermal emittance of 0.75 when tested in accordance with ASTM E408.

**Table 5.3.1.1B
Roof U-Factor Multipliers for Exception to 5.3.1.1**

<i>HDD65</i>	(<i>HDD18</i>)	Roof U-Factor Multiplier
0-900	(0-500)	0.77
901-1800	(501 - 1000)	0.83
1801 - 2700	(1001-1500)	0.85
2701 - 3600	(1501 - 2000)	0.86
> 3600	(>2000)	1.00

5.3.1.2 Above-Grade Wall Insulation. All *above-grade walls*, including *mass walls*, *metal building walls*, *steel-framed walls*, and *wood-framed and other walls*, shall have a *rated R-value of insulation* not less than that specified in Table 5.3. Mass wall heat capacity shall be determined from Table A-6 or A-7, as appropriate.

- (a) For *mass walls*, the *rated R-value of insulation* is for *continuous insulation* uninterrupted by framing other than 20 gauge 1 in. (25 mm) metal clips spaced no closer than 24 in. (600 mm) on center horizontally and 16 in. (400 mm) on center vertically. Where other framing, including metal and wood studs, is used, compliance shall be based on the maximum assembly *U-factor*. Where *rated R-value of insulation* is used for concrete sandwich panels, the insulation shall be continuous throughout the entire panel.

Exception to 5.3.1.2a: Alternatively, for *mass walls*, where the requirement in the table is for a maximum assembly $U=0.151$ (0.86) followed by an asterisk only, ASTM C90 concrete block walls ungrouted or partially grouted at 32 in. (800 mm) on center vertically or less and 48 in. (1200 mm) on center horizontally or less shall have ungrouted cores filled with material having a maximum thermal conductivity of $0.44 \text{ Btu}\cdot\text{in.}/\text{h}\cdot\text{ft}^2\cdot\text{F}$ ($0.063 \text{ W}/\text{m}\cdot\text{K}$). Other *mass walls* with integral insulation shall meet the criteria when their *U-factors* are equal to or less than those for the appropriate thickness and density in the "Partly Grouted Cells Insulated" column of Table A-7.

- (b) For *metal building walls*, the first *rated R-Value of insulation* is for insulation compressed between metal wall panels and the steel structure. For double-layer installations, the second *rated R-value of insulation* is for insulation installed from the inside, covering the girts. For continuous insulation (e.g., insulation boards) it is assumed that the insulation boards are installed on the inside of the girts and uninterrupted by the framing members. Insulation exposed to the *conditioned space* or *semi-heated space* shall have a facing, and all insulation seams shall be continuously sealed to provide a continuous air barrier.
- (c) For *steel-framed walls*, the first *rated R-value of insulation* is for uncompressed insulation installed in the cavity between steel studs. It is acceptable for this insulation to also be *continuous insulation* uninterrupted by framing. If there are two values, the second *rated R-value of insulation* is for *continuous insulation* uninterrupted by framing, etc. to be installed in addition to the first insulation. Opaque mullions in spandrel glass shall be covered with insulation complying with the steel-framed wall requirements.
- (d) For *wood-framed and other walls*, the first *rated R-value of insulation* is for uncompressed insulation installed in the cavity between wood studs. It is acceptable for this insulation to also be *continuous insulation* uninterrupted by framing. If there are two values, the second *rated R-value of insulation* is for *continuous insulation* uninterrupted by framing, etc. to be installed in addition to the first insulation.

When a *wall* consists of both *above-grade* and *below-grade* portions, the entire *wall* for that story shall be insulated on either the exterior or the interior or be integral. If insulated on the interior, the *wall* shall be insulated to the *above-grade wall* requirements. If insulated on the exterior or integral, the *below-grade wall* portion shall be insulated to the *below-grade wall* requirements, and the *above-grade wall* portion shall be insulated to the *above-grade wall* requirements.

