APPENDIX A

DEFAULT HEAT LOSS COEFFICIENTS

SECTION A101
GENERAL REQUIREMENTS

A101.1 Scope. The following defaults shall apply to Chapter 4 of both the (RE) and (CE) sections of the IECC. This chapter includes tables of seasonal average heat loss coefficients for specified nominal insulation.

A101.2 Description. These coefficients were developed primarily from data and procedures from the ASHRAE *Fundamentals Handbook*.

Coefficients not contained in this chapter may be computed using the procedures listed in this reference if the assumptions in the following sections are used, along with data from the sources referenced above.

A101.3 Air films. Default *R*-values used for air films shall be as follows:

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

A101.4 Compression of insulation. Insulation which is compressed shall be rated in accordance with Table A101.4 or reduction in value may be calculated in accordance with the procedures in the ASHRAE *Fundamentals Handbook*.

A101.5 Building materials. Default *R*-values used for building materials shall be as shown in Table A101.5.

TABLE A101.4
R-VALUE OF FIBERGLASS BATTS COMPRESSED WITHIN VARIOUS DEPTH CAVITIES

Insulation *R*-Values at Standard Thickness

RATED *R*-VALUE		82	71	60	49	38	30	22	21	19	15	13	11
Standard Thickness (inches)		26.0	22.5	19.0	15.5	12	9.5	6.5	5.5	6	3.5	3.5	3.5
Nominal Lumber Sizes (inches)	Actual Depth of Cavity (inches)	Insulation *R*-Values When Installed in a Confined Cavity											
Truss	26.0	82	—	—	—	—	—	—	—	—	—	—	—
Truss	22.5	—	71	—	—	—	—	—	—	—	—	—	—
Truss	19.0	—	—	60	—	—	—	—	—	—	—	—	—
Truss	15.5	—	—	—	49	—	—	—	—	—	—	—	—
Truss	12.0	—	—	—	—	38	—	—	—	—	—	—	—
2 × 12	11.25	—	—	—	—	37	—	—	—	—	—	—	—
2 × 10	9.25	—	—	—	—	32	30	—	—	—	—	—	—
2 × 8	7.25	—	—	—	—	27	26	22	21	19	—	—	—
2 × 6	5.5	—	—	—	—	—	21	20	21	18	—	—	—
2 × 4	3.5	—	—	—	—	—	—	14	—	13	15	13	11
	2.5	—	—	—	—	—	—	—	—	—	—	9.8	—
	1.5	—	—	—	—	—	—	—	—	—	—	6.3	6.0

TABLE A101.5
DEFAULT *R*-VALUES FOR BUILDING MATERIALS

MATERIAL	NOMINAL SIZE (inches)	ACTUAL SIZE (inches)	*R*-VALUE (Heat Capacity[c])
Air cavity (unventilated), between metal studs at 16 inches on center[a]	—	—	0.79
Air cavity (unventilated), all other depths and framing materials[a]	—	—	0.91
Airfilm, exterior surfaces[b]	—	—	0.17
Airfilm, interior horizontal surfaces, heat flow up[b]	—	—	0.61
Airfilm, interior horizontal surfaces, heat flow down[b]	—	—	0.92
Airfilm, interior vertical surfaces[b]	—	—	0.68
Brick at R-0.12/in. (face brick, 75% solid/25% core area, 130 lbs/ft^3)	4	3.5	0.32 (5.9)
Carpet and rubber pad	—	—	1.23
Concrete at R-0.0625/in., heavyweight (144 lbs/ft^3)	—	2	0.13 (HC-4.8)
	—	4	0.25 (HC-9.6)
	—	6	0.38 (HC-14.4)
	—	8	0.50 (HC-19.2)
	—	10	0.63 (HC-24.0)
	—	12	0.75 (HC-28.8)
Concrete masonry units, solid grouted, lightweight (95 lbs/ft^3)	6	—	0.80 (HC-11.4)
Concrete masonry units, solid grouted, normal weight (135 lbs/ft^3)	6	—	0.51 (HC-13.2)
Concrete masonry units, partly grouted, lightweight (95 lbs/ft^3)	6	—	1.33 (HC-6.7)
Concrete masonry units, partly grouted, normal weight (135 lbs/ft^3)	6	—	0.82 (HC-9.0)
Concrete masonry units, solid grouted, lightweight (95 lbs/ft^3)	8	—	1.05 (HC-15.5)
Concrete masonry units, solid grouted, normal weight (135 lbs/ft^3)	8	—	0.69 (HC-17.9)
Concrete masonry units, partly grouted, lightweight (95 lbs/ft^3)	8	—	1.44 (HC-9.6)
Concrete masonry units, partly grouted, normal weight (135 lbs/ft^3)	8	—	0.98 (HC-12.0)
Concrete masonry units, solid grouted, lightweight (95 lbs/ft^3)	10	—	1.30 (HC-19.7)
Concrete masonry units, solid grouted, normal weight (135 lbs/ft^3)	10	—	0.87 (HC-22.6)
Concrete masonry units, partly grouted, lightweight (95 lbs/ft^3)	10	—	1.61 (HC-11.9)
Concrete masonry units, partly grouted, normal weight (135 lbs/ft^3)	10	—	1.11 (HC-14.8)
Concrete masonry units, solid grouted, lightweight (95 lbs/ft^3)	12	—	1.53 (HC-23.9)
Concrete masonry units, solid grouted, normal weight (135 lbs/ft^3)	12	—	1.06 (HC-27.2)
Concrete masonry units, partly grouted, lightweight (95 lbs/ft^3)	12	—	1.75 (HC-14.2)
Concrete masonry units, partly grouted, normal weight (135 lbs/ft^3)	12	—	1.23 (HC-17.5)
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

a. There is no credit for cavities that are open to outside air.
b. Air films do not apply to air cavities within an assembly.
c. For heat capacity for concrete and concrete masonry materials with densities other than the values listed in Table A101.5, see Tables A3.1B and A3.1C in ASHRAE/IESNA Standard 90.1.

SECTION A102
CEILINGS

A102.1 General. Table A102.1 lists heat loss coefficients for the opaque portion of exterior ceilings below vented attics, vaulted ceilings and roof decks in units of Btu/h × ft^2 × °F of ceiling.

They are derived from procedures listed in the ASHRAE *Fundamentals Handbook*. Ceiling *U*-factors are modified for the buffering effect of the attic, assuming an indoor temperature of 65°F and an outdoor temperature of 45°F.

A102.1.1 Metal-framed ceilings. The nominal *R*-values in Table A103.3.6.2: Effective *R*-Values for Metal Framing and Cavity Only may be used for purposes of calculating metal-framed ceiling section *U*-factors in lieu of the ASHRAE zone calculation method as provided in Chapter 27 of the ASHRAE *Fundamentals Handbook*.

Metal building roofs have a different construction and are addressed in Table A102.2.5.

A102.2 Component description. The four types of ceilings are characterized as follows:

A102.2.1 Ceilings below a vented attic. Attic insulation is assumed to be blown-in, loose-fill fiberglass with a K-value of 2.6 h × ft^2 × °F/Btu per inch. Full bag count for specified *R*-value is assumed in all cases. Ceiling dimensions for flat ceiling calculations are 45 by 30 feet, with a gabled roof having a 4/12 pitch. The attic is assumed to vent naturally at the rate of 3 air changes per hour through soffit and ridge vents. A void fraction of 0.002 is assumed for all attics with insulation baffles. Standard-framed, unbaffled attics assume a void fraction of 0.008.

