APPENDIX 13-B
SUPPLEMENTAL INFORMATION FOR SUBCHAPTER 13-4

B1.0 General Requirements

B1.1 Testing Procedures.

B1.1.1 Building Material Thermal Properties. If *building material* R-values or thermal conductivities are determined by testing, one of the following test procedures shall be used:

a. ASTM C177,
b. ASTM C236,
c. ASTM C518, or
d. ASTM C976.

For concrete, the oven-dried conductivity shall be multiplied by 1.2 to reflect the moisture content as typically installed.

B1.1.2 Assembly U-Factors. If assembly *U-factors* are determined by testing, one of the following test procedures shall be used:

a. ASTM C236 or
b. ASTM C976.

Product samples tested shall be production line material or representative of material as purchased by the consumer or contractor. If the assembly is too large to be tested at one time in its entirety, then either a representative portion shall be tested or different portions shall be tested separately and a weighted average determined. To be representative, the portion tested shall include edges of panels, joints with other panels, typical framing percentages, and thermal bridges.

B1.1.3 Fenestrations 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.

B1.2 Calculation Procedures and Assumptions. The following procedures and assumptions shall be used for all calculations. R-values for air films, insulation, and *building materials* shall be taken from Sections B1.2.1 through B1.2.3, respectively. In addition, the appropriate assumptions listed in Sections B2.1 through B2.5, including framing factors, shall be used.

B1.2.1 Air Films: Prescribed R-values for air films shall be as follows:

R-Value	Condition
0.17	All exterior surfaces
0.46	All semi-exterior surfaces
0.61	Interior horizontal surfaces, heat flow up
0.92	Interior horizontal surfaces, heat flow down
0.68	Interior vertical surfaces

B1.2.1.1 Exterior surfaces are areas exposed to the wind.

B1.2.1.2 Semi-exterior surfaces are protected surfaces that face attics, crawl spaces, and parking garages with natural or mechanical ventilation.

B1.2.1.3 Interior surfaces are surfaces within enclosed spaces.

B1.2.1.4 The R-value for cavity airspaces shall be taken from Table B-1 based on the emissivity of the cavity from Table B-2. No credit shall be given for airspaces in cavities that contain any insulation or less than 1/2

inch (12.7 mm). The values for 3 ½ inch (84 mm) cavities shall be used for cavities of that width and greater.

B1.2.2 Insulation R-values: Insulation R-values shall be determined as follows:

a. For insulation that is not compressed, the *rated R-value of insulation* shall be used.

b. For calculation purposes, the effective R-value for insulation that is uniformly compressed in confined cavities shall be taken from Table B-3.

c. For calculation purposes, the effective R-value for insulation installed in cavities in attic roofs with steel joists shall be taken from Table B-18.

d. For calculation purposes, the effective R-value for insulation installed in cavities in steel-framed walls shall be taken from Table B-17.

B1.2.3 Building Material Thermal Properties: R-values for *building materials* shall be taken from Table B-4. Concrete block R-values shall be calculated using the isothermal planes method or a two-dimensional calculation program, thermal conductivities from Table B-5 and dimensions from ASTM C90. The parallel path calculation method is not acceptable.

Exception: R-values for *building materials* or thermal conductivities determined from testing in accordance with Section B1.1

B1.2.4 Building Material Heat Capacities: The *heat capacity* of assemblies shall be calculated using published values for the unit weight and specific heat of all building material components that make up the assembly.

B1.2.5 Architectural drawings. All components of the *building envelope* in the *proposed design* shall be modeled as shown on architectural drawings or as installed for existing building envelopes.

Exceptions: The following building elements are permitted to differ from architectural drawings.

1. Any envelope assembly that covers less than 5 percent 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.
2. 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.

B1.3 Insulation Installation. Insulation materials shall be installed in accordance with the insulation installation standards listed in Table C1.2.3 of Appendix C 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: Where *metal building roof* and *metal building wall* insulation is compressed between the *roof* or *wall* skin and the structure.

B1.3.1 Substantial Contact. Insulation shall be installed in a permanent manner in *substantial contact* with the inside surface in accordance with manufacturer's recommendations for the framing system used. Flexible batt insulation installed in floor cavities shall be supported in a permanent manner by supports no greater than 24 inches (610 mm) on center (o.c.).

Exception: Insulation materials that rely on airspaces adjacent to reflective

surfaces for their rated performance.

B1.3.2 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 as to affect the insulation thickness unless:

1. The total combined area affected (including necessary clearances) is less than one percent of the opaque area of the assembly, or
2. The entire *roof*, *wall*, or *floor* is covered with insulation to the full depth required, or
3. The effects of reduced insulation are included in calculations using an area-weighted average method and compressed insulation values obtained from Table B-3.

In all cases, air leakage through or around the recessed equipment to the *conditioned space* shall be limited in accordance with Section 13-406.ABC.1.2.

B1.3.3 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 .3 percent when tested in accordance with ASTM C272.

B1.4 Assembly U-Factor, C-Factor and F-Factor Determination

B1.4.1 Pre-Calculated Assembly U-Factors, C-Factors, F-Factors, or Heat Capacities. The *U-factors*, *C-factors, F-factors,* and *heat capacities* for typical construction assemblies are included in B2.1 through B2.5. These values shall be used for all calculations unless otherwise allowed by applicant-determined assembly U-factors, C-factors, F-factors, or heat capacities. Interpolation between values in a particular table in Appendix B is allowed for *rated R-values of insulation*, including insulated sheathing. Extrapolation beyond values in a table in this appendix is not allowed.

B1.4.2 Applicant-Determined Assembly U-Factors, C-Factors, F-Factors, or Heat Capacities. If the *building official* determines that the proposed construction assembly is not adequately represented in Sections B2.1 through B2.5, the applicant shall determine appropriate values for the assembly using the assumptions in Section B1.5. An assembly is deemed to be adequately represented if:

a. the interior structure, hereafter referred to as the base assembly, for the *class of construction* is the same as described in Sections B2.1 through B2.5 *and*

b. changes in exterior or interior surface *building materials* added to the base assembly do not increase or decrease the R-value by more than 2 from that indicated in the descriptions in Sections B2.1 through B2.5.

Insulation, including insulated sheathing, is not considered a *building material.*

B1.5 Determination of Alternate Assembly U-Factors, C-Factors, F-Factors, or Heat Capacities.

B1.5.1 General. Component *U-factors* for other opaque assemblies shall be determined in accordance with Section B1.5 only if approved by the *building official* in accordance with the applicant-determined assembly U-factors, C-factors, F-factors,

or heat capacities. The procedures required for each class of construction are specified in Section B1.5.2. Testing shall be performed in accordance with Section B1.1. Calculations shall be performed in accordance with Section B1.2.

B1.5.2 Required Procedures. Two- or three-dimensional finite difference and finite volume computer models shall be an acceptable alternative method to calculating the thermal performance values for all assemblies and constructions listed below. The following procedures shall also be permitted to determine all alternative *U-factors*, *F-factors*, and *C-factors*:

B1.5.2.1 Above-Grade Walls.

(1) *Mass walls*: testing or the isothermal planes calculation method or two-dimensional calculation method. The parallel path calculation method is not acceptable.

(2) *Metal building walls*: testing.

(3) *Steel-framed walls*: testing or parallel path calculation method using the insulation/framing layer adjustment factors in Table B-17 or the modified zone method.

(4) *Wood-framed walls*: testing or parallel path calculation method.

(5) Other *walls*: testing or two-dimensional calculation method.

B1.5.2.2 Below-Grade Walls.

(1) *Mass walls*: testing or the isothermal planes calculation method or two-dimensional calculation method. The parallel path calculation method is not acceptable.

(2) *Other walls*: testing or two-dimensional calculation method.

B1.5.2.3 Roofs.

(1) *Roofs with insulation entirely above deck*: testing or series calculation method.

(2) *Metal building roofs*: testing.

(3) *Attic roofs*, wood joists: testing or parallel path calculation method.

(4) *Attic roofs*, steel joists: testing or parallel path calculation method using the insulation/framing layer adjustment factors in Table B-18 or modified zone calculation method.

(5) *Attic roofs*, concrete joists: testing or parallel path calculation method if concrete is solid and uniform or isothermal planes calculation method if concrete has hollow sections.

(6) Other *attic roofs and other roofs*: testing or two dimensional calculation method.

B1.5.2.4 Floors.

(1) *Mass floors*: testing or parallel path calculation method if concrete is solid and uniform or isothermal planes calculation method if concrete has hollow sections.

(2) *Steel joist floors*: testing or modified zone calculation method.

(3) *Wood joist floors*: testing or parallel path calculation method or isothermal planes calculation method.

(4) Other *floors*: testing or two-dimensional calculation method.

(5) *Slab-on-Grade Floors*: no testing or calculations allowed.

TABLE B-1
Emittance Values of Various Surfaces and Effective Emittances of Air Spaces

Surface	Average Emittance *e*	Effective Emittance *e eff* of Air Space: One Surface *e*; Other, 0.9	Both Surfaces Emittance *e*
Aluminum foil,bright	0.05	0.05	0.03
Aluminum foil,with condensate just visible(>0.7gr/ft2)	0.3	0.29	-
Aluminum foil,with condensate clearly visible(>2.9gr/ft2)	0.7	0.65	-
Aluminum sheet	0.12	0.12	0.06
Aluminum coated paper,polished	0.2	0.2	0.11
Steel,galv.,bright	0.25	0.24	0.15
Aluminum paint	0.5	0.47	0.35
Bldg materials: wood, paper, masonry, nonmetallic paints	0.9	0.82	0.82
Regular glass	0.84	0.77	0.72

TABLE B-2
R-Values for Cavity Air Spaces

Component	Airspace Thickness (in.)	R-Value				
		Effective Emissivity				
		0.03	**0.05**	**0.20**	**0.50**	**0.82**
	0.5	2.13	2.04	1.54	1.04	0.77
	0.75	2.33	2.22	1.64	1.09	0.8
	1.5	2.53	2.41	1.75	1.13	0.82
	3.5	2.83	2.66	1.88	1.19	0.85
Wall	0.5	2.54	2.43	1.75	1.13	0.82
	0.75	3.58	3.32	2.18	1.3	0.9
	1.5	3.92	3.62	2.3	1.34	0.93
	3.5	3.67	3.4	2.21	1.31	0.91
Floor	0.5	2.55	1.28	1	0.69	0.53
	0.75	1.44	1.38	1.06	0.73	0.54
	1.5	2.49	2.38	1.76	1.15	0.85
	3.5	3.08	2.9	2.01	1.26	0.9

TABLE B-3
Effective R-Values for Fiberglass

		Insulation R-Value at Standard Thickness							
Rated R-Value		**38**	**30**	**22**	**21**	**19**	**15**	**13**	**11**
Standard Thickness (in.)		**12**	**9.5**	**6.5**	**5.5**	**6**	**3.5**	**3.5**	**3.5**
Nominal Lumber Size (in.)	**Actual Depth of Cavity (in.)**	**Effective Insulation R-Values when Installed in a Confined cavity**							
2x12	11.25	37	-	-	-	-	-	-	-
2x10	9.25	32	30	-	-	-	-	-	-
2x8	7.25	27	26	22	21	19	-	-	-
2x6	5.5		21	20	21	18		-	-
2x4	3.5		-	14	-	13	15	13	11
	2.5		-	-	-	-	-	9.8	
	1.5		-	-	-	-	-	6.3	6

TABLE B-4
R-Values for Building Materials

Material	**Nominal Size (in.)**	**Actual Size (in.)**	**R-Value**
	-	-	1.23
Concrete at R-0.0625/in.	-	2	0.13
	-	4	0.25
	-	6	0.38
	-	8	0.5
	-	10	0.63
	-	12	0.75
Flooring, wood subfloor	-	0.75	0.94
Gypsum board	-	0.5	0.45
	-	0.625	0.56
Metal deck	-	-	0
Roofing, built-up	-	0.375	0.33
Sheathing, vegetable fiber board, 0.78 in.	-	0.78	2.06
Soil at R-0.104/in.	-	12	1.25
Steel, mild		1	0.0031807
Stucco	-	0.75	0.08
Wood, 2 x 4 at R-1.25/in.	4	3.5	4.38
Wood, 2 x 6 at R-1.25/in.	6	5.5	6.88
Wood, 2 x 8 at R-1.25/in.	8	7.25	9.06
Wood, 2 x 10 at R-1.25/in.	10	9.25	11.56
Wood, 2 x 12 at R-1.25/in.	12	11.25	14.06
Wood, 2 x 14 at R-1.25/in.	14	13.25	16.56

TABLE B-5
Thermal Conductivity of Concrete Block Material

Concrete Block Density in lb/ft3	Thermal Conductivity in Btu·in./h·ft2·°F
80	3.7
85	4.2
90	4.7
95	5.1
100	5.5
105	6.1
110	6.7
115	7.2
120	7.8
125	8.9
130	10
135	11.8
140	13.5

B2.0 Building Envelope Characteristics

B2.1 Fenestration. All *fenestration* with *U-factors, SHGC,* or visible light transmittance determined, certified, and labeled in accordance with NFRC 100, 200, and 300, respectively, as specified in B1.1.3 shall be assigned those values. U-factors (thermal transmittances) of fenestration products (windows, doors and skylights) shall be determined by an accredited, independent laboratory in accordance with National Fenestration Rating Council 100, Procedure for Determining Fenestration Product U-Factors. The Solar Heat Gain Coefficient (SHGC) for glazed fenestration products (windows, glazed doors and skylights) shall be determined in accordance with National Fenestration Rating Council 200, Procedure for Determining Fenestration Product Solar Heat Gain Coefficients at Normal Incidence. Visible light transmittance shall be determined in accordance with NFRC 200 and shall be verified and certified by the manufacturer.

B2.1.1 Fenestration Energy Rating Labels. Energy performance values (i.e. U-factor, Solar Heat Gain Coefficient) of fenestration products (i.e. windows, doors and skylights) shall be determined by an accredited, independent laboratory and labeled and certified by the manufacturer. Such certified and labeled fenestration energy ratings shall be accepted for the purposes of determining compliance with the building envelope requirements of this code.

B2.1.2 Unlabeled fenestrations. Where the specified energy performance (U-factor or Solar Heat Gain Coefficient) of the fenestration product is not

labeled nor readily apparent, the default procedures outlined in Tables B-6, B-7 and B-8 of this Appendix for U-factor and SHGC shall be used to determine code compliance by subchapter 4. Product features must be verifiable for the product to qualify for the default value associated with those features. Where the existence of a particular feature cannot be determined with reasonable certainty, the product shall not receive credit for that feature. Where a composite of materials from two different product types are used, the product shall be assigned the worst value.

B2.1.2.1 Unlabeled Skylights. *Unlabeled skylights* shall be assigned the *U-factors* in Table B-6 and are allowed to use the *SHGCs* and visible light transmittances in Table B-7. The metal with thermal break frame category shall not be used unless all frame members have a thermal break equal to or greater than 1/4 in.

B2.1.2.2 Unlabeled Vertical Fenestration. *Unlabeled vertical fenestration*, both operable and fixed, shall be assigned the *U-factors, SHGCs,* and visible light transmittances in Table B-8. No credit shall be given for any other features, including metal frames with thermal breaks, low-emissivity coatings, gas fillings, or insulating spacers, other than as determined in accordance with B1.1.3.

B2.1.3 Shading devices

2.1.3.1 Overhangs. Shading may be by recessing the glazing into the building structure, by permanently mounted overhangs and projections or by permanently mounted sun shades with adequate air movement between the shading device and the fenestration. Complying overhangs shall be completely opaque and have the effect of being solid. Overhangs with slots, slats, grids and other openings are not considered if the sun can penetrate through at any occurring angle. Overhangs shall extend horizontally to points even with the left and right sides of the glazing.

B2.1.3.2 Shell Buildings. Only those shading devices that are installed at the time of construction of the building shell shall be considered when determining compliance for shell buildings.