5.3.1.3 Below-Grade Wall Insulation. *Below-grade walls* shall have a *rated R-value of insulation* not less than that specified in Table 5.3. For *below-grade walls*, the *rated R-value of insulation* is for *continuous insulation* uninterrupted by framing. Where framing, including metal and wood studs, is used, compliance shall be based on the maximum assembly *C-factor*.

5.3.1.4 Floor Insulation. All *floors*, including *mass floors*, *steel joist floors*, and *wood-framed and other floors*, shall have a *rated R-value of insulation* not less than that specified in Table 5.3.

- (a) For *mass floors*, the *rated R-value of insulation* is for *continuous insulation* uninterrupted by framing. Where framing, including metal and wood joists, is used, compliance shall be based on the maximum assembly *U-factor* rather than the minimum *rated R-value of insulation*. For waffle-slab *floors*, the *floor* shall be insulated either on the interior above the slab or on all exposed

surfaces of the waffle. For *floors* with beams that extend below the floor slab, the *floor* shall be insulated either on the interior above the slab or on the exposed floor and all exposed surfaces of the beams that extend 24 in. (600 mm) and less below the exposed floor.

- (b) For *steel joist floors*, the first *rated R-value of insulation* is for uncompressed insulation installed in the cavity between steel joists or for spray-on insulation. It is acceptable for this insulation to also be *continuous insulation* uninterrupted by framing. All *continuous insulation* shall be installed either on the interior above the floor structure or below a framing cavity completely filled with insulation.
- (c) For *wood-framed and other floors*, the first *rated R-value of insulation* is for uncompressed insulation installed in the cavity between wood joists. It is acceptable for this insulation to also be *continuous insulation* uninterrupted by framing. All *continuous insulation* shall be installed either on the interior above the floor structure or below a framing cavity completely filled with insulation.

5.3.1.5 Slab-On-Grade Floor Insulation. All *slab-on-grade floors*, including *heated slab-on-grade floors* and *unheated slab-on-grade floors*, shall have a *rated R-value of insulation* not less than that specified in Table 5.3 and shall be installed around the perimeter of the *slab-on-grade floor* to the distance specified. Perimeter insulation installed inside the foundation wall shall extend downward from the top of the slab a minimum of the distance specified or to the top of the footing, whichever is less. Perimeter insulation installed outside the foundation wall shall extend from the top of the slab, or downward to at least the bottom of the slab and then horizontally to a minimum of the distance specified. In all climates, the horizontal insulation extending outside of the foundation shall be covered by pavement or by soil a minimum of 10 in. (250 mm) thick.

Exception to 5.3.1.5: For a monolithic *slab-on-grade floor*, the insulation shall extend from the top of the slab-on-grade to the bottom of the footing.

5.3.1.6 Opaque Doors. All *opaque doors*, including *swinging doors* and *non-swinging doors*, shall have a *U-factor* not greater than that specified in Table 5.3.

5.3.2 Fenestration. Compliance with *U-factors* and *solar heat gain coefficient (SHGC)* shall be demonstrated for the overall fenestration product, including glass, sash, and frame, as provided in 5.2.2. Gross wall areas and gross roof areas shall be calculated separately for each *space-conditioning category* for the purposes of determining compliance.

Exception to 5.3.2: Alternatively, if there are multiple assemblies within a single *class of construction* for a single *space-conditioning category*, compliance shall be based on an area-weighted average *U-factor* or *SHGC*. It is not acceptable to do an area-weighted average across multiple *classes of construction* or multiple *space-conditioning categories*.

5.3.2.1 Fenestration Area. The total *vertical fenestration area*, including both fixed *vertical fenestration* and operable *vertical fenestration*, shall be less than 50% of the *gross wall area*. The total *skylight area*, including glass *skylights*, plastic *skylights* with a curb, and all *skylights* without a curb shall be less than 5% of the *gross roof area*.

Exception to 5.3.2.1: *Vertical fenestration* complying with Exception (c) to 5.3.2.3.