Attic framing is either standard or advanced. Standard framing assumes tapering of insulation depth around the perimeter with resultant decrease in thermal resistance. An increased *R*-value is assumed in the center of the ceiling due to the effect of piling leftover insulation. Advanced framing assumes full and even depth of insulation extending to the outside edge of exterior walls. Advanced framing does not change from the default value. U-factors for flat ceilings below vented attics with standard framing may be modified with the following table:

ROOF PITCH	*U*-FACTOR FOR STANDARD FRAMING	
	R-30	R-38
4/12	0.036	0.031
5/12	0.035	0.030
6/12	0.034	0.029
7/12	0.034	0.029
8/12	0.034	0.028
9/12	0.034	0.028
10/12	0.033	0.028
11/12	0.033	0.027
12/12	0.033	0.027

Vented scissors truss attics assume a ceiling pitch of 2/12 with a roof pitch of either 4/12 or 5/12. Unbaffled standard framed scissors truss attics are assumed to have a void fraction of 0.016.

A102.2.2 Vaulted ceilings. Insulation is assumed to be fiberglass batts installed in roof joist cavities. In the vented case, at least $1^1/_2$ inches (38 mm) between the top of the batts and the underside of the roof sheathing is left open for ventilation in each cavity. A ventilation rate of 3.0 air changes per hour is assumed. In the unvented or dense pack case, the ceiling cavity is assumed to be fully packed with insulation, leaving no space for ventilation.

A102.2.3 Roof decks. Rigid insulation is applied to the top of roof decking with no space left for ventilation. Roofing materials are attached directly on top of the insulation. Framing members are often left exposed on the interior side.

A102.2.4 Metal truss framing. Overall system tested values for the roof/ceiling U_o for metal-framed truss assemblies from approved laboratories shall be used, when such data are acceptable to the building official.

Alternatively, the U_o for roof/ceiling assemblies using metal truss framing may be obtained from Tables A102.2.4(1) through A102.2.4(5).

TABLE A102.1
DEFAULT *U*-FACTORS FOR CEILINGS

	STANDARD FRAME	ADVANCED FRAME
Ceilings Below Vented Attics		
Flat	**Baffled**	
R–19	0.049	0.047
R–30	0.036	0.032
R–38	0.031	0.026
R–49	0.027	0.020
R–60	0.025	0.017
Scissors Truss		
R–30 (4/12 roof pitch)	0.043	0.031
R–38 (4/12 roof pitch)	0.040	0.025
R–49 (4/12 roof pitch)	0.038	0.020
R–30 (5/12 roof pitch)	0.039	0.032
R–38 (5/12 roof pitch)	0.035	0.026
R–49 (5/12 roof pitch)	0.032	0.020
Vaulted Ceilings	**16″ o.c.**	**24″ o.c.**
Vented		
R–19 2 × 10 joist	0.049	0.048
R–30 2 × 12 joist	0.034	0.033
R–38 2 ×1 4 joist	0.027	0.027
Unvented		
R–30 2 × 10 joist	0.034	0.033
R–38 2 × 12 joist	0.029	0.027
R–21 + R–21 2 × 12 joist	0.026	0.025
Roof Deck	**4 × Beams, 48″ o.c.**	
R–12.5 2″ Rigid insulation	0.064	
R–21.9 3.5″ Rigid insulation	0.040	
R–37.5 6″ Rigid insulation	0.025	
R–50 8″ Rigid insulation	0.019	

For SI: 1 inch = 25.4 mm.

TABLE A102.2.4(1)
STEEL TRUSS[a] FRAMED CEILING U_o

CAVITY *R*-VALUE	TRUSS SPAN (feet)												
	12	14	16	18	20	22	24	26	28	30	32	34	36
19	0.1075	0.0991	0.0928	0.0878	0.0839	0.0807	0.0780	0.0757	0.0737	0.0720	0.0706	0.0693	0.0681
30	0.0907	0.0823	0.0760	0.0710	0.0671	0.0638	0.0612	0.0589	0.0569	0.0552	0.0538	0.0525	0.0513
38	0.0844	0.0759	0.0696	0.0647	0.0607	0.0575	0.0548	0.0525	0.0506	0.0489	0.0474	0.0461	0.0449
49	0.0789	0.0704	0.0641	0.0592	0.0552	0.0520	0.0493	0.0470	0.0451	0.0434	0.0419	0.0406	0.0395

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

a. Assembly values based on 24-inch on center truss spacing; 11 Truss member connections penetrating insulation (4 at the eaves, 7 in the interior space); $^1/_2$-inch drywall ceiling; all truss members are 2 × 4 “C” channels with a solid web.

TABLE A102.2.4(2)
STEEL TRUSS[a] FRAMED CEILING U_o WITH R-3 SHEATHING[b]

CAVITY *R*-VALUE	TRUSS SPAN (feet)												
	12	14	16	18	20	22	24	26	28	30	32	34	36
19	0.0809	0.0763	0.0728	0.0701	0.0679	0.0661	0.0647	0.0634	0.0623	0.0614	0.0606	0.0599	0.0592
30	0.0641	0.0595	0.0560	0.0533	0.0511	0.0493	0.0478	0.0466	0.0455	0.0446	0.0438	0.0431	0.0424
38	0.0577	0.0531	0.0496	0.0469	0.0447	0.0430	0.0415	0.0402	0.0392	0.0382	0.0374	0.0367	0.0361
49	0.0523	0.0476	0.0441	0.0414	0.0393	0.0375	0.0360	0.0348	0.0337	0.0328	0.0319	0.0312	0.0306

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

a. Assembly values based on 24-inch on center truss spacing; 11 Truss member connections penetrating insulation (4 at the eaves, 7 in the interior space); $^1/_2$-inch drywall ceiling; all truss members are 2 × 4 "C" channels with a solid web.

b. Ceiling sheathing installed between bottom chord and drywall.

TABLE A102.2.4(3)
STEEL TRUSS[a] FRAMED CEILING U_o WITH R-5 SHEATHING[b]

CAVITY *R*-VALUE	TRUSS SPAN (feet)												
	12	14	16	18	20	22	24	26	28	30	32	34	36
19	0.0732	0.0697	0.0670	0.0649	0.0633	0.0619	0.0608	0.0598	0.0590	0.0583	0.0577	0.0571	0.0567
30	0.0564	0.0529	0.0502	0.0481	0.0465	0.0451	0.0440	0.0430	0.0422	0.0415	0.0409	0.0403	0.0399
38	0.0501	0.0465	0.0438	0.0418	0.0401	0.0388	0.0376	0.0367	0.0359	0.0351	0.0345	0.0340	0.0335
49	0.0446	0.0410	0.0384	0.0363	0.0346	0.0333	0.0322	0.0312	0.0304	0.0297	0.0291	0.0285	0.0280

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

a. Assembly values based on 24-inch on center truss spacing; 11 Truss member connections penetrating insulation (4 at the eaves, 7 in the interior space); $^1/_2$-inch drywall ceiling; all truss members are 2 × 4 "C" channels with a solid web.

b. Ceiling sheathing installed between bottom chord and drywall.