TABLE B-6
Assembly U-Factors for Unlabeled Skylights

Product Type		Sloped Installation						
		Unlabeled Skylight with Curb (Includes glass/plastic, flat/domed, fixed/operable)				Unlabeled Skylight without Curb (Includes glass/plastic, flat/domed, fixed/operable)		
	Frame Type	Aluminum without Thermal Break	Aluminum with Thermal Break	Reinforced Vinyl/ Aluminum Clad Wood	Wood/ Vinyl	Aluminum without Thermal Break	Aluminum with Thermal Break	Structural Glazing
ID	Glazing Type							
	Single Glazing							
1	1/8" glass	1.98	1.89	1.75	1.47	1.36	1.25	1.25
2	1/4" acrylic/polycarb	1.82	1.73	1.6	1.31	1.21	1.1	1.1
3	1/8" acrylic/polycarb	1.9	1.81	1.68	1.39	1.29	1.18	1.18
	Double Glazing							
4	1/4" airspace	1.31	1.11	1.05	0.84	0.82	0.7	0.66
5	1/2" airspace	1.3	1.1	1.04	0.84	0.81	0.69	0.65
6	1/4" argon space	1.27	1.07	1	0.8	0.77	0.66	0.62
7	1/2" argon space	1.27	1.07	1	0.8	0.77	0.66	0.62
	Double Glazing, e=0.60 on	surface 2 or 3						
8	1/4" airspace	1.27	1.08	1.01	0.81	0.78	0.67	0.63
9	1/2" airspace	1.27	1.07	1	0.8	0.77	0.66	0.62
10	1/4" argon space	1.23	1.03	0.97	0.76	0.74	0.63	0.58
11	1/2" argon space	1.23	1.03	0.97	0.76	0.74	0.63	0.58
	Double Glazing, e=0.40 on	surface 2 or 3						
12	1/4" airspace	1.25	1.05	0.99	0.78	0.76	0.64	0.6
13	1/2" airspace	1.24	1.04	0.98	0.77	0.75	0.64	0.59
14	1/4" argon space	1.18	0.99	0.92	0.72	0.7	0.58	0.54
15	1/2" argon space	1.2	1	0.94	0.74	0.71	0.6	0.56
	Double Glazing, e=0.20 on	surface 2 or 3						
16	1/4" airspace	1.2	1	0.94	0.74	0.71	0.6	0.56
17	1/2" airspace	1.2	1	0.94	0.74	0.71	0.6	0.56
18	1/4" argon space	1.14	0.94	0.88	0.68	0.65	0.54	0.5
19	1/2" argon space	1.15	0.95	0.89	0.68	0.66	0.55	0.51
	Double Glazing, e=0.10 on	surface 2 or 3						
20	1/4" airspace	1.18	0.99	0.92	0.72	0.7	0.58	0.54
21	1/2" airspace	1.18	0.99	0.92	0.72	0.7	0.58	0.54
22	1/4" argon space	1.11	0.91	0.85	0.65	0.63	0.52	0.47
23	1/2" argon space	1.13	0.93	0.87	0.67	0.65	0.53	0.49

	Double Glazing, e=0.05 on	surface 2 or 3						
24	1/4" airspace	1.17	0.97	0.91	0.7	0.68	0.57	0.52
25	1/2" airspace	1.17	0.98	0.91	0.71	0.69	0.58	0.53
26	1/4" argon space	1.09	0.89	0.83	0.63	0.61	0.5	0.45
27	1/2" argon space	1.11	0.91	0.85	0.65	0.63	0.52	0.47
	Triple Glazing							
28	1/4" airspaces	1.12	0.89	0.84	0.64	0.64	0.53	0.48
29	1/2" airspaces	1.1	0.87	0.81	0.61	0.62	0.51	0.45
30	1/4" argon spaces	1.09	0.86	0.8	0.6	0.61	0.5	0.44
31	1/2" argon spaces	1.07	0.84	0.79	0.59	0.59	0.48	0.42
	Triple Glazing, e=0.20 on surface	2,3,4, or 5						
32	1/4" airspaces	1.08	0.85	0.79	0.59	0.6	0.49	0.43
33	1/2" airspaces	1.05	0.82	0.77	0.57	0.57	0.46	0.41
34	1/4" argon spaces	1.02	0.79	0.74	0.54	0.55	0.44	0.38
35	1/2" argon spaces	1.01	0.78	0.73	0.53	0.54	0.43	0.37
	Triple Glazing, e=0.20 on	surfaces 2 or	3 and 4 or 5					
36	1/4" airspaces	1.03	0.8	0.75	0.55	0.56	0.45	0.39
37	1/2" airspaces	1.01	0.78	0.73	0.53	0.54	0.43	0.37
38	1/4" argon spaces	0.99	0.75	0.7	0.5	0.51	0.4	0.35
39	1/2" argon spaces	0.97	0.74	0.69	0.49	0.5	0.39	0.33
	Triple Glazing, e=0.10 on	surfaces 2 or	3 and 4 or 5					
40	1/4" airspaces	1.01	0.78	0.73	0.53	0.54	0.43	0.37
41	1/2" airspaces	0.99	0.76	0.71	0.51	0.52	0.41	0.36
42	1/4" argon spaces	0.96	0.73	0.68	0.48	0.49	0.38	0.32
43	1/2" argon spaces	0.95	0.72	0.67	0.47	0.48	0.37	0.31
	Quadruple Glazing, e=0.10 on	surfaces 2 or	3 and 4 or 5					
44	1/4" airspaces	0.97	0.74	0.69	0.49	0.5	0.39	0.33
45	1/2" airspaces	0.94	0.71	0.66	0.46	0.47	0.36	0.3
46	1/4" argon spaces	0.93	0.7	0.65	0.45	0.46	0.35	0.3
47	1/2" argon spaces	0.91	0.68	0.63	0.43	0.44	0.33	0.28
48	1/4" krypton spaces	0.88	0.65	0.6	0.4	0.42	0.31	0.25

TABLE B-7
Assembly Solar Heat Gain Coefficients (SHGC) and
Assembly Visible Light Transmittances (VLT) for Unlabeled Skylights

Glass Type	Glazing Type: Number of glazing layers Number & emissivity of coatings (glazing is glass except where noted	Unlabeled Skylights (includes glass/plastic, flat/domed, fixed/operable)					
	Frame:	Metal without thermal break		Metal with thermal break		Wood/vinyl/ fiberglass	
	Characteristic:	SHGC	VLT	SHGC	VLT	SHGC	VLT
Clear	Single glazing, 1/8 in. glass	0.82	0.76	0.78	0.76	0.73	0.73
	Single glazing, 1/4 in. glass	0.78	0.75	0.74	0.75	0.69	0.72
	Single glazing, acrylic/polycarbonate	0.83	0.92	0.83	0.92	0.83	0.92
	Double glazing	0.68	0.66	0.64	0.66	0.59	0.64
	Double glazing, E=0.40 on surface 2 or 3	0.71	0.65	0.67	0.65	0.62	0.63
	Double glazing, E=0.20 on surface 2 or 3	0.66	0.61	0.62	0.61	0.57	0.59
	Double glazing, E=0.10 on surface 2 or 3	0.59	0.63	0.55	0.63	0.51	0.61
	Double glazing, acrylic/polycarbonate	0.77	0.89	0.77	0.89	0.77	0.89
	Triple glazing	0.6	0.59	0.56	0.59	0.52	0.57
	Triple glazing, E=0.40 on surface 2, 3, 4, or 5	0.64	0.6	0.6	0.6	0.56	0.57
	Triple glazing, E=0.20 on surface 2, 3, 4, or 5	0.59	0.55	0.55	0.55	0.51	0.53
	Triple glazing, E=0.10 on surface 2, 3, 4, or 5	0.54	0.56	0.5	0.56	0.46	0.54
	Triple glazing, E=0.40 on surfaces 3 and 5	0.62	0.57	0.58	0.57	0.53	0.55
	Triple glazing, E=0.20 on surfaces 3 and 5	0.56	0.51	0.52	0.51	0.48	0.49
	Triple glazing, E=0.10 on surfaces 3 and 5	0.47	0.54	0.43	0.54	0.4	0.52
	Triple glazing, acrylic/polycarbonate	0.71	0.85	0.71	0.85	0.71	0.85
	Quadruple glazing, E=0.10 on surfaces 3 and 5	0.41	0.48	0.37	0.48	0.33	0.46
	Quadruple glazing, acrylic/polycarbonate	0.65	0.81	0.65	0.81	0.65	0.81
Tinted	Single glazing, 1/8 in. glass	0.7	0.58	0.66	0.58	0.62	0.56
	Single glazing, 1/4 in. glass	0.61	0.45	0.56	0.45	0.52	0.44
	Single glazing, acrylic/polycarbonate	0.46	0.27	0.46	0.27	0.46	0.27
	Double glazing	0.5	0.4	0.46	0.4	0.42	0.39
	Double glazing, E=0.40 on surface 2 or 3	0.59	0.5	0.55	0.5	0.5	0.48
	Double glazing, E=0.20 on surface 2 or 3	0.47	0.37	0.43	0.37	0.39	0.36

Double glazing, E=0.10 on surface 2 or 3	0.43	0.38	0.39	0.38	0.35	0.37
Double glazing, acrylic/polycarbonate	0.37	0.25	0.37	0.25	0.37	0.25
Triple glazing	0.42	0.22	0.37	0.22	0.34	0.21
Triple glazing, E=0.40 on surface 2, 3, 4, or 5	0.53	0.45	0.49	0.45	0.45	0.44
Triple glazing, E=0.20 on surface 2, 3, 4, or 5	0.42	0.33	0.38	0.33	0.35	0.32
Triple glazing, E=0.10 on surface 2, 3, 4, or 5	0.39	0.34	0.35	0.34	0.31	0.33
Triple glazing, E=0.40 on surfaces 3 and 5	0.51	0.43	0.47	0.43	0.43	0.42
Triple glazing, E=0.20 on surfaces 3 and 5	0.4	0.31	0.36	0.31	0.32	0.29
Triple glazing, E=0.10 on surfaces 3 and 5	0.34	0.32	0.3	0.32	0.27	0.31
Triple glazing, acrylic/polycarbonate	0.3	0.23	0.3	0.23	0.3	0.23
Quadruple glazing, E=0.10 on surfaces 3 and 5	0.3	0.29	0.26	0.29	0.23	0.28
Quadruple glazing, acrylic/polycarbonate	0.27	0.25	0.27	0.25	0.27	0.25

TABLE B-8
Assembly U-Factors, Assembly Solar Heat Gain Coefficients (SHGC), and Assembly Visible Light Transmittances (VLT) for Unlabeled Vertical Fenestration

All frame types		Unlabeled Vertical Fenestration					
		Clear Glass			Tinted Glass		
		U-Factor	SHGC	VLT	U-Factor	SHGC	VLT
	Singleglazing	1.25	0.82	0.76	1.25	0.7	0.58
	Glassblock	0.6	0.56	0.56	n.a.	n.a.	n.a.
Wood, vinyl, or fiberglass frame							
	Doubleglazing	0.6	0.59	0.64	0.6	0.42	0.39
	Tripleglazing	0.45	0.52	0.57	0.45	0.34	0.21
Metal and other frame types							
	Doubleglazing	0.9	0.68	0.66	0.9	0.5	0.4
	Tripleglazing	0.7	0.6	0.59	0.7	0.42	0.22

B2.2 Walls

B2.2.1 Above-Grade Walls

B2.2.1.1 Mass Wall. *U-factors* for *mass walls* shall be taken from Table B-9 or determined by the procedure in this subsection. It is acceptable to use the *U-factors* in Table B-9 for all *mass walls*, provided that the grouting is equal to or less than that specified. *Heat capacity* for *mass walls* shall be taken from Table B-10 or B-11.

Exception: U-factors for mass walls determined in accordance with Section B2.2.1.1.3.

B2.2.1.1.1 General. For the purpose of applicant-determined assembly U-factors, C-factors, F-factors, or heat capacities, the base assembly is a masonry or concrete *wall*. *Continuous insulation* is installed on the interior, exterior, or within the masonry units, or it is installed on the interior or exterior of the concrete. The *U-factor* includes R-0.17 for exterior air film and R-0.68 for interior air film, vertical surfaces. For insulated walls, the U-factor also includes R-0.45 for ½-inch (12.7 mm) gypsum board. *U-factors* are provided for the following configurations:

a. Concrete *wall*: 8 inches (203 mm) normal weight concrete wall with a density of 145 pound per cubic foot (2323 kg/m^3;).

b. Solid grouted concrete block *wall*: 8 inches (203 mm) medium weight ASTM C90 concrete block with a density of 115 pound per cubic foot (1842 kg/m^3) and solid grouted cores.

c. Partially grouted concrete block *wall*: 8 inches (203~~5~~ mm). medium weight ASTM C90 concrete block with a density of 115 pound per cubic foot (1842 kg/m^3) having reinforcing steel every 32 inches (812 mm) vertically and every 48 inches (1219 mm) horizontally, with cores grouted in those areas only. Other cores are filled with insulating material only if there is no other insulation.

B2.2.1.1.2 Mass Wall Rated R-value of Insulation

B2.2.1.1.2.1 Mass wall heat capacity shall be determined from Table B-10 or B-11.

B2.2.1.1.2.2 The rated R-value of insulation is for continuous insulation uninterrupted by framing other than 20 gauge 1 inch metal clops spaced no closer than 24 inches on center (609 mm) horizontally and 16 inches on center (406 mm) vertically.

B2.2.1.1.2.3 Where other framing, including metal and wood studs, is used, compliance shall be based on the maximum assembly U-factor.

B2.2.1.1.2.4 Where rated R-value of insulation is used for concrete sandwich panels, the insulation shall be continuous throughout the entire panel.

B2.2.1.1.3 Mass Wall U-factor.

B2.2.1.1.3.1 U-factors for mass walls shall be taken from Table B-10 or determined by the procedure in this subsection. It is acceptable to use the U-factors in Table B-9 for all mass walls, provided that the grouting is equal to or less than that specified. Heat capacity for mass walls shall be taken from Table B-10 or B-11.

Exception: For mass walls, where the requirement on Form 400C is for a maximum assembly U-0.151 followed by footnote “a,” ASTM C90 concrete block walls, ungrouted or partially grouted at 32 inches (812

mm) or less on center vertically and 48 inches (1219 mm) or less on center horizontally, shall have ungrouted cores filled with material having a maximum thermal conductivity of 0.44 Btu in./h ft^2 ^oF. 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 B-11.

B2.2.1.1.3.2 Determination of Mass Wall U-Factors. If not taken from Table B-9, *mass wall U-factors* shall be determined from Tables B-10, B-11, and B-12 using the following procedure:

a. If the *mass wall* is uninsulated or only the cells are insulated:

1. For concrete *walls*, determine the *U-factor* from Table B-10 based on the concrete density and *wall* thickness.

2. For concrete block *walls*, determine the *U-factor* from Table B-11 based on the block size, concrete density, degree of grouting in the cells, and whether the cells are insulated.

b. If the *mass wall* has additional insulation:

1. For concrete *walls*, determine the *Ru* from Table B-10 based on the concrete density and *wall* thickness. Next, determine the effective R-value for the insulation/ framing layer from Table B-12 based on the *rated R-value of insulation* installed, the thickness of the insulation, and whether it is installed between wood or metal framing or with no framing. Then, determine the *U-factor* by adding the *Ru* and the effective R-value together and taking the inverse of the total.

2. For concrete block *walls*, determine the *Ru* from Table B-11 based on the block size, concrete density, degree of grouting in the cells, and whether the cells are insulated. Next, determine the effective R-value for the insulation/framing layer from Table B-12 based on the *rated R-value of insulation* installed, the thickness of the insulation, and whether it is installed between wood or metal framing or with no framing. Then, determine the *U-factor* by adding the *Ru* and the effective R-value together and taking the inverse of the total.

B2.2.1.2 Metal Building Walls.

B2.2.1.2.1 General. For the purpose of applicant-determined assembly U-factors, C-factors, F-factors, or heat capacities, the base assembly is a *wall* where the insulation is compressed between metal wall panels and the metal structure. Additional assemblies include *continuous insulation*, uncompressed and uninterrupted by framing.

B2.2.1.2.2 Rated R-value of Insulation for Metal Building Walls.

B2.2.1.2.2.1 The first *rated R-Value of insulation* is for insulation compressed between metal wall panels and the steel structure.

B2.2.1.2.2.2 For double-layer installations, the second *rated R-value of insulation* is for insulation installed from the inside, covering the girts.

B2.2.1.2.2.3 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.

B2.2.1.2.2.4 Insulation exposed to the *conditioned space* or *semiheated space* shall have a facing, and all insulation seams shall be continuously

sealed to provide a continuous air barrier.

B2.2.1.2.3 U-factors for Metal Building Walls. U-factors for metal building walls shall be taken from Table B-13. It is not acceptable to use these U-factors if additional insulation is not continuous.

B2.2.1.3 Steel-Framed Walls.