5.3.2.2 Fenestration U-Factor. *Fenestration*, including fixed *vertical fenestration*, operable *vertical fenestration*, glass *skylights* with a curb, plastic *skylights* with a curb, and all *skylights* without a curb shall have a *U-factor* not greater than that specified in Table 5.3 for the appropriate *fenestration area*. *U-factor* for *fenestration* shall be determined in accordance with 5.2.2.

Exception to 5.3.2.2: *Vertical fenestration* complying with Exception (c) to 5.3.2.3 shall have a *U-factor* not greater than that specified for 40% of the *gross wall area*.

5.3.2.3 Fenestration Solar Heat Gain Coefficient (SHGC). *Vertical fenestration* shall have a *SHGC* not greater than that specified for “all” orientations in Table 5.3 for the appropriate total *vertical fenestration area*. *Skylights*, including glass *skylights* with a curb, plastic *skylights* with a curb, and all *skylights* without a curb shall have a *SHGC* not greater than that specified for “all” orientations in Table 5.3 for the appropriate total *skylight area*. *SHGC* for *fenestration* shall be determined in accordance with 5.2.2. There are no *SHGC* requirements for *semi-heated spaces* or for buildings in climates with greater than 10800 HDD65 (6000 HDD18).

Exceptions to 5.3.2.3: (a) Alternatively, in latitudes greater than 10 degrees, the *SHGC* for *north-oriented vertical fenestration* shall be calculated separately and shall not be greater than that specified in Table 5.3 for *north-oriented fenestration*. When this exception is used, the *fenestration area* used in selecting the criteria shall be calculated separately for *north-oriented* and all other-oriented *fenestration*.

Note to adopting authority: If the project is in the southern hemisphere, change north to south.

(b) For demonstrating compliance for *vertical fenestration* only, the *SHGC* in the proposed building shall be reduced by using the multipliers in Table 5.3.2.3 for each *fenestration* product shaded by permanent projections that will last as long as the building itself.

**Table 5.3.2.3
SHGC Multipliers for Permanent Projections**

Projection Factor	SHGC Multiplier (All Other 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

(c) *Vertical fenestration* located on the street-side of the street-level story only, provided that:

1. the street-side of the street-level story does not exceed 20 ft (6 m) in height,
2. the *fenestration* has a continuous overhang with a weighted average *projection factor* greater than 0.5, and
3. the *fenestration area* for the street-side of the street-level story is less than 75% of the *gross wall area* for the street-side of the street-level story.

When this exception is utilized, separate calculations shall be performed for these sections of the *building envelope*, and these values shall not be averaged with any others for compliance purposes. No credit shall be given here or elsewhere in the building for not fully utilizing the *fenestration area* allowed. This exception does not apply to the *building envelope* trade-off option in 5.4 or the energy cost budget option in 11.

5.3.2.4 Visible Light Transmittance (VLT). There are no minimum visible light transmittance criteria in the Prescriptive Building Envelope Option; however, there are minimum criteria in the Building Envelope Trade-Off Option.

5.4 Building Envelope Trade-Off Option

The *building envelope* complies with the standard if the proposed building satisfies the provisions of 5.1 and 5.2, and the *envelope performance factor* of the proposed building is less than or equal to the *envelope performance factor* of the budget building. The *envelope performance factor* considers only the *building envelope* components. Schedules of operation, lighting power, equipment power, occupant density, and mechanical systems shall be the same for both the proposed building and the budget building. *Envelope performance factor* shall be calculated using the procedures of Normative Appendix C.

5.5 Mandatory Provisions

5.5.1 Insulation General.

5.5.1.1 Insulation Installation. Insulation materials shall be installed in accordance with manufacturer's recommendations and in such a manner as to achieve *rated R-value of insulation*.

Open-blown or poured loose-fill insulation shall not be used in *attic roof* spaces when the slope of the ceiling is more than three in twelve. When eave vents are installed, baffling of the vent openings shall be provided to deflect the incoming air above the surface of the insulation.