TABLE A102.2.4(4)
STEEL TRUSS[a] FRAMED CEILING U_o WITH R-10 SHEATHING[b]

CAVITY *R*-VALUE	TRUSS SPAN (feet)												
	12	14	16	18	20	22	24	26	28	30	32	34	36
19	0.0626	0.0606	0.0590	0.0578	0.0569	0.0561	0.0555	0.0549	0.0545	0.0541	0.0537	0.0534	0.0531
30	0.0458	0.0437	0.0422	0.0410	0.0401	0.0393	0.0387	0.0381	0.0377	0.0373	0.0369	0.0366	0.0363
38	0.0394	0.0374	0.0359	0.0347	0.0337	0.0330	0.0323	0.0318	0.0313	0.0309	0.0305	0.0302	0.0299
49	0.0339	0.0319	0.0304	0.0292	0.0283	0.0275	0.0268	0.0263	0.0258	0.0254	0.0251	0.0247	0.0245

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

a. Assembly values based on 24-inch on center truss spacing; 11 Truss member connections penetrating insulation (4 at the eaves, 7 in the interior space); $^1/_2$-inch drywall ceiling; all truss members are 2 × 4 "C" channels with a solid web.

b. Ceiling sheathing installed between bottom chord and drywall.

TABLE A102.2.4(5)
STEEL TRUSS[a] FRAMED CEILING U_o WITH R-15 SHEATHING[b]

CAVITY *R*-VALUE	TRUSS SPAN (feet)												
	12	14	16	18	20	22	24	26	28	30	32	34	36
19	0.0561	0.0550	0.0541	0.0535	0.0530	0.0526	0.0522	0.0519	0.0517	0.0515	0.0513	0.0511	0.0509
30	0.0393	0.0382	0.0373	0.0367	0.0362	0.0358	0.0354	0.0351	0.0349	0.0347	0.0345	0.0343	0.0341
38	0.0329	0.0318	0.0310	0.0303	0.0298	0.0294	0.0291	0.0288	0.0285	0.0283	0.0281	0.0279	0.0278
49	0.0274	0.0263	0.0255	0.0249	0.0244	0.0239	0.0236	0.0233	0.0230	0.0228	0.0226	0.0225	0.0223

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

a. Assembly values based on 24-inch on center truss spacing; 11 Truss member connections penetrating insulation (4 at the eaves, 7 in the interior space); $^1/_2$-inch drywall ceiling; all truss members are 2 × 4 "C" channels with a solid web.

b. Ceiling sheathing installed between bottom chord and drywall.

A102.2.5 Metal building roof. Table A102.2.5: The base assembly is a roof where the insulation is compressed when installed beneath metal roof panels attached to the steel structure (purlins). Additional assemblies include continuous insulation, uncompressed and uninterrupted by framing.

U-factors for metal building roofs shall be taken from Table A102.2.5, provided the average purlin spacing is at least 52 inches and the *R*-value of the thermal spacer block is greater than or equal to the thermal spacer block *R*-value indicated in Table A102.2.5 for the assembly. It is not acceptable to use the *U*-factors in Table A102.2.6 if additional insulated sheathing is not continuous.

A102.2.5.1 Single layer. The rated *R*-value of insulation is for insulation installed perpendicular to and draped over purlins and then compressed when the metal roof panels are attached. A minimum R-3 (R-0.5) thermal spacer block between the purlins and the metal roof panels is required, unless compliance is shown by the overall assembly *U*-factor.

TABLE A102.2.5
DEFAULT *U*-FACTORS FOR METAL BUILDING ROOFS

INSULATION SYSTEM	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-6.5	R-13	R-19.5	R-26	R-32.5	R-39
Standing Seam Roofs with Thermal Spacer Blocks[a, b]								
Single Layer	None	1.280	0.137	0.073	0.049	0.037	0.030	0.025
	R-10	0.115	0.066	0.046	0.035	0.029	0.024	0.021
	R-11	0.107	0.063	0.045	0.035	0.028	0.024	0.021
	R-13	0.101	0.061	0.044	0.034	0.028	0.024	0.020
	R-16	0.096	0.059	0.043	0.033	0.027	0.023	0.020
	R-19	0.082	0.053	0.040	0.031	0.026	0.022	0.020
Double Layer	R-10 + R-10	0.088	0.056	0.041	0.032	0.027	0.023	0.020
	R-10 + R-11	0.086	0.055	0.041	0.032	0.027	0.023	0.020
	R-11 + R-11	0.085	0.055	0.040	0.032	0.026	0.023	0.020
	R-10 + R-13	0.084	0.054	0.040	0.032	0.026	0.023	0.020
	R-11 + R-13	0.082	0.053	0.040	0.032	0.026	0.022	0.020
	R-13 + R-13	0.075	0.050	0.038	0.030	0.025	0.022	0.019
	R-10 + R-19	0.074	0.050	0.038	0.030	0.025	0.022	0.019
	R-11 + R-19	0.072	0.049	0.037	0.030	0.025	0.022	0.019
	R-13 + R-19	0.068	0.047	0.036	0.029	0.025	0.021	0.019
	R-16 + R-19	0.065	0.046	0.035	0.029	0.024	0.021	0.018
	R-19 + R-19	0.060	0.043	0.034	0.028	0.023	0.020	0.018
Liner System	R-19 + R-11	0.035						
	R-25 + R-11	0.031						
	R-30 + R-11	0.029						
	R-25 + R-11 + R-11	0.026						
Filled Cavity with Thermal Spacer Blocks[c]								
	R-10 + R-19	0.057	0.042	0.033	0.027	0.023	0.020	0.018
Standing Seam Roofs without Thermal Spacer Blocks								
Liner System	R-19 + R-11	0.040						
Thru-Fastened Roofs without Thermal Spacer Blocks								
Single Layer	R-10	0.184						
	R-11	0.182						
	R-13	0.174						
	R-16	0.157						
	R-19	0.151						
Liner System	R-19 + R-11	0.044						

For SI: 1 inch = 25.4 mm.

(Multiple *R*-values are listed in order from inside to outside)

a. A standing seam roof clip that provides a minimum $1^1/_2$-inch distance between the top of the purlins and the underside of the metal roof panels is required.

b. A minimum R-3 thermal spacer block is required.

c. A minimum R-5 thermal spacer block is required.

A102.2.5.2 Double layer. The first rated *R*-value of insulation is for insulation installed perpendicular to and draped over purlins. The second rated *R*-value of insulation is for unfaced insulation installed above the first layer and parallel to the purlins and then compressed when the metal roof panels are attached. A minimum R-3 (R-0.5) thermal spacer block between the purlins and the metal roof panels is required, unless compliance is shown by the overall assembly *U*-factor.

A102.2.5.3 Continuous insulation. For continuous insulation (e.g., insulation boards or blankets), it is assumed that the insulation is installed below the purlins and is uninterrupted by framing members. Insulation exposed to the conditioned space or semi-heated space shall have a facing, and all insulation seams shall be continuously sealed to provide a continuous air barrier.

A102.2.5.4 Liner system (Ls). A continuous membrane is installed below the purlins and uninterrupted by framing members. Uncompressed, unfaced insulation rests on top of the membrane between the purlins. For multilayer installations, the last rated *R*-value of insulation is for unfaced insulation draped over purlins and then compressed when the metal roof panels are attached. A minimum R-3 (R-0.5) thermal spacer block between the purlins and the metal roof panels is required, unless compliance is shown by the overall assembly *U*-factor.