B2.2.1.3.1 General. For the purpose of applicant-determined assembly U-factors, C-factors, F-factors, or heat capacities, the base assembly is a *wall* where the insulation is installed within the cavity of the steel stud framing but where there is not a metal exterior surface spanning member. The steel stud framing is a minimum uncoated thickness of 0.043 inches (1.1 mm) for 18 gauge or 0.054 inches for 16 gauge. The *U-factor* includes R-0.17 for exterior air film, R-0.08 for stucco, R-0.56 for 0.625-inches (16 mm) gypsum board on the exterior, R-0.56 for 0.625-inches (16 mm) gypsum board on the interior, and R-0.68 for interior vertical surfaces air film. The performance of the insulation/framing layer is calculated using the values in Table B-17. Additional assemblies include *continuous insulation*, uncompressed and uninterrupted by framing. *U-factors* are provided for the following configurations:

a. *Standard framing*: steel stud framing at 16 inches (410 mm) on center with cavities filled with 16 inches (410 mm) wide insulation for both 3 ½ inch (89 mm) deep and 6-inch (152 mm) deep wall cavities.

b. *Advanced framing*: steel stud framing at 24 inches (610mm) on center with cavities filled with 24 inch (610 mm) wide insulation for both 3 ½-inch (89 mm) deep and 6-inch (152 mm) deep wall cavities.

B2.2.1.3.2 Rated R-Value of Insulation for Steel-Framed Walls.

B2.2.1.3.2.1 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.

B2.2.1.3.2.2 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.

B2.2.1.3.2.3 Opaque mullions in spandrel glass shall be covered with insulation complying with the steel-framed wall requirements.

B2.2.1.3.3 U-Factors for Steel-Framed Walls.

B2.2.1.3.3.1 *U-factors* for *steel-framed walls* shall be taken from Table B-14.

B2.2.1.3.3.2 For *steel-framed walls* with framing at less than 24 inches (610 mm) on center, use the standard framing values as described in B2.2.1.3.1(a).

B2.2.1.3.3.3 For *steel-framed walls* with framing from 24 inches to 32 inches (610 mm to 813 mm) on center, use the advanced framing values as described in B2.2.1.3.1(b).

B2.2.1.3.3.4 For *steel-framed walls* with framing greater than 32 inches (813 mm) on center, use the *metal building wall* values in Table B-13.

B2.2.1.4 Wood-Framed Walls.

B2.2.1.4.1 General. For the purpose of applicant-determined assembly U-factors, C-factors, F-factors, or heat capacities, the base assembly is a *wall* where the insulation is installed between 2 inches (51 mm) nominal wood

framing. Cavity insulation is full depth, but values are taken from Table B-3 for R-19 insulation, which is compressed when installed in a 5 ½ inch (368 mm) cavity. Headers are double 2 inches (51 mm) nominal wood framing. The *U-factor* includes R-0.17 for exterior air film, R-0.08 for stucco, R-0.56 for 0.625 inches (16 mm) gypsum board on the exterior, R-0.56 for 0.625 inches (16 mm) gypsum board on the interior, and R-0.68 for interior air film, vertical surfaces. Additional assemblies include *continuous insulation*, uncompressed and uninterrupted by framing. *U-factors* are provided for the following configurations:

a. *Standard framing*: wood framing at 16 inches (410 mm) on center with cavities filled with 14 ½ inches (368 mm) wide insulation for both 3 ½ inches (89 mm) deep and 5 ½ inches (140 mm) deep wall cavities. Double headers leave no cavity. Weighting factors are 75 percent insulated cavity, 21 percent studs, plates, and sills, and 4 percent headers.

b. *Advanced framing*: wood framing at 24 inches (610 mm) on center with cavities filled with 22 ½ inches (572 mm) wide insulation for both 3 ½ inches (89 mm) deep and 5 ½ inches (140 mm) deep wall cavities. Double headers leave uninsulated cavities. Weighting factors are 78 percent insulated cavity, 18 percent studs, plates, and sills, and 4 percent headers.

c. *Advanced framing with insulated headers*: wood framing at 24 inches (610 mm) on center with cavities filled with 22 ½ inches (572 mm) wide insulation for both 3 ½ inches (89 mm) deep and 5 ½ inches (140 mm) deep wall cavities. Double header cavities are insulated. Weighting factors are 78 percent insulated cavity, 18 percent plates, and sills, and 4 percent headers.

B2.2.1.4.2 Rated R-value of Insulation for Wood-Framed and Other Walls.

B2.2.1.4.2.1 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.

B2.2.1.4.2.2 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.

B2.2.1.4.2.3 Opaque mullions in spandrel glass shall be covered with insulation complying with the steel-framed wall requirements.

B2.2.1.4.3 U-Factors for Wood-Framed Walls.

B2.2.1.4.3.1 *U-factors* for *wood-framed walls* shall be taken from Table B-15.

B2.2.1.4.3.2 For *wood-framed walls* with framing at less than 24 inches (610 mm). on center, use the standard framing values as described in B2.2.1.4.1(a).

B2.2.1.4.3.3 For *wood-framed walls* with framing from 24 inches to 32 inches (610 mm to 813 mm) on center, use the advanced framing values as described in B2.2.1.4.1(b) if the headers are uninsulated or the advanced framing with insulated headers values as described in B2.2.1.4.1(c) if the headers are insulated.

B2.2.1.4.3.4 For *wood-framed walls* with framing greater than 32 inches (813 mm) on center, U-factors shall be determined in accordance with

B1.5.

B2.2.2 Below-Grade Walls.

B2.2.2.1 General. For the purpose of applicant-determined assembly U-factors, C-factors, F-factors, or heat capacities, the base assembly is 8 inches (203 mm) medium-weight concrete block with a density of 115 pound per cubic foot (1843 kg/m^3) and solid grouted cores. *Continuous insulation* is installed on the interior or exterior. In contrast to the *U-factor* for *above-grade walls*, the *C-factor* for *below grade walls* does not include R-values for exterior or interior air films or for soil. For insulated walls, the *C-factor* does include R-0.45 for 0.5 inches gypsum board.

B2.2.2.2 C-Factors for Below-Grade Walls.

B2.2.2.2.1 *C-factors* for *below-grade walls* shall be taken from Table B-16 or determined by the procedure described in this subsection.

B2.2.2.2.2 It is acceptable to use the *C-factors* in Table B-16 for all *below-grade walls*.

B2.2.2.2.3 If not taken from Table B-16, *below-grade wall C-factors* shall be determined from Tables B-10, B-11, and B-12 using the following procedure:

a. If the *below-grade wall* is uninsulated or only the cells are insulated:
   (1) For concrete *walls*, determine the *C-factor* from Table B-10 based on the concrete density and *wall* thickness.
   (2) For concrete block *walls*, determine the *C-factor* from Table B-11 based on the block size, concrete density, degree of grouting in the cells, and whether the cells are insulated.
b. If the *mass wall* has additional insulation:
   (1) For concrete *walls*, determine the *Rc* from Table B-10 based on the concrete density and *wall* thickness. Next, determine the effective R-value for the insulation/framing layer from Table B-12 based on the *rated R-value of insulation* installed, the thickness of the insulation, and whether it is installed between wood or metal framing or with no framing. Then, determine the *C-factor* by adding the *Rc* and the effective R-value together and taking the inverse of the total.
   (2) For concrete block *walls*, determine the *Rc* from Table B-10 based on the block size, concrete density, degree of grouting in the cells, and whether the cells are insulated. Next, determine the effective R-value for the insulation/ framing layer from Table B-11 based on the *rated R-value of insulation* installed, the thickness of the insulation, and whether it is installed between wood or metal framing or with no framing. Then, determine the *C-factor* by adding the *Rc* and the effective R-value together and taking the inverse of the total.

TABLE B-9
Assembly U-Factors for Above-Grade Concrete Walls and Masonry Walls

Framing Type and Depth	Rated R-Value of Insulation Alone	Assembly U-Factors for 8 in. Normal Weight 145 lb/ft3 Solid Concrete Walls	Assembly U-Factors for 8 in. Medium Weight 115 lb/ft3 Concrete Block Walls: Solid Grouted	Assembly U-Factors for 8 in. Medium Weight 115 lb/ft3 Concrete Block Walls: Partially Grouted (cores uninsulated except where specified)
No Framing	R-0	U-0.740	U-0.580	U-0.480
	Ungrouted Cores Filled with Loose-fill insulation	N.A.	N.A.	U-0.350
Continuous metal framing at 24 in. on center horizontally				
3.5 in.	R-11.0	U-0.168	U-0.158	U-0.149
3.5 in.	R-13.0	U-0.161	U-0.152	U-0.144
3.5 in.	R-15.0	U-0.155	U-0.147	U-0.140
4.5 in.	R-17.1	U-0.133	U-0.126	U-0.121
4.5 in.	R-22.5	U-0.124	U-0.119	U-0.114
4.5 in.	R-25.2	U-0.122	U-0.116	U-0.112
5.0 in.	R-19.0	U-0.122	U-0.117	U-0.112
5.0 in.	R-25.0	U-0.115	U-0.110	U-0.106
5.0 in.	R-28.0	U-0.112	U-0.107	U-0.103
5.5 in.	R-19.0	U-0.118	U-0.113	U-0.109
5.5 in.	R-20.9	U-0.114	U-0.109	U-0.105
5.5 in.	R-21.0	U-0.113	U-0.109	U-0.105
5.5 in.	R-27.5	U-0.106	U-0.102	U-0.099
5.5 in.	R-30.8	U-0.104	U-0.100	U-0.096
6.0 in.	R-22.8	U-0.106	U-0.102	U-0.098
6.0 in.	R-30.0	U-0.099	U-0.095	U-0.092
6.0 in.	R-33.6	U-0.096	U-0.093	U-0.090
6.5 in.	R-24.7	U-0.099	U-0.096	U-0.092
7.0 in.	R-26.6	U-0.093	U-0.090	U-0.087
7.5 in.	R-28.5	U-0.088	U-0.085	U-0.083
8.0 in.	R-30.4	U-0.083	U-0.081	U-0.079
1 in. metal clips at 24 in. on center horizontally and 16 in. vertically				
1.0 in.	R-3.8	U-0.210	U-0.195	U-0.182
1.0 in.	R-5.0	U-0.184	U-0.172	U-0.162
1.0 in.	R-5.6	U-0.174	U-0.163	U-0.154
1.5 in.	R-5.7	U-0.160	U-0.151	U-0.143
1.5 in.	R-7.5	U-0.138	U-0.131	U-0.125
1.5 in.	R-8.4	U-0.129	U-0.123	U-0.118
2.0 in.	R-7.	U-0.129	U-0.123	U-0.118
2.0 in.	R-10.0	U-0.110	U-0.106	U-0.102
2.0 in.	R-11.2	U-0.103	U-0.099	U-0.096
2.5 in.	R-9.	U-0.109	U-0.104	U-0.101
2.5 in.	R-12.	U-0.092	U-0.089	U-0.086
2.5 in.	R-14.0	U-0.086	U-0.083	U-0.080
3.0 in.	R-11.4	U-0.094	U-0.090	U-0.088
3.0 in.	R-15.0	U-0.078	U-0.076	U-0.074
3.0 in.	R-16.8	U-0.073	U-0.071	U-0.069
3.5 in.	R-13.3	U-0.082	U-0.080	U-0.077
3.5 in	R-17.5	U-0.069	U-0.067	U-0.065
3.5 in.	R-19.6	U-0.064	U-0.062	U-0.061

TABLE B-9. Assembly U-Factors for Above-Grade Concrete Walls and Masonry Walls,

Framing Type and Depth	Rated R-Value of Insulation Alone	Assembly U-Factors for 8 in. Normal Weight 145 lb/ft3 Solid Concrete Walls	Assembly U-Factors for 8 in.,Medium Weight 115 lb/ft3 Concrete Block Walls: Solid Grouted	Assembly U-Factors for 8 in. Medium Weight 115 lb/ft3 Concrete Block Walls: Partially Grouted (cores uninsulated except where specified)
No Framing	R-0	U-0.740	U-0.580	U-0.480
	Ungrouted Cores Filled with Loose-fill insulation	N.A.	N.A.	U-0.350
1 in. metal clips at 24 in. on center horizontally and 16 in. vertically				
4.0 in	R-15.2	U-0.073	U-0.071	U-0.070
4.0 in.	R-20.0	U-0.061	U-0.060	U-0.058
4.0 in.	R-22.4	U-0.057	U-0.056	U-0.054
5.0 in	. R-28.0	U-0.046	U-0.046	U-0.045
6.0 in.	R-33.6	U-0.039	U-0.039	U-0.038
7.0 in.	R-39.2	U-0.034	U-0.034	U-0.033
8.0 in.	R-44.8	U-0.030	U-0.030	U-0.029
9.0 in.	R-50.4	U-0.027	U-0.027	U-0.026
10.0 in.	R-56.0	U-0.024	U-0.024	U-0.024
11.0 in.	R-61.6	U-0.022	U-0.022	U-0.022
Continuous insulation uninterrupted by framing				
No Framing	R-1.0	U-0.425	U	U-0.324
No Framing	R-2.0	U-0.298	U	U-0.245
No Framing	R-3.0	U-0.230	U	U-0.197
No Framing	R-4.0	U-0.187	U	U-0.164
No Framing	R-5.0	U-0.157	U	U-0.141
No Framing	R-6.0	U-0.	U-0.129	U-0.124
No Framing	R-7.0	U-0.120	U-0.115	U-0.110
No Framing	R-8.0	U-0.107	U-0.103	U-0.099
No Framing	R-9.0	U-0.097	U-0.093	U-0.090
No Framing	R-10.0	U-0.088	U-0.085	U-0.083
No Framing	R-11.0	U-0.081 U	U-0.079	U-0.076
No Framing	R-12.0	U-0.075	U-0.073	U-0.071
No Framing	R-13.0	U-0.070	U-0.068	U-0.066
No Framing	R-14.0	U-0.065	U-0.064	U-0.062
No Framing	R-15.0	U-0.061	U-0.060	U-0.059
No Framing	R-16.0	U-0.	U-0.056	U-0.055
No Framing	R-17.0	U-0.054	U-0.053	U-0.052
No Framing	R-18.0	U-0.052	U-0.051	U-0.050
No Framing	R-19.0	U-0.049	U-0.048	U-0.047
No Framing	R-20.0	U-0.047	U-0.046	U-0.045
No Framing	R-21.0	U-0.045	U-0.044	U-0.043
No Framing	R-22.0	U-0.043	U-0.042	U-0.042
No Framing	R-23.0	U-0.041	U-0.040	U-0.040
No Framing	R-24.0	U-0.039	U-0.039	U-0.038
No Framing	R-25.0	U-0.038	U-0.037	U-0.037
No Framing	R-30.0	U-0.032	U-0.032	U-0.031
No Framing	R-35.0	U-0.028	U-0.027	U-0.027
No Framing	R-40.0	U-0.024	U-0.024	U-0.024
No Framing	R-45.0	U-0.022	U-0.021	U-0.021
No Framing	R-50.0	U-0.019	U-0.019	U-0.019
No Framing	R-55.0	U-0.018	U-0.018	U-0.018
No Framing	R-60.0	U-0.016	U-0.016	U-0.016