Exception to 5.5.1.1: Where *metal building roof* and *metal building wall* insulation is compressed between the *roof* or *wall* skin and the structure.

5.5.1.2 Substantial Contact. Insulation shall be installed in a permanent manner in *substantial contact* with the inside surface. Flexible batt insulation installed in floor cavities shall be supported in a permanent manner by supports no greater than 24 in. (600 mm) on center.

Exception to 5.5.1.2: Insulation materials that rely on air spaces adjacent to reflective surfaces for their rated performance.

5.5.1.3 Recessed Equipment. Lighting fixtures; heating, ventilating, and air-conditioning equipment, including wall heaters, ducts, and plenums; and other equipment shall not be recessed in such a manner to affect the insulation thickness unless:

- (a) the total combined area affected (including necessary clearances) is less than one percent of the opaque area of the assembly, or
- (b) the entire *roof, wall, or floor* is covered with insulation to the full depth required, or
- (c) the effects of reduced insulation are included in calculations using an area weighted average method and compressed insulation values obtained from Table A-24.

In all cases, air leakage through or around the recessed equipment to the *conditioned space* shall be limited in accordance with 5.5.3.1.

5.5.1.4 Location of Roof Insulation. The *roof* insulation shall not be installed on a suspended ceiling with removable ceiling panels.

5.5.1.5 Insulation Protection. Exterior insulation shall be covered with a protective material to prevent damage from sunlight, moisture, landscaping operations, equipment maintenance, and wind. In *attics* and mechanical rooms, a way to access equipment that prevents damaging or compressing the insulation shall be provided. Foundation vents shall not interfere with the insulation.

Insulation materials in ground contact shall have a water absorption rate no greater than 0.3 percent when tested in accordance with ASTM C272.

5.5.2 Fenestration and Doors. Product samples used for determining *fenestration* performance shall be production line units or representative of units as purchased by the consumer or contractor.

5.5.2.1 U-Factor. *U-factors* shall be determined in accordance with NFRC 100. *U-factors* for *skylights* shall be determined for a slope of 20° above the horizontal. *U-factor* shall be determined by a laboratory accredited by a nationally recognized accreditation organization, such as the National Fenestration Rating Council, and shall be *labeled* and certified by the manufacturer.

Exceptions to 5.5.2.1:

- (a) *U-factors* from A.8.1 shall be an acceptable alternate for determining compliance with the *U-factor* criteria for *glazed wall systems* in *vertical fenestration* and *skylights*. Where credit is being taken for a low-emissivity coating, the emissivity of the coating shall be determined in accordance with NFRC 301. Emissivity shall be verified and certified by the manufacturer.
- (b) *U-factors* from A.8.2 shall be an acceptable alternate for determining compliance with the *U-factor* criteria for other *vertical fenestration* that does not qualify for exception (a).

- (c) *U-factors* from A.7 shall be an acceptable alternate for determining compliance with the *U-factor* criteria for *opaque doors*.
- (d) For garage *doors*, NAGDM 105 shall be an acceptable alternate for determining *U-factors*.

5.5.2.2 Solar Heat Gain Coefficient. *SHGC* for the overall *fenestration area* shall be determined in accordance with NFRC 200. *SHGC* shall be determined by a laboratory accredited by a nationally recognized accreditation organization, such as the National Fenestration Rating Council, and shall be *labeled* and certified by the manufacturer.