A102.2.5.5 Filled cavity. The first rated *R*-value of insulation is for faced insulation installed parallel to the purlins. The second rated *R*-value of insulation is for unfaced insulation installed above the first layer, parallel to and between the purlins and compressed when the metal roof panels are attached. The facer of the first layer of insulation is of sufficient width to be continuously sealed to the top flange of the purlins and to accommodate the full thickness of the second layer of insulation. A supporting structure retains the bottom of the first layer at the prescribed depth required for the full thickness of the second layer of insulation being installed above it. A minimum R-5 (R-0.9) thermal spacer block between the purlins and the metal roof panels is required, unless compliance is shown by the overall assembly *U*-factor.

A102.2.6 Roofs with insulation entirely above deck (uninterrupted by framing). Table A102.2.6: The base assembly is continuous insulation over a structural deck. Added insulation is continuous and uninterrupted by framing. For the insulation, the first column lists the *R*-value for continuous insulation with a uniform thickness; the second column lists the comparable area-weighted average *R*-value for continuous insulation provided that the insulation thickness is never less than R-5 (except at roof drains) and that the slope is no greater than $^1/_4$ inch per foot.

SECTION A103
ABOVE-GRADE WALLS

A103.1 General. Tables A103.3.1(1) through A103.3.3(2), A103.3.6(1) through A103.3.6(3), and A103.7.1(1) through A103.3.7.1(3) ((~~The tables in this section~~)) list heat loss coefficients for the opaque portion of above-grade wood stud frame walls, metal stud frame walls and concrete masonry walls (Btu/h × ft^2 × °F). They are derived from procedures listed in the ASHRAE *Fundamentals Handbook*. For intermediate floor slabs which penetrate the insulated wall, use the concrete ((~~wall~~)) peripheral edge *U*-factors in Table ((~~A103.3.7.1(1)~~)) A103.3.7.1(2).

Insulation is assumed to uniformly fill the entire cavity and to be installed as per manufacturer's directions. All walls are assumed to be finished on the inside with $^1/_2$-inch gypsum wallboard, and on the outside with either beveled wood siding over $^1/_2$-inch plywood sheathing or with $^5/_8$-inch T1-11 siding. Insulated sheathing (either interior or exterior) is assumed to cover the entire opaque wall surface, except where modified in accordance with footnote h to Table C402.1.1.

Metal building walls have a different construction and are addressed in Table A103.3.6.3.

A103.2 Framing description. For wood stud frame walls, three framing types are considered and defined as follows:

A103.2.1 Standard. Studs framed on 16 inch centers with double top plate and single bottom plate. Corners use three studs and each opening is framed using two studs. Headers consist of double 2× or single 4× material with an air space left between the header and the exterior sheathing. Interior partition wall/exterior wall intersections use two studs in the exterior wall.

Standard framing weighting factors:

Studs and plates	0.19
Insulated cavity	0.77
Headers	0.04

A103.2.2 Intermediate. Studs framed on 16-inch centers with double top plate and single bottom plate. Corners use two studs or other means of fully insulating corners, and each opening is framed by two studs. Headers consist of double 2× material with R-10 insulation. Interior partition wall/exterior wall intersections are fully insulated in the exterior wall.

Intermediate framing weighting factors:

Studs and plates	0.18
Insulated cavity	0.78
Headers	0.04

A103.2.3 Advanced. Studs framed on 24-inch centers with double top plate and single bottom plate. Corners use two studs or other means of fully insulating corners, and one stud is used to support each header. Headers consist of double 2× material with R-10 insulation. Interior partition wall/exterior wall intersections are fully insulated in the exterior wall.

Advanced framing weighting factors:

Studs and plates	0.13
Insulated cavity	0.83
Headers	0.04

TABLE A102.2.6
ASSEMBLY *U*-FACTORS FOR ROOFS WITH INSULATION ENTIRELY ABOVE DECK
(UNINTERRUPTED BY FRAMING)

RATED *R*-VALUE OF INSULATION ALONE: MINIMUM THROUGHOUT, UNSLOPED	RATED *R*-VALUE OF INSULATION ALONE: AVERAGE (R-5 MINIMUM), SLOPED ($^1/_4$ inch per foot maximum)	OVERALL *U*-FACTOR FOR ENTIRE ASSEMBLY
R-0	Not Allowed	U-1.282
R-1	Not Allowed	U-0.562
R-2	Not Allowed	U-0.360
R-3	Not Allowed	U-0.265
R-4	Not Allowed	U-0.209
R-5	Not Allowed	U-0.173
R-6	R-7	U-0.147
R-7	R-8	U-0.129
R-8	R-9	U-0.114
R-9	R-10	U-0.102
R-10	R-12	U-0.093
R-11	R-13	U-0.085
R-12	R-15	U-0.078
R-13	R-16	U-0.073
R-14	R-18	U-0.068
R-15	R-20	U-0.063
R-16	R-22	U-0.060
R-17	R-23	U-0.056
R-18	R-25	U-0.053
R-19	R-27	U-0.051
R-20	R-29	U-0.048
R-21	R-31	U-0.046
R-22	R-33	U-0.044
R-23	R-35	U-0.042
R-24	R-37	U-0.040
R-25	R-39	U-0.039
R-26	R-41	U-0.037
R-27	R-43	U-0.036
R-28	R-46	U-0.035
R-29	R-48	U-0.034
R-30	R-50	U-0.032
R-35	R-61	U-0.028
R-40	R-73	U-0.025
R-45	R-86	U-0.022
R-50	R-99	U-0.020
R-55	R-112	U-0.018
R-60	R-126	U-0.016

A103.3 Component description. Default coefficients for the following types of walls are listed: Single-stud walls, strap walls, double-stud walls, log walls, stress-skin panels, metal stud walls, and metal building walls.

A103.3.1 Single-stud wall. Tables A103.3.1(1) through A103.3.1(8): Assumes either 2 × 4 or 2 × 6 studs framed on 16- or 24-inch centers. Headers are solid for 2 × 4 walls and double 2× for 2 × 6 walls, with either dead-air or rigid-board insulation in the remaining space.

TABLE A103.3.1(1)
2 × 4 SINGLE WOOD STUD: R-11 BATT

	SIDING MATERIAL/FRAMING TYPE				
	R-VALUE OF FOAM BOARD	Lapped Wood		T1-11	
		STD	ADV	STD	ADV
NOTE: Nominal Batt *R*-value: R-11 at 3.5-inch thickness	0	0.088	0.084	0.094	0.090
	1	0.080	0.077	0.085	0.082
	2	0.074	0.071	0.078	0.075
	3	0.069	0.066	0.072	0.070
	4	0.064	0.062	0.067	0.065
Installed Batt *R*-value: R-11 in 3.5-inch cavity	5	0.060	0.058	0.063	0.061
	6	0.056	0.055	0.059	0.057
	7	0.053	0.052	0.055	0.054
	8	0.051	0.049	0.052	0.051
	9	0.048	0.047	0.050	0.049
	10	0.046	0.045	0.047	0.046
	11	0.044	0.043	0.045	0.044
	12	0.042	0.041	0.043	0.042