TABLE B-10
Assembly U-Factors, C-Factors, Ru, Rc, and Heat Capacity for Concrete

Density in lb/ft^3	Properties	Thickness in Inches 3	4	5	6	7	8	9	10	11	12
20	U-factor	0.22	0.17	0.14	0.12	0.10	0.09	0.08	0.07	0.07	0.06
	C-factor	0.27	0.20	0.16	0.13	0.11	0.10	0.09	0.08	0.07	0.07
	R_u	4.60	5.85	7.10	8.35	9.60	10.85	12.10	13.35	14.60	15.85
	R_c	3.75	5.00	6.25	7.50	8.75	10.00	11.25	12.50	13.75	15.00
	HC	1.0	1.3	1.7	2.0	2.3	2.7	3.0	3.3	3.7	4.0
30	U-factor	0.28	0.22	0.19	0.16	0.14	0.12	0.11	0.10	0.09	0.09
	C-factor	0.37	0.28	0.22	0.18	0.16	0.14	0.12	0.11	0.10	0.09
	R_u	3.58	4.49	5.40	6.30	7.21	8.12	9.03	9.94	10.85	11.76
	R_c	2.73	3.64	4.55	5.45	6.36	7.27	8.18	9.09	10.00	10.91
	HC	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
40	U-factor	0.33	0.27	0.23	0.19	0.17	0.15	0.14	0.13	0.11	0.11
	C-factor	0.47	0.35	0.28	0.23	0.20	0.18	0.16	0.14	0.13	0.12
	R_u	2.99	3.71	4.42	5.14	5.85	6.56	7.28	7.99	8.71	9.42
	R_c	2.14	2.86	3.57	4.29	5.00	5.71	6.43	7.14	7.86	8.57
	HC	2.0	2.7	3.3	4.0	4.7	5.3	6.0	6.7	7.3	8.0
50	U-factor	0.38	0.31	0.26	0.23	0.20	0.18	0.16	0.15	0.14	0.13
	C-factor	0.57	0.43	0.34	0.28	0.24	0.21	0.19	0.17	0.15	0.14
	R_u	2.61	3.2	3.79	4.38	4.97	5.56	6.14	6.73	7.32	7.91
	R_c	1.76	2.35	2.94	3.53	4.12	4.71	5.29	5.88	6.47	7.06
	HC	2.5	3.3	4.2	5.0	5.8	6.7	7.5	8.3	9.2	10.0
85	U-factor	0.65	0.56	0.50	0.44	0.40	0.37	0.34	0.31	0.29	0.27
	C-factor	1.43	1.08	0.86	0.71	0.61	0.54	0.48	0.43	0.39	0.36
	R_u	1.55	1.78	2.01	2.25	2.48	2.71	2.94	3.18	3.41	3.64
	R_c	0.70	0.93	1.16	1.40	1.63	1.86	2.09	2.33	2.56	2.79
	HC	4.3	5.7	7.1	8.5	9.9	11.3	12.8	14.2	15.6	17.0
95	U-factor	0.72	0.64	0.57	0.52	0.48	0.44	0.41	0.38	0.36	0.33
	C-factor	1.85	1.41	1.12	0.93	0.80	0.70	0.62	0.56	0.51	0.47
	R_u	1.39	1.56	1.74	1.92	2.10	2.28	2.46	2.64	2.81	2.99
	R_c	0.54	0.71	0.89	1.07	1.25	1.43	1.61	1.79	1.96	2.14
	HC	4.8	6.3	7.9	9.5	11.1	12.7	14.3	15.8	17.4	19.0
105	U-factor	0.79	0.71	0.65	0.59	0.54	0.51	0.47	0.44	0.42	0.39
	C-factor	2.38	1.79	1.43	1.18	1.01	0.88	0.79	0.71	0.65	0.59
	R_u	1.27	1.41	1.557	1.70	1.84	1.98	2.12	2.26	2.40	2.54
	R_c	0.42	0.56	0.70	0.85	0.99	1.13	1.27	1.41	1.55	1.69
	HC	5.3	7.0	8.8	10.5	12.3	14.0	15.8	17.5	19.3	21.0
115	U-factor	0.84	0.77	0.70	0.65	0.61	0.57	0.53	0.50	0.48	0.45
	C-factor	2.94	2.22	1.75	1.47	1.25	1.10	0.98	0.88	0.80	0.74
	R_u	1.19	1.30	1.42	1.53	1.65	1.76	1.87	1.99	2.10	2.21
	R_c	0.34	0.45	0.57	0.68	0.80	0.91	1.02	1.14	1.25	1.36
	HC	5.8	7.7	9.6	11.5	13.4	15.3	17.3	19.2	21.1	23.0
125	U-factor	0.88	0.82	0.76	0.71	0.67	0.63	0.60	0.56	0.53	0.51
	C-factor	3.57	2.70	2.17	1.79	1.54	1.35	1.20	1.08	0.98	0.90
	R_u	1.13	1.22	1.31	1.41	1.50	1.59	1.68	1.78	1.87	1.96
	R_c	0.28	0.37	0.46	0.56	0.65	0.74	0.83	0.93	1.02	1.11
	HC	6.3	8.3	10.4	12.5	14.6	16.7	18.8	20.8	22.9	25.0
135	U-factor	0.93	0.87	0.82	0.77	0.73	0.69	0.66	0.63	0.60	0.57
	C-factor	4.55	3.33	2.70	2.22	1.92	1.67	1.49	1.33	1.22	1.11
	R_u	1.07	1.15	1.22	1.30	1.37	1.45	.52	1.60	1.67	1.75
	R_c	0.22	0.30	0.37	0.45	0.52	0.60	0.67	0.75	0.82	0.90
	HC	6.8	9.0	11.3	13.5	15.8	18.0	20.3	22.5	24.8	27.0
144	U-factor	0.96	0.91	0.86	0.81	0.78	0.74	0.71	0.68	0.65	0.63
	C-factor	5.26	4.00	3.23	2.63	2.27	2.00	1.79	1.59	1.45	1.33
	R_u	1.04	1.10	1.16	1.23	1.29	1.35	1.41	1.48	1.54	1.60
	R_c	0.19	0.25	0.31	0.38	0.44	0.50	0.56	0.63	0.69	0.75

	HC	7.2	9.6	12.0	14.4	16.8	19.2	21.6	24.0	26.4	28.8

The U-factors and R_u include standard air film resistances.

The C-factors and R_c are for the same assembly without air film resistances.

Note that the following assemblies do not qualify as a mass wall or mass floor: 3 in. thick concrete with densities of 85, 95, 125 and 135 lbs/ft^3

TABLE B-11
Assembly U-Factors, C-Factors, Ru, Rc, and Heat Capacity for Concrete Block Walls

Density	Properties	Concrete Block Grouting and Cell Treatment				
		Solid grouted	Partly Grouted, Cells Empty	Partly Grouted, Cells Insulated	Unreinforced, Cells Empty	Unreinforced, Cells Insulated
6 in. block						
85	U-factor	0.57	0.46	0.34	0.4	0.2
	C-factor	1.11	0.75	0.47	0.6	0.23
	Ru	1.75	2.18	2.97	2.52	5.13
	Rc	0.9	1.33	2.12	1.67	4.28
	HC	10.9	6.7	7	4.2	4.6
95	U-factor	0.61	0.49	0.36	0.42	0.22
	C-factor	1.25	0.83	0.53	0.65	0.27
	Ru	1.65	2.06	2.75	2.38	4.61
	Rc	0.8	1.21	1.9	1.53	3.76
	HC	11.4	7.2	7.5	4.7	5.1
105	U-factor	0.64	0.51	0.39	0.44	0.24
	C-factor	1.38	0.91	0.58	0.71	0.3
	Ru	1.57	1.95	2.56	2.26	4.17
	Rc	0.72	1.1	1.71	1.41	3.32
	HC	11.9	7.7	7.9	5.1	5.6
115	U-factor	0.66	0.54	0.41	0.46	0.26
	C-factor	1.52	0.98	0.64	0.76	0.34
	Ru	1.51	1.87	2.41	2.16	3.79
	Rc	0.66	1.02	1.56	1.31	2.94
	HC	12.3	8.1	8.4	5.6	6
125	U-factor	0.7	0.56	0.45	0.49	0.3
	C-factor	1.7	1.08	0.73	0.84	0.4
	Ru	1.44	1.78	2.23	2.04	3.38
	Rc	0.59	0.93	1.38	1.19	2.53
	HC	12.8	8.6	8.8	6	6.5
135	U-factor	0.73	0.6	0.49	0.53	0.35
	C-factor	1.94	1.23	0.85	0.95	0.49
	Ru	1.36	1.67	2.02	1.9	2.89
	Rc	0.51	0.82	1.17	1.05	2.04
	HC	13.2	9	9.3	6.5	6.9
8 in. block						
85	U-factor	0.49	0.41	0.28	0.37	0.15
	C-factor	0.85	0.63	0.37	0.53	0.17
	Ru	2.03	2.43	3.55	2.72	6.62
	Rc	1.18	1.58	2.7	1.87	5.77
	HC	15	9	9.4	5.4	6
95	U-factor	0.53	0.44	0.31	0.39	0.17
	C-factor	0.95	0.7	0.41	0.58	0.2
	Ru	1.9	2.29	3.27	2.57	5.92
	Rc	1.05	1.44	2.42	1.72	5.07
	HC	15.5	9.6	10	6	6.6
105	U-factor	0.55	0.46	0.33	0.41	0.19
	C-factor	1.05	0.76	0.46	0.63	0.22
	Ru	1.81	2.17	3.04	2.44	5.32
	Rc	0.96	1.32	2.19	1.59	4.47
	HC	16.1	10.2	10.6	6.6	7.2
115	U-factor	0.58	0.48	0.35	0.43	0.21
	C-factor	1.14	0.82	0.5	0.68	0.25
	Ru	1.72	2.07	2.84	2.33	4.78
	Rc	0.87	1.22	1.99	1.48	3.93
	HC	16.7	10.8	11.2	7.2	7.8
125	U-factor	0.61	0.51	0.38	0.45	0.24
	C-factor	1.27	0.9	0.57	0.74	0.3

	Ru	1.64	1.96	2.62	2.2	4.2
	Rc	0.79	1.11	1.77	1.35	3.35
	HC	17.3	11.4	11.8	7.8	8.4
135	U-factor	0.65	0.55	0.42	0.49	0.28
	C-factor	1.44	1.02	0.67	0.83	0.37
	Ru	1.54	1.83	2.35	2.05	3.55
	Rc	0.69	0.98	1.50	1.2	2.70
	HC	17.9	12.0	12.4	8.4	9.0
10 in block						
85	U-factor	0.44	0.38	0.25	0.35	0.13
	C-factor	0.70	0.57	0.31	0.50	0.14
	Ru	2.29	2.61	4.05	2.84	7.87
	Rc	1.44	1.76	3.20	1.99	7.02
	HC	19.0	11.2	11.7	6.50	7.30
95	U-factor	0.47	0.41	0.27	0.37	0.14
	C-factor	0.77	0.62	0.35	0.55	0.16
	Ru	2.15	2.46	3.73	2.67	6.94
	Rc	1.30	1.61	2.88	1.82	6.09
	HC	19.7	11.9	12.4	7.3	8.10
105	U-factor	0.49	0.43	0.29	0.39	0.16
	C-factor	0.85	0.68	0.39	0.59	0.19
	Ru	2.03	2.33	3.45	2.54	6.17
	Rc	1.18	1.48	2.60	1.69	5.32
	HC	20.4	12.6	13.1	8.00	8.80
115	U-factor	0.52	0.45	0.31	0.41	0.18
	C-factor	0.92	0.73	0.42	0.64	0.21
	Ru	1.94	2.22	3.21	2.42	5.52
	Rc	1.09	1.37	2.36	1.57	4.67
	HC	21.1	13.4	13.9	8.70	9.50
125	U-factor	0.54	0.48	0.34	0.44	0.21
	C-factor	1.01	0.80	0.48	0.70	0.25
	Ru	1.84	2.10	2.;95	2.28	4.81
	Rc	0.99	1.25	2.10	1.43	3.96
	HC	21.8	14.1	14.6	9.40	10.2
135	U-factor	0.58	0.51	0.38	0.47	0.25
	C-factor	1.14	0.90	0.56	0.79	0.32
	Ru	1.72	1.96	2.64	2.12	4.00
	Rc	0.87	1.11	1.79	1.27	3.15
	HC	22.6	14.8	15.3	10.2	11.0
12 in. block						
85	U-factor	0.40	0.36	0.22	0.34	0.11
	C-factor	0.59	0.52	0.27	0.48	0.12
	Ru	2.53	2.77	4.59	2.93	9.43
	Rc	1.68	1.92	3.74	2.08	8.58
	HC	23.1	13.3	14.0	7.50	8.50
95	U-factor	0.42	0.38	0.24	0.36	0.12
	C-factor	0.66	0.57	0.30	0.52	0.13
	Ru	2.30	2.60	4.22	2.76	8.33
	Rc	1.53	1.75	3.37	1.91	7.48
	HC	23.9	14.2	14.8	8.30	9.30
105	U-factor	0.44	0.41	0.26	0.38	0.14
	C-factor	0.71	0.62	0.33	0.57	0.15
	Ru	2.25	2.47	3.90	2.62	7.35
	Rc	1.40	1.62	3.05	1.77	6.50
	HC	24.7	15.0	15.6	9.10	10.2
115	U-factor	0.47	0.42	0.28	0.40	0.15
	C-factor	0.77	0.66	0.36	0.61	0.18
	Ru	2.15	2.36	3.63	2.49	6.54
	Rc	1.30	1.51	2.78	1.64	5.69
	HC	25.6	15.8	16.4	10.0	11.0

125	U-factor	0.49	0.45	0.30	0.42	0.18
	C-factor	0.84	0.72	0.40	0.66	0.21
	Ru	2.04	2.23	3.34	2.36	5.68
	Rc	1.19	1.38	2.49	1.51	4.83
	HC	26.4	16.6	17.3	10.8	11.8
135	U-factor	0.52	0.48	0.34	0.46	0.21
	C-factor	0.94	0.81	0.47	-.74	0.26
	Ru	1.91	2.08	2.98	2.19	4.67
	Rc	1.06	1.23	2.13	1.34	3.82
	HC	27.2	17.5	18.1	11.60	12.6

TABLE B-12
Effective R-Values for Insulation/Framing Layers Added to Above-Grade Mass Walls and Below-Grade Walls

Depth (in.)	Framing Type	*Rated R-Value of Insulation* 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
		Effective R-value if continuous insulation uninterrupted by framing (includes gypsun board)																				
	None	0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5	15.5	16.5	17.5	18.5	19.5	20.5
		Effective R-value if insulation is installed in cavity between framing (includes gypsum board)																				
	Wood	1.3	1.3	1.9	2.4	2.7	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
	Metal	0.9	0.9	1.1	1.1	1.2	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
0.5																						
	Wood	1.4	1.4	2.1	2.7	3.1	3.5	3.8	na	na	na	na	na	na	na	na	na	na	na	na	na	na
	Metal	1	1	1.3	1.4	1.5	1.5	1.6	na	na	na	na	na	na	na	na	na	na	na	na	na	na
0.75																						
	Wood	1.3	1.5	2.2	2.9	3.4	3.9	4.3	4.6	4.9	na	na	na	na	na	na	na	na	na	na	na	na
	Metal	1	1.1	1.4	1.6	1.7	1.8	1.8	1.9	1.9	na	na	na	na	na	na	na	na	na	na	na	na
1																						
	Wood	1.3	1.5	2.4	3.1	3.8	4.4	4.9	5.4	5.8	6.2	6.5	6.8	7.1	na	na	na	na	na	na	na	na
	Metal	1.1	1.2	1.6	1.9	2.1	2.2	2.3	2.4	2.5	2.5	2.6	2.6	2.7	na	na	na	na	na	na	na	na
1.5																						
	Wood	1.4	1.5	2.5	3.3	4	4.7	5.3	5.9	6.4	6.9	7.3	7.7	8.1	8.4	8.7	9	9.3	na	na	na	na
	Metal	1.1	1.2	1.7	2.1	2.3	2.5	2.7	2.8	2.9	3	3.1	3.2	3.2	3.3	3.3	3.4	3.4	na	na	na	na
2																						
	Wood	1.4	1.5	2.5	3.4	4.2	4.9	5.6	6.3	6.8	7.4	7.9	8.4	8.8	9.2	9.6	10	10.3	10.6	10.9	11.2	11.5
	Metal	1.2	1.3	1.8	2.3	2.6	2.8	3	3.2	3.3	3.5	3.6	3.6	3.7	3.8	3.9	3.9	4	4	4.1	4.1	4.1
2.5																						
	Wood	1.4	1.5	2.5	3.5	4.3	5.1	5.8	6.5	7.2	7.8	8.3	8.9	9.4	9.9	10.3	10.7	11.1	11.5	11.9	12.2	12.5
	Metal	1.2	1.3	1.9	2.4	2.8	3.1	3.3	3.5	3.7	3.8	4	4.1	4.2	4.3	4.4	4.4	4.5	4.6	4.6	4.7	4.7
3																						
	Wood	1.4	1.5	2.6	3.5	4.4	5.2	6	6.7	7.4	8.1	8.7	9.3	9.8	10.4	10.9	11.3	11.8	12.2	12.6	13	13.4
	Metal	1.2	1.3	2	2.5	2.9	3.2	3.5	3.8	4	4.2	4.3	4.5	4.6	4.7	4.8	4.9	5	5.1	5.1	5.2	5.2
3.5																						
	Wood	1.4	1.6	2.6	3.6	4.5	5.3	6.1	6.9	7.6	8.3	9	9.6	10.2	10.8	11.3	11.9	12.4	12.8	13.3	13.7	14.2
	Metal	1.2	1.3	2	2.6	3	3.4	3.7	4	4.2	4.5	4.6	4.8	5	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8
4																						
4.5	Wood	1.4	1.6	2.6	3.6	4.5	5.4	6.2	7.1	7.8	8.5	9.2	9.9	10.5	11.2	11.7	12.3	12.8	13.3	13.8	14.3	14.8
	Metal	1.2	1.3	2.1	2.6	3.1	3.5	3.9	4.2	4.5	4.7	4.9	5.1	5.3	5.4	5.6	5.7	5.8	5.9	6	6.1	6.2