Exceptions to 5.5.2.2:

- (a) *Shading coefficient* of the center of glass multiplied by 0.86 shall be an acceptable alternate for determining compliance with the *SHGC* requirements for the overall *fenestration area*. *Shading coefficient* shall be determined using a spectral data file determined in accordance with NFRC 300. *Shading coefficient* shall be verified and certified by the manufacturer.
- (b) *SHGC* of the center of glass shall be an acceptable alternate for determining compliance with the *SHGC* requirements for the overall *fenestration area*. *SHGC* shall be determined using a spectral data file determined in accordance with NFRC 300. *SHGC* shall be verified and certified by the manufacturer.
- (c) *SHGC* from A.8.1 shall be an acceptable alternate for determining compliance with the *SHGC* criteria for *glazed wall systems* in *vertical fenestration* and *skylights*. Where credit is being taken for a low-emissivity coating, the emissivity of the coating shall be determined in accordance with NFRC 301. Emissivity shall be verified and certified by the manufacturer.
- (d) *SHGC* from A.8.2 shall be an acceptable alternate for determining compliance with the *SHGC* criteria for other *vertical fenestration* that does not qualify for exception (c).

5.5.2.3 Visible Light Transmittance. When 5.4 is used, visible light transmittance shall be determined in accordance with NFRC 200. Visible light transmittance shall be verified and certified by the manufacturer.

5.5.3 Air Leakage

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

- (a) joints around *fenestration* and *door* frames
- (b) junctions between *walls* and foundations, between walls at building corners, between walls and structural floors or roofs, and between *walls* and *roof* or *wall* panels
- (c) openings at penetrations of utility services through, *roofs*, *walls*, and *floors*
- (d) site-built *fenestration* and *doors*
- (e) building assemblies used as ducts or plenums
- (f) joints, seams, and penetrations of vapor retarders
- (g) all other openings in the *building envelope*.

Outside air intakes, exhaust outlets, relief outlets, stair shaft, elevator shaft smoke relief openings, and other similar elements shall also comply with 6.2.3.2.4 and 6.2.3.3.

5.5.3.2 Fenestration and Doors. Air leakage for *fenestration* and *doors* shall be determined in accordance with NFRC 400. Air leakage shall be determined by a laboratory accredited by a nationally recognized accreditation organization, such as the National Fenestration Rating Council, and shall be *labeled* and certified by the manufacturer. Air leakage shall not exceed 1.0 cfm/ft² (5.0 L/s·m²) for glazed swinging entrance doors and for revolving doors, and 0.4 cfm/ft² (2.0 L/s·m²) for all other products.

Exceptions to 5.5.3.2:

- (a) Field fabricated fenestration and doors.
- (b) For garage *doors*, air leakage determined by test at standard test conditions in accordance with NAGDM 105 shall be an acceptable alternate for compliance with air leakage requirements.
- (c) Until December 31, 1999, air leakage determined by test at standard test conditions in accordance with ASTM E283 shall be an acceptable alternate for compliance with air leakage requirements. This exception shall cease to exist on January 1, 2000.

5.5.3.3 Loading Dock Weatherseals. In climates that exceed 3600 *HDD65* (2000 *HDD18*), cargo *doors* and loading dock *doors* shall be equipped with weatherseals to restrict *infiltration* when vehicles are parked in the doorway.

5.5.3.4 Vestibules. A *door* that separates *conditioned space* from the exterior shall be protected with an enclosed vestibule, with all *doors* opening into and out of the vestibule equipped with self-closing devices. Vestibules shall be designed so that in passing through the vestibule it is not necessary for the interior and exterior *doors* to open at the same time. Interior and exterior *doors* shall have a minimum distance between them of not less than 7 ft (2.1 m) when in the closed position.

Exceptions to 5.5.3.4:

- (a) doors in buildings in climates that have less than 1800 *HDD65* (1000 *HDD18*).
- (b) *doors* in buildings less than four stories above grade.
- (c) *doors* not intended to be used as a *building entrance door*, such as mechanical or electrical equipment rooms.
- (d) *doors* opening directly from a *dwelling unit*.
- (e) *doors* that open directly from a space less than 3000 ft² (300 m²) in area.
- (f) *doors* in building entrances with revolving *doors*.
- (g) *doors* used primarily to facilitate vehicular movement or material handling and adjacent personnel *doors*.