TABLE A103.3.1(2)
2 × 4 SINGLE WOOD STUD: R-13 BATT

	SIDING MATERIAL/FRAMING TYPE				
	R-VALUE OF FOAM BOARD	Lapped Wood		T1-11	
		STD	ADV	STD	ADV
NOTE: Nominal Batt *R*-value: R-13 at 3.63-inch thickness	0	0.082	0.078	0.088	0.083
	1	0.075	0.072	0.080	0.076
	2	0.069	0.066	0.073	0.070
	3	0.065	0.062	0.068	0.065
	4	0.060	0.058	0.063	0.061
Installed Batt *R*-value: R-12.7 in 3.5-inch cavity	5	0.057	0.055	0.059	0.057
	6	0.053	0.052	0.056	0.054
	7	0.051	0.049	0.052	0.051
	8	0.048	0.047	0.050	0.048
	9	0.046	0.045	0.047	0.046
	10	0.044	0.043	0.045	0.044
	11	0.042	0.041	0.043	0.042
	12	0.040	0.039	0.041	0.040

TABLE A103.3.1(3)
2 × 4 SINGLE WOOD STUD: R-15 BATT

	SIDING MATERIAL/FRAMING TYPE				
	R-VALUE OF FOAM BOARD	Lapped Wood		T1-11	
		STD	ADV	STD	ADV
NOTE: Nominal Batt *R*-value: R-15 at 3.5-inch thickness Installed Batt *R*-value: R-15 in 3.5-inch cavity	0	0.076	0.071	0.081	0.075
	1	0.069	0.065	0.073	0.069
	2	0.064	0.061	0.068	0.069
	3	0.060	0.057	0.063	0.059
	4	0.056	0.053	0.059	0.056
	5	0.053	0.051	0.055	0.052
	6	0.050	0.048	0.052	0.050
	7	0.047	0.046	0.049	0.047
	8	0.045	0.044	0.047	0.045
	9	0.043	0.042	0.044	0.043
	10	0.041	0.040	0.042	0.041
	11	0.039	0.038	0.041	0.039
	12	0.038	0.037	0.039	0.038

TABLE A103.3.1(4)
2 × 6 SINGLE WOOD STUD: R-19 BATT

	SIDING MATERIAL/FRAMING TYPE						
	R-VALUE OF FOAM BOARD	Lapped Wood			T1-11		
		STD	INT	ADV	STD	INT	ADV
NOTE: Nominal Batt *R*-value: R-19 at 6-inch thickness Installed Batt *R*-value: R-18 in 5.5-inch cavity	0	0.062	0.058	0.055	0.065	0.061	0.058
	1	0.058	0.055	0.052	0.060	0.057	0.055
	2	0.054	0.052	0.050	0.056	0.054	0.051
	3	0.051	0.049	0.047	0.053	0.051	0.049
	4	0.048	0.046	0.045	0.050	0.048	0.046
	5	0.046	0.044	0.043	0.048	0.046	0.044
	6	0.044	0.042	0.041	0.045	0.044	0.042
	7	0.042	0.040	0.039	0.043	0.042	0.040
	8	0.040	0.039	0.038	0.041	0.040	0.039
	9	0.038	0.037	0.035	0.039	0.038	0.037
	10	0.037	0.036	0.035	0.038	0.037	0.036
	11	0.036	0.035	0.034	0.036	0.035	0.035
	12	0.034	0.033	0.033	0.035	0.034	0.033

TABLE A103.3.1(5)
2 × 6 SINGLE WOOD STUD: R-21 BATT

	SIDING MATERIAL/FRAMING TYPE						
	R-VALUE OF FOAM BOARD	Lapped Wood			T1-11		
		STD	INT	ADV	STD	INT	ADV
NOTE:	0	0.057	0.054	0.051	0.060	0.056	0.053
Nominal Batt *R*-value:	1	0.054	0.051	0.048	0.056	0.053	0.050
R-21 at 5.5-inch thickness	2	0.050	0.048	0.045	0.052	0.050	0.047
	3	0.048	0.045	0.043	0.049	0.047	0.045
	4	0.045	0.043	0.041	0.047	0.045	0.043
Installed Batt *R*-value:	5	0.043	0.041	0.040	0.044	0.042	0.041
R-21 in 5.5-inch cavity	6	0.041	0.039	0.038	0.042	0.041	0.039
	7	0.039	0.038	0.036	0.040	0.039	0.037
	8	0.038	0.036	0.035	0.039	0.037	0.036
	9	0.036	0.035	0.034	0.037	0.036	0.035
	10	0.035	0.034	0.033	0.036	0.035	0.033
	11	0.033	0.033	0.032	0.034	0.033	0.032
	12	0.032	0.031	0.031	0.033	0.032	0.031

TABLE A103.3.1(6)
2 × 6 SINGLE WOOD STUD: R-22 BATT

	SIDING MATERIAL/FRAMING TYPE						
	R-VALUE OF FOAM BOARD	Lapped Wood			T1-11		
		STD	INT	ADV	STD	INT	ADV
NOTE:	0	0.059	0.055	0.052	0.062	0.058	0.054
Nominal Batt *R*-value:	1	0.055	0.052	0.049	0.057	0.054	0.051
R-22 at 6.75-inch thickness	2	0.052	0.049	0.047	0.054	0.051	0.048
	3	0.049	0.046	0.044	0.050	0.048	0.046
	4	0.046	0.044	0.042	0.048	0.046	0.044
Installed Batt *R*-value:	5	0.044	0.042	0.041	0.045	0.043	0.042
R-20 in 5.5-inch cavity	6	0.042	0.040	0.039	0.043	0.042	0.040
	7	0.040	0.039	0.037	0.041	0.040	0.038
	8	0.038	0.037	0.036	0.039	0.038	0.037
	9	0.037	0.036	0.035	0.038	0.037	0.035
	10	0.035	0.034	0.033	0.036	0.035	0.034
	11	0.034	0.033	0.032	0.035	0.034	0.033
	12	0.033	0.032	0.031	0.034	0.033	0.032

TABLE A103.3.1(7)
2 × 6 SINGLE WOOD STUD: TWO R-11 BATTS

	SIDING MATERIAL/FRAMING TYPE						
	R-VALUE OF FOAM BOARD	Lapped Wood			T1-11		
		STD	INT	ADV	STD	INT	ADV
NOTE:	0	0.060	0.057	0.054	0.063	0.059	0.056
Nominal Batt *R*-value:	1	0.056	0.053	0.051	0.059	0.056	0.053
R-22 at 7-inch thickness	2	0.053	0.050	0.048	0.055	0.052	0.050
	3	0.050	0.048	0.046	0.052	0.049	0.047
	4	0.047	0.045	0.044	0.049	0.047	0.045
Installed Batt *R*-value:	5	0.045	0.043	0.042	0.046	0.045	0.043
R-18.9 in 5.5-inch cavity	6	0.043	0.041	0.040	0.044	0.043	0.041
	7	0.041	0.040	0.038	0.042	0.041	0.039
	8	0.039	0.038	0.037	0.040	0.039	0.038
	9	0.038	0.037	0.036	0.039	0.038	0.036
	10	0.036	0.035	0.034	0.037	0.036	0.035
	11	0.035	0.034	0.033	0.036	0.035	0.034
	12	0.034	0.033	0.032	0.034	0.034	0.033