	Wood	1.4	1.6	2.6	3.6	4.6	5.5	6.3	7.2	8	8.7	9.4	10.1	10.8	11.5	12.1	12.7	13.2	13.8	14.3	14.8	15.3
	Metal	1.2	1.4	2.1	2.7	3.2	3.7	4.1	4.4	4.7	5	5.2	5.4	5.6	5.8	5.9	6.1	6.2	6.3	6.5	6.6	6.7
5																						
	Wood	1.4	1.6	2.6	3.6	4.6	5.5	6.4	7.3	8.1	8.9	9.6	10.3	11	11.7	12.4	13	13.6	14.2	14.7	15.3	15.8
5.5	Metal	1.3	1.4	2.1	2.8	3.3	3.8	4.2	4.6	4.9	5.2	5.4	5.7	5.9	6.1	6.3	6.4	6.6	6.7	6.8	7	7.1

TABLE B-13
Assembly U-Factors for Metal Building Walls

Insulation System	Rated R-Value of Insulation	Total Rated R-Value of Insulation	Overall U-Factor for Entire Base Wall Assembly	Overall U-Factor for Assembly of Base Wall Plus Continuous Insulation (uninterrupted by framing) Rated R-Value of Continuous Insulation					
				R-5.6	R-11.2	R-16.8	R-22.4	R-28.0	R-33.6
Single Layer of Mineral Fiber									
	None	0	1.18	0.161	0.086	0.059	0.045	0.036	0.03
	R-6	6	0.184	0.091	0.06	0.045	0.036	0.03	0.026
	R-10	10	0.134	0.077	0.054	0.041	0.033	0.028	0.024
	R-11	11	0.123	0.073	0.052	0.04	0.033	0.028	0.024
	R-13	13	0.113	0.069	0.05	0.039	0.032	0.027	0.024
Double Layer of Mineral Fiber (Second layer inside of girts) (Multiple layers are listed in order from inside to outside)									
	R-6+R-13	19	0.07	Na	na	na	na	na	na
	R-10+R-13	23	0.061	Na	na	na	na	na	na
	R-13+R-13	26	0.057	Na	na	na	na	na	na
	R-19+R-13	32	0.048	Na	na	na	na	na	na

TABLE B-14
Assembly U-Factors for Steel Frame Walls

Cavity Insulation R-Value: Rated/ (effective installed [see Table A-21])	Overall U-Factor for Entire Base Wall Assembly	Overall U-Factor for Assembly of Base Wall Plus Continuous Insulation (uninterrupted by framing), Rated R-Continuous Insulation																		
		R-1.0	R-2.0	R-3.0	R-4.0	R-5.0	R-6.0	R-7.0	R-8.0	R-9.0	R-10.0	R-11.0	R-12.0	R-13.0	R-15.0	R-15.0	R-20.0	R-25.0	R-30.0	R-35.
Steel Framing at 16 in. OC																				
None(0.0)	0.352	0.26	0.207	0.171	0.146	0.128	0.113	0.102	0.092	0.084	0.078	0.072	0.067	0.063	0.059	0.056	0.044	0.036	0.03	0.0
R-11(5.5)	0.132	0.117	0.105	0.095	0.087	0.08	0.074	0.069	0.064	0.06	0.057	0.054	0.051	0.049	0.046	0.044	0.036	0.031	0.027	0.0
R-13(6.0)	0.124	0.111	0.1	0.091	0.083	0.077	0.071	0.066	0.062	0.059	0.055	0.052	0.05	0.048	0.045	0.043	0.036	0.03	0.026	0.0
R-15(6.4)	0.118	0.106	0.096	0.087	0.08	0.074	0.069	0.065	0.061	0.057	0.054	0.051	0.049	0.047	0.045	0.043	0.035	0.03	0.026	0.0
R-19(7.1)	0.109	0.099	0.09	0.082	0.076	0.071	0.066	0.062	0.058	0.055	0.052	0.05	0.047	0.045	0.043	0.041	0.034	0.029	0.026	0.0
R-21(7.4)	0.106	0.096	0.087	0.08	0.074	0.069	0.065	0.061	0.057	0.054	0.051	0.049	0.047	0.045	0.043	0.041	0.034	0.029	0.025	0.0
Steel Framing at 24 in. OC																				
None(0.0)	0.338	0.253	0.202	0.168	0.144	0.126	0.112	0.1	0.091	0.084	0.077	0.072	0.067	0.063	0.059	0.056	0.044	0.036	0.03	0.0
R-11(6.6)	0.116	0.104	0.094	0.086	0.079	0.073	0.068	0.064	0.06	0.057	0.054	0.051	0.048	0.046	0.044	0.042	0.035	0.03	0.026	0.0
R-13(7.2)	0.108	0.098	0.089	0.082	0.075	0.07	0.066	0.062	0.058	0.055	0.052	0.049	0.047	0.045	0.043	0.041	0.034	0.029	0.025	0.0
R-15(7.8)	0.102	0.092	0.084	0.078	0.072	0.067	0.063	0.059	0.056	0.053	0.05	0.048	0.046	0.044	0.042	0.04	0.034	0.029	0.025	0.0
R-19(8.6)	0.094	0.086	0.079	0.073	0.068	0.064	0.06	0.057	0.054	0.051	0.048	0.046	0.044	0.042	0.041	0.039	0.033	0.028	0.025	0.0
R-21(9.0)	0.09	0.083	0.077	0.071	0.066	0.062	0.059	0.055	0.052	0.05	0.048	0.045	0.043	0.042	0.04	0.038	0.032	0.028	0.024	0.0

Table B-15
Assembly U-Factors for Wood Frame Walls

Framing Type and Spacing Width (actual Depth)	Cavity Insulation R-Value: Rated/(effective stalled [see Table A-24])	Overall U-Factor for Entire Bas Wall	Overall U-Factor for Assembly of Base Wall Plus Continuous Insulatio Rated R-Value of Continuous Insulation													
			R-1.0	E-2.0	R-3.0	R-4.0	R-5.0	R-6.0	R-7.0	R-8.0	R-9.0	R-10.0	R-11.0	R-12.0		R-14
Wood Studs at 16 in. OC																
(3.5 in. depth)	None(0.0)	0.292	0.223	0.181	0.152	0.132	0.116	0.104	0.094	0.086	0.079	0.073	0.068	0.064	0.06	0.0
	R-11(11.0)	0.096	0.087	0.079	0.073	0.068	0.063	0.059	0.056	0.053	0.05	0.048	0.046	0.044	0.042	0.
	R-13(13.0)	0.089	0.08	0.074	0.068	0.063	0.059	0.056	0.053	0.05	0.047	0.045	0.043	0.041	0.04	0.0
	R-15(15.0)	0.083	0.075	0.069	0.064	0.06	0.056	0.053	0.05	0.047	0.045	0.043	0.041	0.039	0.038	0.0
(5.5 in. depth)	R-19(18.0)	0.067	0.062	0.058	0.054	0.051	0.048	0.046	0.044	0.042	0.04	0.038	0.037	0.036	0.034	0.0
	R-21(21.0)	0.063	0.058	0.054	0.051	0.048	0.045	0.043	0.041	0.039	0.038	0.036	0.035	0.034	0.032	0.0
+R-10 headers)	R-19(18.0)	0.063	0.059	0.055	0.052	0.049	0.047	0.045	0.043	0.041	0.039	0.038	0.036	0.035	0.034	0.0
	R-21(21.0)	0.059	0.055	0.051	0.049	0.046	0.044	0.042	0.04	0.038	0.037	0.035	0.034	0.033	0.032	0.0
Wood Studs at 24 in.OC																
(3.5 in. depth)	None(0.0)	0.298	0.227	0.183	0.154	0.133	0.117	0.105	0.095	0.086	0.079	0.074	0.068	0.064	0.06	0.0
	R-11(11.0)	0.094	0.085	0.078	0.072	0.067	0.062	0.059	0.055	0.052	0.05	0.047	0.045	0.043	0.041	0.
	R-13(13.0)	0.086	0.078	0.072	0.067	0.062	0.058	0.055	0.052	0.049	0.047	0.045	0.043	0.041	0.039	0.0
	R-15(15.0)	0.08	0.073	0.067	0.062	0.058	0.055	0.052	0.049	0.046	0.044	0.042	0.04	0.039	0.037	0.0
(5.5 in. depth)	R-19(18.0)	0.065	0.06	0.056	0.053	0.05	0.047	0.045	0.043	0.041	0.039	0.038	0.036	0.035	0.034	0.0
	R-21(21.0)	0.06	0.056	0.052	0.049	0.046	0.044	0.042	0.04	0.038	0.037	0.036	0.034	0.033	0.032	0.0
(+ R-10 headers)	R-19(18.0)	0.062	0.058	0.054	0.051	0.048	0.046	0.044	0.042	0.04	0.039	0.037	0.036	0.034	0.033	0.0
	R-21(21.0)	0.057	0.053	0.05	0.047	0.045	0.043	0.041	0.039	0.037	0.036	0.035	0.033	0.032	0.031	0.

TABLE B-16
Assembly C-Factors for Below-Grade Walls

Framing Type & Depth	Rated R-Value of Insulation Alone	Specified C-Factors (wall only, without soil & air films)
No Framing	0	1.140
Exterior Insulation continuous and uninterrupted by framing		
No Framing	5.0	0.170
No Framing	7.5	0.119
No Framing	10.0	0.092
No Framing	12.5	0.075
No Framing	15.0	0.063
No Framing	17.5	0.054
No Framing	20.0	0.048
No Framing	25.0	0.039
No Framing	30.0	0.032
No Framing	35.0	0.028
No Framing	40.0	0.025
No Framing	45.0	0.022
No Framing	50.0	0.020
Continuous Framing at 24 in. OC horizontally		
3.5 in	11.0	0.182
3.5 in	13.0	0.174
3.5 in	15.0	0.168
5.5 in	19.0	0.125
5.5 in	21.0	0.120
1 in metal clips at 24 in. OC horizontally & 16 in. vertically		
1 in	3.8	0.233
1 in	5.0	0.201
1 in	5.6	0.189
1.5 in	5.7	0.173
1.5 in	7.5	0.147
1.5 in	8.4	0.138
2 in	7.6	0.138
2 in	10.0	0.116
2 in	11.2	0.108
2.5 in	9.5	0.114
2.5 in	12.5	0.096
2.5 in	14.0	0.089
3 in	11.4	0.098
3 in	15.0	0.082
3 in	16.8	0.076
3.5 in	13.3	0.085
3.5 in	17.5	0.071
3.5 in	19.6	0.066
4 in	15.2	0.076
4 in	20.0	0.063
4 in	22.4	0.058

TABLE B-17
Effective Insulation/Framing Layer R-Values for Wall Insulation Installed Between Steel Framing

Nominal Depth of Cavity (in.)	Actual Depth of Cavity (in.)	Rated R-Value of Airspace or Insulation	Effective Framing/ Cavity R-Value at 16 in. on center	Effective Framing/Cavity at 24 in. on center
Empty cavity, no insulation				
4	3.5	R-0.91	0.79	0.91
Insulated Cavity				
4	3.5	R-11	5.5	6.6
4	3.5	R-13	6	7.2
4	3.5	R-15	6.4	7.8
6	6	R-19	7.1	8.6
6	6	R-21	7.4	9
8	8	R-25	7.8	9.6

B2.3 Opaque Doors. All *opaque doors* with *U-factors* determined, certified, and labeled in accordance with NFRC 100 as specified in B1.1.3 shall be assigned those *U-factors*. *Unlabeled opaque doors* shall be assigned those *U-factors*.

B2.3.1 Unlabeled Opaque Doors. Unlabeled opaque doors shall be assigned the following *U-factors*.

a. Uninsulated single-layer metal *swinging doors* or *nonswinging doors*, including single-layer uninsulated access hatches and uninsulated smoke vents: 1.45
b. Uninsulated double-layer metal *swinging doors* or *nonswinging doors*, including double-layer uninsulated access hatches and uninsulated smoke vents: 0.70
c. Insulated metal *swinging doors*, including fire-rated *doors*, insulated access hatches, and insulated smoke vents: 0.50
d. Wood *doors*, minimum nominal thickness of 1 3/4 inches (44 mm), including panel *doors* with minimum panel thickness of 1 1/8 inches (29 mm), solid core flush *doors*, and hollow core flush *doors*: 0.50.
e. Any other wood *door*: 0.60

B2.4 Roofs

B2.4.1 General. The buffering effect of suspended ceilings or attic spaces shall not be included in *U-factor* calculations.

B2.4.2 Roofs with Insulation Entirely Above Deck.

B2.4.2.1 General. For the purpose of applicant-determined assembly U-factors, C-factors, f-factors, or heat capacities, the base assembly is continuous insulation over a structural deck. The U-factor includes R-0.17 for exterior air film, R-0 for metal deck, and R-0.61 for interior air film heat flow up. Added insulation is continuous and uninterrupted by framing. The framing factor is 0.

B2.4.2.2 Rated R-Value of insulation. For roofs with insulation entirely above deck, the rated R-value of insulation is for continuous insulation. Exception: Interruptions for framing and pads for mechanical equipment are permitted with a combined total area not exceeding one percent of the total opaque assembly area.

B2.4.2.3 U-factor. U-factors for roofs with insulation entirely above deck shall be taken from Table B-19 It is not acceptable to use these U-factors if the

insulation is not entirely above deck or not continuous.

B2.4.3 Metal Building Roofs.

B2.4.3.1 General. For the purpose of applicant-determined assembly U-factors, C-factors, f-factors, or heat capacities, the base assembly is a *roof* where the insulation is draped over the steel structure (purlins) and then compressed when the metal roof panels ~~spanning members~~ are attached to the steel structure (purlins). Additional assemblies include *continuous insulation*, uncompressed and uninterrupted by framing.

B2.4.3.2 Rated R-Value of insulation.

B2.4.3.2.1 The first rated R-value of insulation is for insulation draped over purlins and then compressed when the metal roof panels ~~spanning members~~ are attached, or for insulation hung between the purlins~~,~~. ~~provided there is a~~ A minimum 1 inch (25 mm) thermal spacer block ~~break~~ between the purlins and the metal roof panels is required when specified in Table B-20 ~~spanning members~~.

B2.4.3.2.2 For double-layer installations, the second rated R-value of insulation is for insulation installed parallel to the purlins.

B2.4.3.2.3 For continuous insulation (e.g. insulation boards or blankets), it is assumed that the insulation is ~~boards are~~ installed below the purlins and is ~~are~~ uninterrupted by framing members. Insulation exposed to the conditioned space or semiheated space shall have a facing, and all insulation seams shall be continuously sealed to provide a continuous air barrier.

B2.4.3.3 U-factor. U-factors for metal building roofs shall be taken from Table B-20. It is not acceptable to use these U-factors if additional insulated sheathing is not continuous.

B2.4.4 Attic Roofs with Wood Joists.

B2.4.4.1 General. For the purpose of applicant-determined assembly U-factors, C-factors, F-factors, or heat capacities, the base attic roof assembly is a roof with a nominal 4 inch (102 mm) deep wood as the lower chord of a roof truss or ceiling joist.

The ceiling is attached directly to the lower chord of the truss and the attic space above is ventilated. Insulation is located directly on top of the ceiling, first filling the cavities between the wood and then later covering both the wood and cavity areas. No credit is given for roofing materials. The *single-rafter roof* is similar to the base *attic roof*, with the key difference being that there is a single, deep rafter to which both the *roof* and the ceiling are attached. The heat flow path through the rafter is calculated to be the same depth as the insulation. The *U-factor* includes R-0.46 for semi-exterior air film, R-0.56 for 0.625 inches (16 mm) gypsum board, and R-0.61 for interior air film heat flow up. *U-factors* are provided for the following configurations:

a. *Attic roof*, *standard framing*: insulation is tapered around the perimeter with resultant decrease in thermal resistance. Weighting factors are 85 percent full-depth insulation, 5 percent half-depth insulation, and 10 percent joists.

b. *Attic roof*, *advanced framing*: full and even depth of insulation extending to the outside edge of exterior walls. Weighting factors are 90 percent full-depth insulation and 10 percent joists.

c. *Single-rafter roof*: an *attic roof* where the roof sheathing and ceiling are attached to the same rafter. Weighting factors are 90 percent full-depth

insulation and 10 percent joists.

B2.4.4.2 Rated R-Value of Insulation.

B2.4.4.2.1 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.

B2.4.4.2.2 Occasional interruption by framing members is allowed but required that the framing members be covered with insulation when the depth of the insulation exceeds the depth of the framing cavity.