TABLE A103.3.1(8)
2 × 8 SINGLE STUD: R-25 BATT

	SIDING MATERIAL/FRAMING TYPE						
	R-VALUE OF FOAM BOARD	Lapped Wood			T1-11		
		STD	INT	ADV	STD	INT	ADV
NOTE:	0	0.051	0.047	0.045	0.053	0.049	0.046
Nominal Batt *R*-value:	1	0.048	0.045	0.043	0.049	0.046	0.044
R-25 at 8-inch thickness	2	0.045	0.043	0.041	0.047	0.044	0.042
	3	0.043	0.041	0.039	0.044	0.042	0.040
	4	0.041	0.039	0.037	0.042	0.040	0.038
Installed Batt *R*-value:	5	0.039	0.037	0.036	0.040	0.038	0.037
R-23.6 in 7.25-inch cavity	6	0.037	0.036	0.035	0.038	0.037	0.036
	7	0.036	0.035	0.033	0.037	0.035	0.034
	8	0.035	0.033	0.032	0.035	0.034	0.033
	9	0.033	0.032	0.031	0.034	0.033	0.032
	10	0.032	0.031	0.030	0.033	0.032	0.031
	11	0.031	0.030	0.029	0.032	0.031	0.030
	12	0.030	0.029	0.028	0.031	0.030	0.029

A103.3.2 Strap wall. Table A103.3.2: Assumes 2 × 6 studs framed on 16- (406 mm) or 24-inch (610 mm) centers. 2 × 3 or 2 × 4 strapping is run horizontally along the interior surface of the wall to provide additional space for insulation.

TABLE A103.3.2
2 × 6: STRAP WALL

	SIDING MATERIAL/FRAME TYPE			
	Lapped Wood		T1-11	
	STD	ADV	STD	ADV
R-19 + R-11 Batts	0.036	0.035	0.038	0.036
R-19 + R-8 Batts	0.041	0.039	0.042	0.040

A103.3.3 Double stud wall. Tables A103.3.3(1) and A103.3.3(2): Assumes an exterior structural wall and a separate interior, nonstructural wall. Insulation is placed in both wall cavities and in the space between the two walls. Stud spacing is assumed to be on 24-inch (610 mm) centers for both walls.

A103.3.4 Log wall. See Table A103.3.4.

A103.3.5 Stress-skin panel. See Table A103.3.5.

A103.3.6 Metal stud walls. The nominal *R*-values in Tables A103.3.6.1(1) through A103.3.6.3 may be used for purposes of calculating metal stud wall section *U*-factors in lieu of the ASHRAE zone calculation method as provided in Chapter 27 of the ASHRAE *Handbook of Fundamentals*.

TABLE A103.3.3(1)
2 × 6 + 2 × 4: DOUBLE WOOD STUD

BATT CONFIGURATION			SIDING MATERIAL/FRAME TYPE			
			Lapped Wood		T1-11	
Exterior	Middle	Interior	STD	ADV	STD	ADV
R-19	—	R-11	0.040	0.037	0.041	0.038
R-19	—	R-19	0.034	0.031	0.035	0.032
R-19	R-8	R-11	0.029	0.028	0.031	0.029
R-19	R-11	R-11	0.027	0.026	0.028	0.027
R-19	R-11	R-19	0.024	0.023	0.025	0.023
R-19	R-19	R-19	0.021	0.020	0.021	0.020

TABLE A103.3.3(2)
2 × 4 + 2 × 4: DOUBLE WOOD STUD

BATT CONFIGURATION			SIDING MATERIAL/FRAME TYPE			
			Lapped Wood		T1-11	
Exterior	Middle	Interior	STD	ADV	STD	ADV
R-11	—	R-11	0.050	0.046	0.052	0.048
R-19	—	R-11	0.039	0.037	0.043	0.039
R-11	R-8	R-11	0.037	0.035	0.036	0.036
R-11	R-11	R-11	0.032	0.031	0.033	0.032
R-13	R-13	R-13	0.029	0.028	0.029	0.028
R-11	R-19	R-11	0.026	0.026	0.027	0.026

TABLE A103.3.4
LOG WALLS

	AVERAGE LOG DIAMETER (inches)	*U*-FACTOR
NOTE: *R*-value of wood: R-1.25 per inch thickness	6	0.148
	8	0.111
	10	0.089
Average wall thickness 90% average log diameter	12	0.074
	14	0.063
	16	0.056

TABLE A103.3.5
STRESS SKIN PANEL

	PANEL THICKESS (inches)	*U*-factor
NOTE: *R*-value of expanded polystyrene: R-3.85 per inch Framing: 6% Spline: 8%	$3^1/_2$	0.071
	$5^1/_2$	0.048
	$7^1/_4$	0.037
	$9^1/_4$	0.030
	$11^1/_4$	0.025
No thermal bridging between interior and exterior splines		

A103.3.6.1 Metal stud wall, overall assembly *U*-factors. Tables A103.3.6.1(1) and A103.6.1(2): Assumes metal studs spaced on 16- or 24-inch centers with insulation installed to fill wall cavities. Continuous rigid board insulation is applied without creating uninsulated voids in the wall assembly.

A103.3.6.2 Metal stud wall, effective *R*-values for metal framing and cavity only. Table A103.3.6.2: These values may be used for the metal-framing/cavity layers in walls with metal studs spaced on 16- or 24-inch centers with insulation installed to fill wall cavities in lieu of using the zone method provided in Chapter 27 of the ASHRAE *Handbook of Fundamentals*.

TABLE A103.3.6.1(1)
OVERALL ASSEMBLY *U*-FACTORS
FOR METAL STUD WALLS WITH CONTINUOUS INSULATION

METAL FRAMING	*R*-VALUE OF CONTINUOUS FOAM BOARD INSULATION	CAVITY INSULATION					
		R-0	R-11	R-13	R-15	R-19	R-21
16″ o.c.	R-0 (none)	0.352	0.132	0.124	0.118	0.109	0.106
	R-1	0.260	0.117	0.111	0.106	0.099	0.096
	R-2	0.207	0.105	0.100	0.096	0.090	0.087
	R-3	0.171	0.095	0.091	0.087	0.082	0.080
	R-4	0.146	0.087	0.083	0.080	0.076	0.074
	R-5	0.128	0.080	0.077	0.074	0.071	0.069
	R-6	0.113	0.074	0.071	0.069	0.066	0.065
	R-7	0.102	0.069	0.066	0.065	0.062	0.061
	R-8	0.092	0.064	0.062	0.061	0.058	0.057
	R-9	0.084	0.060	0.059	0.057	0.055	0.054
	R-10	0.078	0.057	0.055	0.054	0.052	0.051
	R-11	0.072	0.054	0.052	0.051	0.050	0.049
	R-12	0.067	0.051	0.050	0.049	0.047	0.047
	R-13	0.063	0.049	0.048	0.047	0.045	0.045
	R-14	0.059	0.046	0.045	0.045	0.043	0.043
	R-15	0.056	0.044	0.043	0.043	0.041	0.041
	R-20	0.044	0.036	0.036	0.035	0.034	0.034
24″ o.c	R-0 (none)	0.338	0.116	0.108	0.102	0.094	0.090
	R-1	0.253	0.104	0.098	0.092	0.086	0.083
	R-2	0.202	0.094	0.089	0.084	0.079	0.077
	R-3	0.168	0.086	0.082	0.078	0.073	0.071
	R-4	0.144	0.079	0.075	0.072	0.068	0.066
	R-5	0.126	0.073	0.070	0.067	0.064	0.062
	R-6	0.112	0.068	0.066	0.063	0.060	0.059
	R-7	0.100	0.064	0.062	0.059	0.057	0.055
	R-8	0.091	0.060	0.058	0.056	0.054	0.052
	R-9	0.084	0.057	0.055	0.053	0.051	0.050
	R-10	0.077	0.054	0.052	0.050	0.048	0.048
	R-11	0.072	0.051	0.049	0.048	0.046	0.045
	R-12	0.067	0.048	0.047	0.046	0.044	0.043
	R-13	0.063	0.046	0.045	0.044	0.042	0.042
	R-14	0.059	0.044	0.043	0.042	0.041	0.040
	R-15	0.056	0.042	0.041	0.040	0.039	0.038
	R-20	0.044	0.035	0.034	0.034	0.033	0.032

For SI: 1 inch = 25.4 mm.