B2.4.4.2.3 Insulation in such roofs shall be permitted to be tapered at the eaves where the building structure does not allow full depth.

B2.4.4.2.4 For single-rafter roofs, the requirement is the lesser of the values for attics and other roofs and those listed in Table B-21A.

TABLE B-21A
Single Rafter Roofs

Minimum Insulation R-Value or Maximum Assembly U-Factor		
Wood Rafter Depth, *d* (actual)		
d < 8 in.	8 < *d* < 10 in.	10 < *d* < 12 in.
R-19 U-0.055	R-30 U-0.036	R-38 U-0.028

B2.4.4.3 U-factors for attic roofs with wood joists. U-factors for attic roofs with wood joists shall be taken from Table B-21B. It is not acceptable to use these U-factors if the framing is not wood. For attic roofs with steel joists, see Section B2.4.5.

B2.4.5 Attic Roofs with Steel Joists.

B2.4.5.1 General. For the purpose of applicant-determined assembly U-factors, C-factors, f-factors, or heat capacities, the base assembly is a roof supported by steel joists with insulation between the joists. The assembly represents a *roof* in many ways similar to a *roof with insulation entirely above deck* and a *metal building roof*. It is distinguished from the *metal building roof* category in that there is no metal exposed to the exterior. It is distinguished from the *roof with insulation entirely above deck* in that the insulation is located below the deck and is interrupted by metal trusses that provide thermal bypasses to the insulation. The *U-factor* includes R-0.17 for exterior air film, R-0 for metal deck, and R-0.61 for interior air film heat flow up. The performance of the insulation/framing layer is calculated using the values in Table B-18.

B2.4.5.2 U-factors for attic roofs with steel joists shall be taken from Table B-22.

TABLE B-18
Effective Insulation/Framing Layer R-Values for Roof and Floor Insulation Installed Between Metal Framing (4 ft on center)

Rated R-Value of Insulation	**Correction Factor**	**Framing/Cavity R-Value**
0	1	0

4	0.97	3.88
5	0.96	4.8
8	0.94	7.52
10	0.92	9.2
11	0.91	10.01
12	0.9	10.8
13	0.9	11.7
15	0.88	13.2
16	0.87	13.92
19	0.86	16.34
20	0.85	17
21	0.84	17.64
24	0.82	19.68
25	0.81	20.25
30	0.79	23.7
35	0.76	26.6
38	0.74	28.12
40	0.73	29.2
45	0.71	31.95
50	0.69	34.5
55	0.67	36.85

TABLE B-19
Assembly U-Factors for Roofs with Insulation Entirely Above Deck

Rated R-Value of Insulation Alone	Overall U-Factor for Entire Assembly
R-0	U-1.282
R-1	U-0.562
R-2	U-0.360
R-3	U-0.265
R-4	U-0.209
R-5	U-0.173
R-6	U-0.147
R-7	U-0.129
R-8	U-0.114
R-9	U-0.102
R-10	U-0.093
R-11	U-0.085
R-12	U-0.078
R-13	U-0.073
R-14	U-0.068
R-15	U-0.063
R-16	U-0.060
R-17	U-0.056
R-18	U-0.053
R-19	U-0.051
R-20	U-0.048
R-21	U-0.046
R-22	U-0.044
R-23	U-0.042
R-24	U-0.040
R-25	U-0.039
R-26	U-0.037
R-27	U-0.036
R-28	U-0.035
R-29	U-0.034
R-30	U-0.032
R-35	U- 0.028
R-40	U-0.025
R-45	U-0.020
R-50	U-0.020
R-55	U-0.018
R-60	U-0.016

TABLE B-20
Assembly U-Factors for Metal Building Roofs

Insulation System	Rated R-Valueof Insulation	Total rated R-value of Insulation	Overall U-Factor for Entire Base Roof Assembly	Overall U-Factor for Assembly of Base Roof Plus Continuous Insulation (uninterrupted by framing Rated R-Value of Continuous Insulation					
				R-5.6	R-11.2	R-16.8	R-22.4	R-28.0	R-33.6
Standing Seam Roofs with Thermal Spacer Blocks									
Single Layer	None	0	**1.280**	0.162	0.087	0.059	0.045	0.036	0.030
	R-6	6	**0.167**	0.086	0.058	0.044	0.035	0.029	0.025
	R-10	10	**0.097**	0.063	0.046	0.037	0.031	0.026	0.023
	R-11	11	**0.092**	0.061	0.045	0.036	0.030	0.026	0.022
	R-13	13	**0.083**	0.057	0.043	0.035	0.029	0.025	0.022
	R-16	16	**0.072**	0.051	0.040	0.033	0.028	0.024	0.021
	R-19	19	**0.065**	0.048	0.038	0.031	0.026	0.023	0.020
Double Layer	R-10 + R-10	20	**0.063**	0.047	0.037	0.031	0.026	0.023	0.020
	R-10 + R-11	21	**0.061**	0.045	0.036	0.030	0.026	0.023	0.020
	R-11 + R-11	22	**0.060**	0.045	0.036	0.030	0.026	0.022	0.020
	R-10 + R-13	23	**0.058**	0.044	0.035	0.029	0.025	0.022	0.020
	R-11 + R-13	24	**0.057**	0.043	0.035	0.029	0.025	0.022	0.020
	R-13 + R-13	26	**0.055**	0.042	0.034	0.029	0.025	0.022	0.019
	R-10 + R-19	29	**0.052**	0.040	0.033	0.028	0.024	0.021	0.019
	R-11 + R-19	30	**0.051**	0.040	0.032	0.027	0.024	0.021	0.019
	R-13 + R-19	32	**0.049**	0.038	0.032	0.027	0.023	0.021	0.019
	R-16 + R-19	35	**0.047**	0.037	0.031	0.026	0.023	0.020	0.018
	R-19 + R-19	38	**0.046**	0.037	0.030	0.026	0.023	0.020	0.018
~~(Multiple R-values are listed in order from inside to outside)~~									
Thru-Fastened Roofs without Thermal Spacer Blocks ~~Screw Down Roofs~~									
	R-10	10	**0.153**	~~0.082~~	~~0.056~~	~~0.043~~	~~0.035~~	~~0.029~~	~~0.025~~
	R-11	11	**0.139**	~~0.078~~	~~0.054~~	~~0.042~~	~~0.034~~	~~0.028~~	~~0.025~~
	R-13	13	**0.130**	~~0.075~~	~~0.053~~	~~0.041~~	~~0.033~~	~~0.028~~	~~0.024~~
	R-16	16	**0.106**						
	R-19	19	**0.098**						
Filled Cavity with Thermal Spacer Blocks									
	R19 + R-10	29	**0.041**	0.033	0.028	0.024	0.021	0.0198	0.017
(Multiple R-values are listed in order from inside to outside)									

TABLE B-21B
Assembly U-Factors for Attic Roofs with Wood Joists

Rated R-Value of Insulation Alone	Overall U-Factor for Entire Assembly
Wood-framed attic, standard framing	0.613
None	0.091
R-11	0.081
R-13	0.053
R-19	0.034
R-30	0.027
R-38	0.021
R-49	0.017
R-60	0.015
R-71	0.013
R-82	0.011
R-93	0.010
R-104	0.009
R-115	0.008
R-126	
Wood-framed attic, advanced framing	0.613
None	0.088
R-11	0.078
R-13	0.051
R-19	0.032
R-30	0.026
R-38	0.020
R-49	0.016
R-60	0.014
R-71	0.012
R-82	0.011
R-93	0.010
R-104	0.009
R-115	0.008
R-126	
Wood joists, single rafter roof	0.417
None	0.088
R-11	0.078
R-13	0.071
R-15	0.055
R-19	0.052
R-21	0.043
R-25	0.036
R-30	0.028
R-38	

TABLE B-22
Assembly U-Factors for Attic Roofs with Steel Joists (4.0 ft on center)

Rated R-Value of Insulation Area	Overall U-Factor for Entire Assembly
R-0	U-1.282
R-4	U-0.215
R-5	U-0.179
R-8	U-0.120
R-10	U-0.100
R-11	U-0.093
R-12	U-0.086
R-13	U-0.080
R-15	U-0.072
R-16	U-0.068
R-19	U-0.058
R-20	U-0.056
R-21	U-0.054
R-24	U-0.049
R-25	U-0.048
R-30	U-0.041
R-35	U-0.037
R-38	U-0.035
R-40	U-0.033
R-45	U-0.031
R-50	U-0.028
R-55	U-0.027

B2.5 Floors

B2.5.1 General. The buffering effect of crawl spaces or parking garages shall not be included in *U-factor* calculations. See Section B2.5.5 for *slab-on-grade floors.*

B2.5.2 Mass Floors.

B2.5.2.1 General. For the purpose of applicant-determined assembly U-factors, C-factors, f-factors, or heat capacities, the base assembly is *continuous insulation* over or under a solid concrete *floor*. The *U-factor* includes R-0.92 for interior air film—heat flow down, R-1.23 for carpet and rubber pad, R-0.50 for 8 inch (203 mm) concrete, and R-0.46 for semi-exterior air film. Added insulation is continuous and uninterrupted by framing. Framing factor is zero.

B2.5.2.2 Rated R-Value of Insulation for Mass Floors.

B2.5.2.2.1 The *rated R-value of insulation* is for *continuous insulation* uninterrupted by framing.

B2.5.2.2.2 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*.

B2.5.2.2.3 For waffle-slab *floors*, the *floor* shall be insulated either on the interior above the slab or on all exposed surfaces of the waffle.

B2.5.2.2.4 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 inches (610 mm) and less below the exposed floor.

B2.5.2.3 U-Factors for Mass Floors.

B2.5.2.3.1. The U-factors for mass floors shall be taken from Table B-23.

B2.5.2.3.2 It is not acceptable to use the U-factors in Table B-23 if the insulation is not continuous.

B2.5.3 Steel Joist Floors.

B2.5.3.1 General. For the purpose of applicant-determined assembly U-factors, C-factors, f-factors, or heat capacities, the base assembly is a *floor* where the insulation is either placed between the steel joists or is sprayed on the underside of the *floor* and the joists. In both cases, the steel provides a thermal bypass to the insulation. The *U-factor* includes R-0.92 for interior air film—heat flow down, R-1.23 for carpet and pad, R-0.25 for 4 inch (102 mm) concrete, R-0 for metal deck, and R-0.46 for semi-exterior air film. The performance of the insulation/framing layer is calculated using the values in Table B-18.

B2.5.3.2 Rated R-Value of Insulation for Steel-Joist Floors.

B2.5.3.2.1 The first *rated R-value of insulation* is for uncompressed insulation installed in the cavity between steel joists or for spray-on insulation.

B2.5.3.2.2 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.

B2.5.3.3 U-Factors for Steel-Joist Floors.

B2.5.3.3.1 U-factors for steel joist floors shall be taken from Table B-24.

B2.5.3.3.2 It is acceptable to use these *U-factors* for any *steel joist floor*.

B2.5.4 Wood-Framed and other Floors.

B2.5.4.1 General. For the purpose of applicant-determined assembly U-factors, C-factors, f-factors, or heat capacities, the base assembly is a *floor* attached directly to the top of the wood joist and with insulation located directly below the *floor*, with a ventilated airspace below the insulation. The heat flow path through the joist is calculated to be the same depth as the insulation. The *U-factor* includes R-0.92 for interior air film—heat flow down, R-1.23 for carpet and pad, R-0.94 for 0.75 inch (19 mm) wood subfloor, and R-0.46 for semi-exterior air film. The weighting factors are 91 percent insulated cavity and 9 percent framing.

B2.5.4.2 Rated R-Value of Insulation for Wood-Framed and Other Floors.

B2.5.4.2.1 . The first *rated R-value of insulation* is for uncompressed insulation installed in the cavity between wood joists.

B2.5.4.2.2 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.

B2.5.4.3 U-Factors for Wood-Framed Floors

B2.5.4.3.1 *U-factors* for *wood-framed floors* shall be taken from Table B-25.

B2.5.4.3.2 It is not acceptable to use these *U-factors* if the framing is not wood.

B2.5.5 Slab-on-Grade Floors.

B2.5.5.1 General. For the purpose of applicant-determined assembly U-factors, C-factors, f-factors, or heat capacities, the base assembly is a slab floor of 6 inch (152 mm). concrete poured directly on to the earth, the bottom of the slab is at grade line, and soil conductivity is 0.75 Btu/h·ft^{2}·^{o}F. In contrast to the *U-factor* for *floors*, the *F-factor* for *slab-on-grade floors* is expressed per lineal foot of building perimeter. *F-factors* are provided for unheated slabs and for heated slabs. *Unheated slab-on-grade floors* do not have heating elements, and *heated slab-on-grade floors* do have heating elements within or beneath the slab. *F-factors* are provided for three insulation configurations:

a. Horizontal insulation: *continuous insulation* is applied directly to the underside of the slab and extends inward horizontally from the perimeter for the distance specified or *continuous insulation* is applied downward from the top of the slab and then extends horizontally to the interior or the exterior from the perimeter for the distance specified.

b. Vertical insulation: *continuous insulation* is applied directly to the slab exterior, extending downward from the top of the slab for the distance specified.

c. Fully insulated slab: *continuous insulation* extends downward from the top of the slab and along the entire perimeter and completely covers the entire area under the slab.

B2.5.5.2 Rated R-Value of Insulation for Slab-on-Grade Floors.

B2.5.5.2.1 The rated R-value of insulation shall be installed around the perimeter of the slab-on-grade floor to the distance specified.

Exception. 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.

B2.5.5.2.2 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. The horizontal insulation extending outside of the foundation shall be covered by pavement or by soil a minimum of 10 inches (254 mm) thick.

B2.5.5.3 F-Factors for Slab-on-Grade Floors.

B2.5.5.3.1 F-factors for slab-on-grade floors shall be taken from Table B-26.

B2.5.5.3.2 These F-factors are acceptable for all slab-on-grade floors.

TABLE B-23
Assembly U-Factors for Mass Floors

Framing Type & Spacing Width (actual depth)	Cavity Insulation R-Value:Rated/ (effective installed)	Overall U-Factor for Entire Base Wall Assembly	Overall U-Factor for Assembly of Base Floor Plus Continuous Insulation (unint Rated R-Value of Continuous Insulation													
			R-1.0	R-2.0	R-3.0	R-4.0	R-5.0	R-6.0	R-7.0	R-8.0	R-9.0	R-10.0	R-11.0	R-12.0	R-13.0	R
Concrete Floor with Rigid Foam																
	None(0.0)	0.322	0.243	0.196	0.164	0.141	0.123	0.11	0.099	0.09	0.083	0.076	0.071	0.066	0.062	0
Concrete Floor with Pinned Boards																
	R-4.2(4.2)	0.137	0.121	0.108	0.097	0.089	0.081	0.075	0.07	0.065	0.061	0.058	0.055	0.052	0.049	0
	R-6.3(6.3)	0.107	0.096	0.088	0.081	0.075	0.07	0.065	0.061	0.058	0.054	0.052	0.049	0.047	0.045	0
	R-8.3(8.3)	0.087	0.08	0.074	0.069	0.065	0.061	0.057	0.054	0.051	0.049	0.047	0.045	0.043	0.041	0
	R-10.4(10.4)	0.074	0.069	0.064	0.06	0.057	0.054	0.051	0.049	0.046	0.044	0.042	0.041	0.039	0.038	0
	R-12.5(12.5)	0.064	0.06	0.057	0.054	0.051	0.048	0.046	0.044	0.042	0.041	0.039	0.038	0.036	0.035	0
	R-14.6(14.6)	0.056	0.053	0.051	0.048	0.046	0.044	0.042	0.04	0.039	0.037	0.036	0.035	0.034	0.033	0
	R-16.7(16.7)	0.051	0.048	0.046	0.044	0.042	0.04	0.039	0.037	0.036	0.035	0.034	0.032	0.031	0.03	0
Concrete Floor with Spray-on Insulation																
(1in.)	R-4(4.0)	0.141	0.123	0.11	0.099	0.09	0.083	0.076	0.071	0.066	0.062	0.058	0.055	0.052	0.05	0
(2in.)	R-8(8.0)	0.09	0.083	0.076	0.071	0.066	0.062	0.058	0.055	0.052	0.05	0.047	0.045	0.043	0.041	0
(3in.)	R-12(12.0)	0.066	0.062	0.058	0.055	0.052	0.05	0.047	0.045	0.043	0.041	0.04	0.038	0.037	0.036	0
(4in.)	R-16(16.0)	0.052	0.05	0.047	0.045	0.043	0.041	0.04	0.038	0.037	0.036	0.034	0.033	0.032	0.031	0
(5in.)	R-20(20.0)	0.043	0.041	0.04	0.038	0.037	0.036	0.034	0.033	0.032	0.031	0.03	0.029	0.028	0.028	0
(6in.)	R-24(24.0)	0.037	0.036	0.034	0.033	0.032	0.031	0.03	0.029	0.028	0.028	0.027	0.026	0.026	0.025	0