Continuous foam board insulation: Continuous insulation assumes no thermal bridging of insulation by framing or z-furring through applied foam board. Zone calculation method as provided in the ASHRAE *Fundamentals Handbook* must be used for thermally bridged foam board insulation. Values for attachment of insulation with z-furring are given in Table A103.3.6.1(2).

TABLE A103.3.6.1(2)
OVERALL ASSEMBLY *U*-FACTORS FOR METAL STUD WALLS WITH INSULATION SUPPORTED BY Z-FURRING

METAL FRAMING	*R*-VALUE OF FOAM BOARD INSULATION	Z-FURRING ATTACHMENT	CAVITY INSULATION					
			R-0	R-11	R-13	R-15	R-19	R-21
16″ o.c.	R-0 (none)	Horizontal	0.352	0.132	0.124	0.118	0.109	0.106
	R-5	Horizontal	0.155	0.089	0.086	0.083	0.078	0.077
	R-7.5	Horizontal	0.128	0.080	0.077	0.074	0.071	0.069
	R-10	Horizontal	0.110	0.072	0.070	0.068	0.065	0.064
	R-12.5	Horizontal	0.099	0.068	0.065	0.064	0.061	0.060
	R-15	Horizontal	0.091	0.064	0.062	0.060	0.058	0.057
	R-17.5	Horizontal	0.084	0.060	0.058	0.057	0.055	0.054
	R-20	Horizontal	0.078	0.057	0.056	0.054	0.052	0.052
	R-22.5	Horizontal	0.074	0.055	0.054	0.052	0.051	0.050
	R-25	Horizontal	0.071	0.053	0.052	0.051	0.049	0.048
	R-0 (none)	Vertical	0.352	0.132	0.124	0.118	0.109	0.106
	R-5	Vertical	0.165	0.093	0.089	0.086	0.081	0.079
	R-7.5	Vertical	0.142	0.085	0.081	0.079	0.075	0.073
	R-10	Vertical	0.126	0.079	0.076	0.074	0.070	0.069
	R-12.5	Vertical	0.115	0.074	0.072	0.070	0.066	0.065
	R-15	Vertical	0.107	0.071	0.069	0.067	0.064	0.063
	R-17.5	Vertical	0.100	0.068	0.065	0.064	0.061	0.060
	R-20	Vertical	0.094	0.065	0.063	0.061	0.059	0.058
	R-22.5	Vertical	0.090	0.063	0.061	0.060	0.057	0.056
	R-25	Vertical	0.086	0.061	0.059	0.058	0.056	0.055
24″ o.c	R-0 (none)	Horizontal	0.338	0.116	0.108	0.102	0.094	0.090
	R-5	Horizontal	0.152	0.082	0.078	0.074	0.070	0.068
	R-7.5	Horizontal	0.126	0.074	0.070	0.068	0.064	0.062
	R-10	Horizontal	0.109	0.067	0.065	0.062	0.059	0.058
	R-12.5	Horizontal	0.098	0.063	0.061	0.059	0.056	0.055
	R-15	Horizontal	0.090	0.060	0.058	0.056	0.053	0.052
	R-17.5	Horizontal	0.083	0.057	0.055	0.053	0.051	0.050
	R-20	Horizontal	0.078	0.054	0.052	0.051	0.049	0.048
	R-22.5	Horizontal	0.074	0.052	0.050	0.049	0.047	0.046
	R-25	Horizontal	0.070	0.050	0.049	0.047	0.046	0.045
	R-0 (none)	Vertical	0.338	0.116	0.108	0.102	0.094	0.090
	R-5	Vertical	0.162	0.084	0.080	0.077	0.072	0.070
	R-7.5	Vertical	0.140	0.078	0.074	0.071	0.067	0.065
	R-10	Vertical	0.124	0.073	0.070	0.067	0.063	0.062
	R-12.5	Vertical	0.113	0.069	0.066	0.064	0.061	0.059
	R-15	Vertical	0.106	0.066	0.063	0.061	0.058	0.057
	R-17.5	Vertical	0.098	0.063	0.061	0.059	0.056	0.055
	R-20	Vertical	0.093	0.061	0.059	0.057	0.054	0.053
	R-22.5	Vertical	0.089	0.059	0.057	0.055	0.053	0.051
	R-25	Vertical	0.085	0.057	0.055	0.054	0.051	0.050

For SI: 1 inch = 25.4 mm.

Interpolation in Table A105.3.6.1(2) is not allowed. The value of the foam board insulation must meet or exceed the value listed in the table in order to use the value shown.

A103.3.6.3 Metal building wall. Table A103.3.6.3: A wall whose structure consists of metal spanning panels supported by steel structural members (does not include spandrel glass or metal panels in curtain wall systems). The first nominal *R*-value is for insulation compressed between metal wall panels and the steel structure. For double-layer installations, the second rated *R*-value of insulation is for insulation installed from the inside, covering the girts. For continuous insulation (e.g., insulation boards) it is assumed that the insulation boards are installed on the inside of the girts and uninterrupted by the framing members. Insulation exposed to the conditioned space or semi-heated space shall have a facing, and all insulation seams shall be continuously sealed to provide a continuous air barrier.

A103.3.7 Concrete and masonry walls.

A103.3.7.1 Concrete masonry walls. The nominal *R*-values in Tables A103.3.7.1(1) ((~~and A103.3.7.1(2)~~)) or Table A103.3.7.1(3) may be used for purposes of calculating concrete masonry wall section *U*-factors in lieu of the ASHRAE isothermal planes calculation method as provided in Chapter 27 of the ASHRAE *Handbook of Fundamentals*. The nominal *U*-values in Table A103.3.7.1(2) are permitted to be used for purposes of calculating concrete wall *U*-factors.

A103.3.7.2 Peripheral edges of intermediate concrete floors. See Table A103.3.7.2.

TABLE A103.3.6.2
EFFECTIVE *R*-VALUES FOR METAL FRAMING AND CAVITY ONLY

	CAVITY		INSULATION		
	Nominal Depth (inches)	Actual Depth (inches)	Nominal *R*-Value	Effective *R*-Value	
				16″ o.c.	24″ o.c.
Air Cavity	Any	Any	R-0.91 (air)	0.79	0.91
Wall	4	$3^1/_2$	R-11	5.5	6.6
	4	$3^1/_2$	R-13	6.0	7.2
	4	$3^1/_2$	R-15	6.4	7.8
	6	$5^1/_2$	R-19	7.1	8.6
	6	$5^1/_2$	R-21	7.4	9.0
	8	$7^1/_4$	R-25	7.8	9.6
Roof	—	Insulation is uncompressed	R-11	5.5	6.1
			R-19	7.0	9.1
			R-30	9.3	11.4

For SI: 1 inch = 25.4 mm.