TABLE B-24
Assembly U-Factors for Steel Joist Floors

Framing Type and Spacing Width (actual depth)	Cavity Insulation R-Value: Rated/ (effective installed [see Table A-20])	Overall U-Factor for Entire Base Wall Assembly	Overall U-Factor for Assembly of Base Floor Plus Continuous Insulation (uninterrupted I Rated R-Value of Continuous Insulation														
			R-1.0	R-2.0	R-3.0	R-4.0	R-5.0	R-6.0	R-7.0	R-8.0	R-9.0	R-10.0	R-11.0	R-12.0	R-13.0	R-14.0	R-15.0
Steel Joist Floor with Rigid Foam																	
	None(0.0)	0.35	0.259	0.206	0.171	0.146	0.127	0.113	0.101	0.092	0.084	0.078	0.072	0.067	0.063	0.059	0.056
Steel Joist Floor with Spray-on Insulation																	
(1in.)	R-4(3.88)	0.148	0.129	0.114	0.103	0.093	0.085	0.078	0.073	0.068	0.064	0.06	0.056	0.053	0.051	0.048	0.046
(2in.)	R-8(7.52)	0.096	0.088	0.081	0.075	0.07	0.065	0.061	0.058	0.054	0.052	0.049	0.047	0.045	0.043	0.041	0.039
(3in.)	R-12(10.8)	0.073	0.068	0.064	0.06	0.057	0.054	0.051	0.048	0.046	0.044	0.042	0.041	0.039	0.038	0.036	0.035
(4in.)	R-16(13.92)	0.06	0.056	0.053	0.051	0.048	0.046	0.044	0.042	0.04	0.039	0.037	0.036	0.035	0.034	0.032	0.031
(5in.)	R-20(17.0)	0.05	0.048	0.046	0.044	0.042	0.04	0.039	0.037	0.036	0.035	0.033	0.032	0.031	0.03	0.03	0.029
(6in.)	R-24(19.68)	0.044	0.042	0.041	0.039	0.038	0.036	0.035	0.034	0.033	0.032	0.031	0.03	0.029	0.028	0.027	0.027
Steel Joist Floor with Batt Insulation																	
	None(0.0)	0.35	0.259	0.206	0.171	0.146	0.127	0.113	0.101	0.092	0.084	0.078	0.072	0.067	0.063	0.059	0.056
	R-11(10.01)	0.078	0.072	0.067	0.063	0.059	0.056	0.053	0.05	0.048	0.046	0.044	0.042	0.04	0.039	0.037	0.036
	R-13(11.7)	0.069	0.064	0.06	0.057	0.054	0.051	0.049	0.046	0.044	0.042	0.041	0.039	0.038	0.036	0.035	0.034
	R-15(13.2)	0.062	0.059	0.055	0.052	0.05	0.047	0.045	0.043	0.042	0.04	0.038	0.037	0.036	0.034	0.033	0.032
	R-19(16.34)	0.052	0.05	0.047	0.045	0.043	0.041	0.04	0.038	0.037	0.035	0.034	0.033	0.032	0.031	0.03	0.029
	R-21(17.64)	0.049	0.047	0.044	0.043	0.041	0.039	0.038	0.036	0.035	0.034	0.033	0.032	0.031	0.03	0.029	0.028
	R-25(20.25)	0.043	0.041	0.04	0.038	0.037	0.036	0.034	0.033	0.032	0.031	0.03	0.029	0.028	0.028	0.027	0.026

R-30C(23.70)	0.038	0.036	0.035	0.034	0.033	0.032	0.031	0.03	0.029	0.028	0.027	0.027	0.026	0.025	0.025	0.024
R-30(23.7)	0.038	0.036	0.035	0.034	0.033	0.032	0.031	0.03	0.029	0.028	0.027	0.027	0.026	0.025	0.025	0.024
R-38C(28.12)	0.032	0.031	0.03	0.029	0.029	0.028	0.027	0.026	0.026	0.025	0.024	0.024	0.023	0.023	0.022	0.022
R-38(28.12)	0.032	0.031	0.03	0.029	0.029	0.028	0.027	0.026	0.026	0.025	0.024	0.024	0.023	0.023	0.022	0.022

TABLE B-25
Assembly U-Factors for Wood Joist Floors

Framing Type & Spacing Width (actual Depth)	Cavity Insulation R-Value: Rated/ (effective installed)	Overall U-Factor for Entire Base Wall Assembly	Overall U-Factor for Assembly of Base Floor Plus Continuous Insulation (uninterrupted Rated R-Value of Continuous Insulation														
			R-1.0	R-2.0	R-3.0	R-4.0	R-5.0	R-6.0	R-7.0	R-8.0	R-9.0	R-10.0	R-11.0	R-12.0	R-13.0	R-14.0	R-15.0
Wood Joists																	
(5.5in.)	None(0.0)	0.282	0.22	0.18	0.153	0.132	0.117	0.105	0.095	0.087	0.08	0.074	0.069	0.064	0.06	0.057	0.05
	R-11(11.0)	0.074	0.069	0.064	0.06	0.057	0.054	0.051	0.048	0.046	0.044	0.042	0.04	0.039	0.037	0.036	0.03
	R-13(13.0)	0.066	0.062	0.058	0.055	0.052	0.049	0.047	0.045	0.043	0.041	0.039	0.038	0.036	0.035	0.034	0.03
	R-15(15.0)	0.06	0.057	0.053	0.05	0.048	0.046	0.044	0.042	0.04	0.038	0.037	0.036	0.034	0.033	0.032	0.03
	R-19(18.0)	0.051	0.048	0.046	0.044	0.042	0.04	0.038	0.037	0.036	0.034	0.033	0.032	0.031	0.03	0.029	0.02
	R-21(21.0)	0.046	0.043	0.042	0.04	0.038	0.037	0.035	0.034	0.033	0.032	0.031	0.03	0.029	0.028	0.027	0.02
(7.25in.)	R-25(25.0)	0.039	0.037	0.036	0.035	0.033	0.032	0.031	0.03	0.029	0.028	0.028	0.027	0.026	0.025	0.025	0.02
	R-30C(30.0)	0.034	0.033	0.032	0.031	0.03	0.029	0.028	0.027	0.026	0.026	0.025	0.024	0.024	0.023	0.023	0.02
(9.25in.)	R-30(30.0)	0.033	0.032	0.031	0.03	0.029	0.028	0.027	0.027	0.026	0.025	0.024	0.024	0.023	0.023	0.022	0.02
(11.25in.)	R-38C(38.0)	0.027	0.026	0.025	0.025	0.024	0.024	0.023	0.022	0.022	0.021	0.021	0.02	0.02	0.02	0.019	0.01
(13.25in.)	R-38938.0)	0.026	0.026	0.025	0.024	0.024	0.023	0.023	0.022	0.022	0.021	0.021	0.02	0.02	0.019	0.019	0.01

TABLE B-26
Assembly F-Factors for Slab-on-Grade Floors

Insulation Description	Rated R-Value of Insulation												
	R-0	R-5	R-7.5	R-10	R-15	R-20	R-25	R-30	R-35	R-40	R-45	R-50	R-55
Unheated Slabs													
None	0.73												
12 in. horizontal		0.72	0.71	0.71	0.71								
24 in. horizontal		0.7	0.7	0.7	0.69								
36in. Horizontal		0.68	0.67	0.66	0.66								
48 in. horizontal		0.67	0.65	0.64	0.63								
12 in. vertical		0.61	0.6	0.58	0.57	0.567	0.565	0.564					
24 in. vertical		0.58	0.56	0.54	0.52	0.51	0.505	0.502					
36 in. vertical		0.56	0.53	0.51	0.48	0.472	0.464	0.46					
48 in. vertical		0.54	0.51	0.48	0.45	0.434	0.424	0.419					
Fully insulated slab		0.46	0.41	0.36	0.3	0.261	0.233	0.213	0.198	0.186	0.176	0.168	0.161
Heated Slabs													
None	1.35												
12 in. horizontal		1.31	1.31	1.3	1.3								
24 in. horizontal		1.28	1.27	1.26	1.25								
36 in. horizontal		1.24	1.21	1.2	1.18								
48 in. horizontal		1.2	1.17	1.13	1.11								
12 in. vertical		1.06	1.02	1	0.98	0.968	0.964	0.961					
24 in vertical		0.99	0.95	0.9	0.86	0.843	0.832	0.827					
36 in. vertical		0.95	0.89	0.84	0.79	0.762	0.747	0.74					
48in. Vertical		0.91	0.85	0.78	0.72	0.688	0.671	0.659					
Fully insulated slab		0.74	0.64	0.55	0.44	0.373	0.326	0.296	0.273	0.255	0.239	0.227	0.217

B3.1 Calculation Procedures

B3.1.1 Cooling System Design Loads. Cooling system design loads, for the purpose of sizing HVAC systems and equipment, shall be determined in accordance with one of the procedures described in Chapter 26 of the ASHRAE Handbook of Fundamentals or ACCA Manual N, Commercial Load Calculation.

B3.1.2 Interior Design Conditions. Indoor design temperature and humidity conditions for general comfort applications shall be in accordance with the comfort criteria established in ANSI/ASHRAE Standard 55, Thermal Environmental Conditions for Human Occupancy, or Chapter 8 of the ASHRAE Handbook of Fundamentals, except that winter humidification and summer dehumidification are not required.

B3.1.3 Exterior Design Conditions. Outdoor design conditions shall be selected from the ASHRAE Handbook of Fundamentals, or from data obtained from the National Climatic Center or a similar recognized weather data source. Cooling design temperatures shall be no greater than the temperature listed in the 2.0 percent column or statistically similar 0.5 percent annualized value. Heating design temperatures shall be no lower than the temperature listed in the 99 percent column or statistically similar 0.2 percent annualized value.

Exception: Where necessary to assure the prevention of damage to the building or to material and equipment within the building, the 1 percent column for cooling may be used.

B4.1 Lighting calculation procedures.

B4.1.1 Luminaire Wattage. Luminaire wattage incorporated into the installed interior lighting power shall be determined in accordance with the following criteria:

1. The wattage of incandescent or tungsten-halogen luminaires with medium screw base sockets and not containing permanently installed ballasts shall be the maximum labeled wattage of the luminaire.
2. The wattage of luminaires with permanently installed or remote ballasts or transformers shall be the operating input wattage of the maximum lamp/ auxiliary combination based on values from the auxiliary manufacturer's literature or recognized testing laboratories or shall be the maximum labeled wattage of the luminaire.
3. For ~~The wattage of~~ line-voltage lighting track and plug-in busway designed to ~~that~~ allow the addition and/or relocation of luminaires without altering the wiring of the system, the wattage shall be:
   a. the specified wattage of the luminaries included in the system with a minimum of 30 watts per linear foot (98 W/lin m), or
   b. the wattage limit of the system's circuit breaker, or
   c. the wattage limit of other permanent current-limiting devices(s) on the system.
4. The wattage of low-voltage lighting track, cable conductor, rail conductor, and other flexible lighting systems that allow the addition and/or relocation of luminaires without altering the wiring of the system shall be the specified wattage of the transformer supplying the system.
5. The wattage of all other miscellaneous lighting equipment shall be the specified wattage of the lighting equipment.

B5.0 Minimum and Baseline Components. Components used in the EnergyGauge Summit Fla/Com 2008 computer program to determine code compliance were derived from the following four documents:

ASHRAE Advanced Energy Design Guide for Small Office Buildings,
ASHRAE Advanced Energy Design Guide for Small Retail Buildings,
ASHRAE Advanced Energy Design Guide for K-12 School Buildings,
ASHRAE Standard 90.1-2007.

B5.1 Compliance Method A. Components in Tables B5.1 through B5.5 constitute Baseline features that are used by the EnergyGauge Summit Fla/Com computer program to establish a budget for a building, by building type, for compliance with Method A. The As-Built building shall, as a whole, come in under that budget to comply with the code. Where equipment efficiencies are not designated in Tables B5.1 through B5.5, the Baseline component is the minimum allowable efficiency for the type of equipment to be installed. Baseline lighting power densities are those in Table 13-415.B.1 by space type.

B5.2 Compliance Method B. Components in Tables B5.1 through B5.5 are used by the EnergyGauge Summit Fla/Com computer program to establish a budget for envelope features, by building type, which must be met by the envelope as a whole to comply with Method B. Equipment shall meet minimum efficiency for that type of equipment in the code. Lighting power for the building shall meet a budget established by the lighting power densities in Table 13-415.B.1.

B5.3 Compliance Method C. Components in Tables B5.1 through B5.5 must be met for the appropriate building category to be in compliance with Method C when demonstrated by use of the EnergyGauge Summit computer program. Buildings complying by the hand compliance Form $400C_{AllClimateZones}$ shall meet the minimum efficiencies listed on the form.

Table B5.1
Component Features for Offices up to 20,000 s.f.

Item	Component	Requirement or Baseline
Roof	Insulation entirely above deck	R-15 c.i.
	Metal building	R-19
	Attic and other	R-30
	Single rafter	R-30
	Surface reflectance/emittance	0.65 initial/0.86
Walls	Mass (HC>7 Btu/ft^2)	No recommendation
	Metal building	R-13
	Steel framed	R-13
	Wood framed and other	R-13
	Below-grade walls	No recommendation
Floors	Mass	R-4.2 c.i.
	Steel framed	R-19
	Wood framed and other	R-19
Slabs	Unheated	No recommendation
	Heated	No recommendation
Doors	Swinging	U-0.70

	Non-swinging	U-1.45
Vert. Glazing	Window to wall ratio (WWR)	20% to 40% maximum
	Thermal transmittance	U-0.56
	Solar heat gain coefficient (SHGC)	N, S, E, W - 0.35 / N only - 0.49
	Window orientation	$(A_N*SHGC_N+A_S*SHGC_S)>(A_E*SHGC_E+A_W*SHGC_W)$
	Exterior sun control (S, E, W only)	Projection factor (PF) 0.5
Skylights	Maximum percent of roof area	3%
	Thermal transmittance	U-1.36
	Solar heat gain coefficient (SHGC)	0.19
Int. Lighting	Lighting power density (LPD)	0.9 W/ ft^2
	Light source (linear fluorescent)	90 mean lumens/watt
	Ballast	Electronic ballast
	Dimming controls for daylight Harvesting for WWR ≥ 25%	Dim fixtures within 12 ft of N/S window wall or within 8 ft of skylight edge
	Interior room surface reflectances	80%+ on ceilings, 70%+ on walls and vertical partitions
HVAC	Air conditioner (0-65 kBtu/h)	13.0 SEER
	Air conditioner (>65-135 kBtu/h)	11.3 EER / 11.5 IPLV
	Air conditioner (>135-240 kBtu/h)	11.0 EER / 11.5 IPLV
	Air conditioner (>240 kBtu/h)	10.6 EER / 11.2 IPLV
	Gas furnace (0-225 kBtu/h – SP)	80% AFUE or E_t
	Gas furnace (0-225 kBtu/h – Split)	80% AFUE or E_t
	Gas furnace (>225 kBtu/h)	80% E_c
	Heat pump (0-65 kBtu/h)	13 SEER / 7.7 HSPF
	Heat pump (>65-135 kBtu/h)	10.6 EER / 11.0 IPLV / 3.2 COP
	Heat pump (>135 kBtu/h)	10.1 EER / 11.5 IPLV / 3.1 COP
Economizer	Air conditioners & heat pumps - SP	No recommendation
Ventilation	Outdoor air damper	Motorized control
	Demand control	CO_2 sensors
Ducts	Friction rate	0.08 in. w.c. / 100 feet
	Sealing	Seal class B
	Location	Interior only
	Insulation level	R-6
Service Water Heater	Gas storage	90% E_t
	Gas instantaneous	0.81 EF or 81% E_t
	Electric storage 12 kW	EF > 0.99 – 0.0012*Volume
	Pipe insulation (d<1 ½ in/d >1 ½ in)	1 in. / 1 ½ in.

TABLE B5.2
Component Features for Retail Buildings up to 20,000 s.f.

Item	Component	Requirement or Baseline	
Roof	Insulation entirely above deck	R-15 c.i.	
	Metal building	R-19	
	Attic and other	R-38	
	Single rafter	R-38	
	Surface reflectance/emittance	0.65 initial/0.86	
Walls	Mass (HC>7 Btu/ft^2)	R-7.6 c.i.	
	Metal building	R-13	
	Steel framed	R-13	
	Wood framed and other	R-13	
	Below-grade walls	No recommendation	
Floors	Mass	R-6.3 c.i.	
	Steel framed	R-19	
	Wood framed and other	R-19	
Slabs	Unheated	No recommendation	
	Heated	No recommendation	
Doors	Swinging	U-0.70	
	Non-swinging	U-1.45	
Vert. Glazing	Window to wall ratio (WWR)	20% to 40% maximum	
	Thermal transmittance	U-0.45	
	Solar heat gain coefficient (SHGC)	N, S, E, W - 0.31	N only - 0.44
	Window orientation	(A_N*$SHGC_N$+A_S*$SHGC_S$)> (A_E*$SHGC_E$+A_W*$SHGC_W$)	
	Exterior sun control (S, E, W only)	Projection factor (PF) 0.5	
Skylights	Maximum percent of roof area	3%	
	Thermal transmittance	U-1.36	
	Solar heat gain coefficient (SHGC)	0.19	
Int. Lighting	Lighting power density (LPD)	0.9 W/ ft^2	
	Light source (linear fluorescent)	90 mean lumens/watt	
	Ballast	Electronic ballast	
	Dimming controls for daylight Harvesting for WWR ≥ 25%	Dim fixtures within 12 ft of N/S window wall or within 8 ft of skylight edge	
	Interior room surface reflectances	80%+ on ceilings, 70%+ on walls and vertical partitions	
HVAC	Air conditioner (0-65 kBtu/h)	13.0 SEER	
	Air conditioner (>65-135 kBtu/h)	11.3 EER / 11.5 IPLV	
	Air conditioner (>135-240 kBtu/h)	11.0 EER / 11.5 IPLV	
	Air conditioner (>240 kBtu/h)	10.6 EER / 11.2 IPLV	
	Gas furnace (0-225 kBtu/h – SP)	80% AFUE or E_t	
	Gas furnace (0-225 kBtu/h – Split)	80% AFUE or E_t	
	Gas furnace (>225 kBtu/h)	80% E_c	
	Heat pump (0-65 kBtu/h)	13 SEER / 7.7 HSPF	
	Heat pump (>65-135 kBtu/h)	10.6 EER / 11.0 IPLV / 3.2 COP	
	Heat pump (>135 kBtu/h)	10.1 EER / 11.5 IPLV / 3.1 COP	
Economizer	Air conditioners & heat pumps - SP	No recommendation	
Ventilation	Outdoor air damper	Motorized control	
	Demand control	CO_2 sensors	
Ducts	Friction rate	0.08 in. w.c. / 100 feet	
	Sealing	Seal class B	
	Location	Interior only	
	Insulation level	R-6	
Service Water Heater	Gas storage	90% E_t	
	Gas instantaneous	0.81 EF or 81% E_t	
	Electric storage 12 kW	EF > 0.99 – 0.0012*Volume	
	Pipe insulation (d<1 ½ in/d >1 ½ in)	1 in. / 1 ½ in.	

TABLE B5.3
Component Features for K-12 School Buildings

Item	Component	Requirement or Baseline
Roof	Insulation entirely above deck	R-25 c.i.
	Metal building	R-19
	Attic and other	R-30
	Single rafter	R-30
	Surface reflectance	0.78
Walls	Mass (HC>7 Btu/ft^2)	R-5.7 c.i.
	Metal building	R-16
	Steel framed	R-13
	Wood framed and other	R-13
	Below-grade walls	No recommendation
Floors	Mass	R-4.2 c.i.
	Steel framed	R-19
	Wood framed and other	R-19
Slabs	Unheated	No recommendation
	Heated	R-7.5 for 12 in.
Doors	Swinging	U-0.70
	Non-swinging	U-1.45
Vert. Glazing	Window to wall ratio (WWR)	35% maximum
	Thermal transmittance	U-0.56
	SHGC – all types and orientation	SHGC – 0.25
	Exterior sun control (S, E, W only)	Projection factor (PF) 0.5
Int. Finishes	Interior room surface average reflectance	70%+ on ceilings and walls above 7 ft 50%+ on walls below 7 ft
Interior Lighting-Daylighting option	Classroom daylighting (daylighting fenestration to floor area ratio)	Toplighted – South-facing roof monitors: 8% - 11% North-facing roof monitors: 12%-15%
		Sidelighted- South-facing: 8% - 11% North-facing: 15%-20%
		Combined tiplighted and sidelighted- Southfacing sidelighted: 6% - 8% Toplighted: 2% - 3% Northfacing sidelighted: 9% - 13% Toplighted: 3% - 5%
	Gym toplighting (daylighting fenestration to floor area ratio)	South-facing roof monitors: 5% - 8% North-facing roof monitors: 7% -10%
	Lighting power density (LPD)	1.2 W/ ft^2
	Light source system efficacy (linear fluorescent)	75 mean lm/W minimum
	Light source system efficacy (all other sources)	50 mean lm/W minimum
	Occupancy controls	Manual on, auto, off all zones
	Dimming controls daylight harvesting	Dim all fixtures in classrooms and gym and other fixtures within 15 ft of sidelighting edge and within 10 ft of toplighting edge
Interior Lighting-Non-Daylighting option	Lighting power density (LPD)	1.1 W/ ft^2
	Light source system efficacy (linear fluorescent)	85 mean lm/W minimum
	Light source system efficacy (all other sources)	50 mean lm/W minimum
	Occupancy controls	Manual on, auto, off all zones
	Dimming controls daylight harvesting	Dim fixtures within 15 ft of sidelighting edge and within 10 ft of toplighting edge
Packaged DX Rooftops	Air conditioner (0-65 kBtu/h)	13.0 SEER
	Air conditioner (>65-135 kBtu/h)	11.3 EER
	Air conditioner (>135-240 kBtu/h)	11.0 EER

(or DX Split Systems)	Air conditioner (>240 kBtu/h)	10.6 EER / 11.2 IPLV
	Heat pump (0-65 kBtu/h)	13 SEER / 7.7 HSPF
	Heat pump (>65-135 kBtu/h)	10.6 EER / 3.2 COP
	Heat pump (>135 kBtu/h)	10.1 EER / 11.5 IPLV / 3.1 COP
	Gas furnace (<225 kBtu/h)	80% AFUE or E_t
	Gas furnace (>225 kBtu/h)	80% E_c
	Economizer	Comply with ASHRAE 90.1
	Ventilation	Energy recovery or demand control
	Fans	Constant volume: 1 hp/1000 cfm Variable volume: 1.3 hp/1000 cfm
WSHP System	Water source heat pump (<65 KBtu/h)	Cooling: 12 SEER at 86 ºF Heating: 4.5 COP at 68 ºF
	Water source heat pump (≥65 KBtu/h)	Cooling: 12 SEER at 86 ºF Heating: 4.2 COP at 68 ºF
	Ground source heat pump (GSHP) (<65 kBtu/h)	Clg: 14.1 EER at 77ºF, 17 EER at 59ºF Htg: 3.5 COP at 32ºF, 4.0 COP at 50ºF
	GSHP (65 ≥ kBtu/h)	Clg: 13 EER at 77ºF, 16 EER at 59ºF Htg: 3.1 COP at 32ºF, 3.5 COP at 50ºF
	Gas boiler	85% E_c
	Economizer	Comply with ASHRAE 90.1
	Ventilation	Energy recovery or demand control
	WSHP duct pressure drop	Total ESP < 0.2 in. H_2O
Fan Coil and Chiller System	Air-cooled chiller efficiency	10.0 EER and 11.5 IPLV
	Water-cooled chiller efficiency	Comply with ASHRAE 90.1
	Gas boiler	80% E_c
	Economizer	Comply with ASHRAE 90.1
	Ventilation	DOAS with either energy recovery or demand control
	Pressure drop	Total ESP < 0.2 in. H_2O
Packaged Rooftop VAV System	Rooftop air conditioner (≥240 kBtu/h)	10.0 EER and 11.2 IPLV
	Gas furnace (≥225 kBtu/h)	80% E_c
	Gas boiler	80% E_c
	Economizer	Comply with ASHRAE 90.1
	Ventilation	DOAS with either energy recovery or demand control
	Pressure drop	Total ESP < 0.2 in. H_2O
VAV and Chiller System	Air-cooled chiller efficiency	10.0 EER and 11.5 IPLV
	Water-cooled chiller efficiency	Comply with ASHRAE 90.1
	Gas boiler	80% E_c
	Economizer	Comply with ASHRAE 90.1
	Ventilation	Energy recovery or demand control
Ducts and Dampers	Outdoor air damper	Motorized
	Friction rate	0.08 in. w.c. / 100 feet
	Sealing	Seal class B
	Location	Interior only
	Insulation level	R-6
Service Water Heater	Gas storage	90% E_t
	Gas instantaneous	0.81 EF or 81% E_t
	Electric storage 12 kW	EF > 0.99 – 0.0012*Volume
	Pipe insulation (d<1 ½ in/d >1 ½ in)	1 in. / 1 ½ in.

[Table is based on Form 400C-07 for ASHRAE Climate Zone 1. Values are the same except as underlined.]

TABLE B5.4
Building Envelope Requirements For ASHRAE Climate Zone 1
Other than Small Office*, Small Retail* and K – 12 School Buildings

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-0.063	R-15.0 c.i.	U-0.048	R-20 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-1.2280	NR
Attic and Other	U-0.034	R-30.0	U-0.027	R-38.0	U-0.081	R-13
Walls, Above-Grade						
Mass	U-0.580	NR	U-0.151[1]	R-5.7 c.i.[1]	U-0.580	NR
Metal Building	U-0.113	R-13.0	U-0.113	R-13.0	U-1.180	NR
Steel-Framed	U-0.124	R-13.0	U-0.124	R-13.0	U-0.352	NR
Wood-Framed and Other						
Walls, Below-Grade						
Below-Grade Wall	C-1.140	NR	C-1.140	NR	C-1.140	NR
Floors						
Mass	U-0.322	NR	U-0.322	NR	U-0.322	NR
Steel-Joist	U-0.350	NR	U-0.350	NR	U-0.350	NR
Wood-Framed and Other	U-0.282	NR	U-0.282	NR	U-0.282	NR
Slab-On_Grade Floors						
Unheated	F-0.730		F-0.730		F-0.730	
Heated	F-1.020		F-1.020		F-1.020	
Opaque Doors						
Swinging	U-0.700		U-0.700		U-0.700	
Nonswinging	U-1.450		U-1.450		U-1.450	
Fenestration	**Assembly Max. U**	**Assembly Max. SHGC**	**Assembly Max. U**	**Assembly Max. SHGC**	**Assembly Max. U**	**Assembly Max. SHGC**
Vertical Glazing, 0%-40% of Wall						
Nonmetal framing (all)[2]	U-1.2	SHGC 0.25_{All}	U-1.2	SHGC 0.25_{All}	U-1.2	SHGC 0.25_{All}
Metal framing (curtainwall/storefront)[3]	U-1.2	SHGC 0.25_{All}	U-1.2	SHGC 0.25_{All}	U-1.2	SHGC 0.25_{All}
Metal framing (entrance door)[3]	U-1.2	SHGC 0.25_{All}	U-1.2	SHGC 0.25_{All}	U-1.2	SHGC 0.25_{All}
Metal framing (all other)[3]	U-1.2	SHGC 0.25_{All}	U-1.2	SHGC 0.25_{All}	U-1.2	SHGC 0.25_{All}
Skylight	**Assembly Max. U**	**Assembly Max. SHGC**	**Assembly Max. U**	**Assembly Max. SHGC**	**Assembly Max. U**	**Assembly Max. SHGC**
Skylight with Curb, Glass, % of Roof						
0 % - 2.0 %	U-1.98	SHGC 0.36	U_{All}-1.98	$SHGC_{All}$ 0.19	U_{All}-1.98	$SHGC_{All}$ NR
2.1 % - 5.0 %	U-1.98	SHGC 0.19	U_{All}-1.98	$SHGC_{All}$ 0.16	U_{All}-1.98	$SHGC_{All}$ NR
Skylight with Curb, Plastic, % of Roof						
0 % - 2.0 %	U-1.90	SHGC 0.34	U_{All}-1.90	$SHGC_{All}$ 0.27	U_{All}-1.90	$SHGC_{All}$ NR
2.1 % - 5.0 %	U-1.90	SHGC 0.27	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-1.36	SHGC 0.36	U_{All}-1.36	$SHGC_{All}$ 0.19	U_{All}-1.36	$SHGC_{All}$ NR
2.1 % - 5.0 %	U-1.36	SHGC 0.19	U_{All}-1.36	$SHGC_{All}$ 0.19	U_{All}-1.36	$SHGC_{All}$ NR

The following definitions apply: c.i.=continuous insulation; NR = No requirement.

[1] Exception to Section B2.2.1.1 of Appendix 13-B applies.

[2] Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.

[3] Metal framing includes metal framing with or without thermal break. The "all other" subcategory includes operable windows, fixed windows and non-entrance doors.

[Table is based on Form 400C-07 for ASHRAE Climate Zone 2. Values are the same except as underlined.]

TABLE B5.5
Building Envelope Requirements For ASHRAE Climate Zone 2
Other than Small Office, Small Retail and K – 12 School Buildings

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 c.i.	U-0.048	R-20 c.i.	U-0.218	R-3.8 c.i.
Metal Building	U-0.65	R-19	U-0.065	R-19.0	U-0.167	R-6.0
Attic and Other	U-0.027	R-38	U-0.034	R-30.0	U0.081	R-13.0
Walls, Above-Grade						
Mass	U-0.151[1]	R-5.7 c.i.[1]	U-0.123	R-7.6 c.i.	U-0.580	NR
Metal Building	U-0.113	R-13	U-0.113	R-13.0	U-0.184	R-6.0
Steel-Framed	U-0.124	R-13	U-0.064	R-13+R-7.5c.i.	U-0.124	R-13
Wood-Framed and Other	U-0.089	R-13	U-0.089	R-13.0	U-0.089	R-13
Walls, Below-Grade						
Below-Grade Wall	C1.140	NR	C1.140	NR	C1.140	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	U-0.052	R-19	U-0.069	R-13
Wood-Framed and Other	U-0.051	R-19	U-0.033	R-30	U-0.066	R-13
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”	F-0.730	NR	F-0.730	NR
Opaque Doors						
Swinging	U-0.70		U-0.70		U-0.70	
Nonswinging	U-1.45		U-0.500		U-1.45	
Fenestration	**Assembly Max. U**	**Assembly Max. SHGC**	**Assembly Max. U**	**Assembly Max. SHGC**	**Assembly Max. U**	**Assembly Max. SHGC**
Vertical Glazing, 0%-40% of Wall						
Nonmetal framing (all)[2]	U-0.75	SHGC 0.25	U-0.75	SHGC 0.25	U-1.20	SHGC NR
Metal framing (curtainwall/storefront)[3]	U-0.70	SHGC 0.25	U-0.70	SHGC 0.25	U-1.20	SHGC NR
Metal framing (entrance door)[3]	U-1.10	SHGC 0.25	U-1.10	SHGC 0.25	U-1.20	SHGC NR
Metal framing (all other)[3]	U-0.75	SHGC 0.25	U-0.75	SHGC 0.25	U-1.20	SHGC NR
Skylight	**Assembly Max. U**	**Assembly Max. SHGC**	**Assembly Max. U**	**Assembly Max. SHGC**	**Assembly Max. U**	**Assembly Max. SHGC**
Skylight with Curb, Glass, % of Roof						
0 % - 2.0 %	U-1.98	SHGC 0.36	U_{All}-1.98	$SHGC_{All}$ 0.19	U_{All}-1.98	$SHGC_{All}$ NR
2.1 % - 5.0 %	U-1.98	SHGC 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-1.90	SHGC 0.39	U_{All}-1.90	$SHGC_{All}$ 0.27	U_{All}-1.90	$SHGC_{All}$ NR
2.1 % - 5.0 %	U-1.90	SHGC 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-1.36	SHGC 0.36	U_{All}-1.36	$SHGC_{All}$ 0.19	U_{All}-1.36	$SHGC_{All}$ NR
2.1 % - 5.0 %	U-1.36	SHGC 0.19	U_{All}-1.36	$SHGC_{All}$ 0.19	U_{All}-1.36	$SHGC_{All}$ NR

The following definitions apply: c.i.=continuous insulation; NR = No requirement.

[1] Exception to Section B2.2.1.1 of Appendix 13-B applies.

[2] Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.

[3] Metal framing includes metal framing with or without thermal break. The “all other” subcategory includes operable windows, fixed windows and non-entrance doors.