TABLE A103.3.6.3
DEFAULT METAL BUILDING WALL *U*-FACTORS

INSULATION SYSTEM	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)					
			R-6.5	R-13	R-19.5	R-26	R-32.5	R-39
Single Layer of Mineral Fiber								
	None	1.180	0.136	0.072	0.049	0.037	0.030	0.025
	R-10	0.186	0.084	0.054	0.040	0.032	0.026	0.023
	R-11	0.185	0.084	0.054	0.040	0.032	0.026	0.023
	R-13	0.162	0.079	0.052	0.039	0.031	0.026	0.022
	R-16	0.155	0.077	0.051	0.039	0.031	0.026	0.022
	R-19	0.147	0.075	0.050	0.038	0.030	0.025	0.022

TABLE A103.3.7.1(1)
DEFAULT *U*-FACTORS FOR CONCRETE MASONRY (CMU) WALLS

	8-INCH MEDIUM-WEIGHT (115 lb/CF) CMU								
	All Cells Grouted	Grout @ 16-inches OC		Grout @ 32 inches OC		Grout @ 48 inches OC		No Grout (unreinforced)	
Additional Insulation		Cores Empty	Cores Filled	Cores Empty	Cores Filled	Cores Empty	Cores Filled	Cores Empty	Cores Filled
None	0.58	0.52	0.43	0.48	0.35	0.46	0.27	0.43	0.21
R-5 continuous insulation	0.15	0.14	0.14	0.14	0.12	0.14	0.11	0.14	0.10
R-10 continuous insulation	0.09	0.08	0.08	0.08	0.07	0.08	0.07	0.08	0.07
R-15 continuous insulation	0.06	0.06	0.06	0.06	0.05	0.06	0.05	0.06	0.05
R-13 insulation 2x4 wood studs	0.08	0.08	0.08	0.08	0.08	0.08	0.07	0.08	0.07
R-21 insulation 2x6 wood studs	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.06	0.05
R-13 insulation $3^5/_8$" metal studs	0.16	0.15	0.14	0.14	0.13	0.14	0.12	0.14	0.11
R-21 insulation 6" metal studs	0.12	0.11	0.11	0.11	0.10	0.11	0.09	0.11	0.09

	12-INCH MEDIUM-WEIGHT (115 LB/CF) CMU								
	All Cells Grouted	Grout @ 16 inches OC		Grout @ 32 inches OC		Grout @ 48 inches OC		No Grout (unreinforced)	
Additional Insulation	Cores Filled	Cores Empty	Cores Filled	Cores Empty	Cores Filled	Cores Empty	Cores Filled	Cores Empty	Cores Filled
None	0.47	0.44	0.34	0.42	0.28	0.41	0.21	0.40	0.15
R-5 continuous insulation	0.14	0.14	0.12	0.14	0.11	0.13	0.10	0.13	0.09
R-10 continuous insulation	0.08	0.08	0.08	0.08	0.07	0.08	0.07	0.08	0.06
R-15 continuous insulation	0.06	0.06	0.06	0.06	0.05	0.06	0.05	0.06	0.05
R-13 insulation 2x4 wood studs	0.08	0.08	0.08	0.08	0.07	0.08	0.07	0.08	0.06
R-21 insulation 2x6 wood studs	0.06	0.06	0.05	0.06	0.05	0.06	0.05	0.06	0.05
R-13 insulation $3^5/_8$" metal studs	0.15	0.14	0.13	0.14	0.12	0.14	0.11	0.14	0.11
R-21 insulation 6" metal studs	0.11	0.11	0.10	0.11	0.09	0.11	0.08	0.11	0.09

Notes:

1. Interpolation is allowed between 8-inch and 12-inch CMU values (for 10-inch CMU).
2. Interpolation is allowed between 16 and 32-inch grout spacing (for 24-inch spacing).
3. Interpolation is allowed between 32 and 48-inch grout spacing (for 40-inch spacing).
4. "Cores filled" means that all cores not grouted are filled with perlite or vermiculite insulation.
5. Values are based on stud spacing of 16 inches on center.
6. Values are based on horizontal grout spacing of 48 inches OC.
7. Stud wall values include one layer of gypsum board on the interior.

TABLE A103.3.7.1(2) (((1)))
DEFAULT *U*-FACTORS FOR CONCRETE ((AND MASONRY)) WALLS

((8″ Concrete Masonry

WALL DESCRIPTION	CORE TREATMENT			
	Partial Grout with Ungrouted Cores			Solid Grout
	Empty	Loose-fill insulated		
		Perlite	Vermiculite	
Exposed Block, Both Sides	0.40	0.23	0.24	0.43
R-5 Interior Insulation, Wood Furring	0.14	0.11	0.12	0.15
R-6 Interior Insulation, Wood Furring	0.14	0.11	0.11	0.14
R-10.5 Interior Insulation, Wood Furring	0.11	0.09	0.09	0.11
R-8 Interior Insulation, Metal Clips	0.11	0.09	0.09	0.11
R-6 Exterior Insulation	0.12	0.10	0.10	0.12
R-10 Exterior Insulation	0.08	0.07	0.07	0.08
R-9.5 Rigid Polystyrene Integral Insulation, Two Webbed Block	0.11	0.09	0.09	0.12

12″ Concrete Masonry

WALL DESCRIPTION	CORE TREATMENT			
	Partial Grout with Ungrouted Cores			Solid Grout
	Empty	Loose-fill insulated		
		Perlite	Vermiculite	
Exposed Block, Both Sides	0.35	0.17	0.18	0.33
R-5 Interior Insulation, Wood Furring	0.14	0.10	0.10	0.13
R-6 Interior Insulation, Wood Furring	0.13	0.09	0.10	0.13
R-10.5 Interior Insulation, Wood Furring	0.11	0.08	0.08	0.10
R-8 Interior Insulation, Metal Clips	0.10	0.08	0.08	0.09
R-6 Exterior Insulation	0.11	0.09	0.09	0.11
R-10 Exterior Insulation	0.08	0.06	0.06	0.08
R-9.5 Rigid Polystyrene Integral Insulation, Two Webbed Block	0.11	0.08	0.09	0.12

8″ Clay Brick

WALL DESCRIPTION	CORE TREATMENT			
	Partial Grout with Ungrouted Cores			Solid Grout
	Empty	Loose-fill insulated		
		Perlite	Vermiculite	
Exposed Block, Both Sides	0.50	0.31	0.32	0.56
R-5 Interior Insulation, Wood Furring	0.15	0.13	0.13	0.16
R-6 Interior Insulation, Wood Furring	0.15	0.12	0.12	0.15
R-10.5 Interior Insulation, Wood Furring	0.12	0.10	0.10	0.12
R-8 Interior Insulation, Metal Clips	0.11	0.10	0.10	0.11
R-6 Exterior Insulation	0.12	0.11	0.11	0.13
R-10 Exterior Insulation	0.08	0.08	0.08	0.09

(continued)

TABLE A103.3.7.1(2) (~~(1)~~)—continued
DEFAULT *U*-FACTORS FOR CONCRETE AND MASONRY WALLS[a, b, c, d, e]

6″ Concrete Poured or Precast

WALL DESCRIPTION	CORE TREATMENT			
	Partial Grout with Ungrouted Cores			Solid Grout
	Empty	Loose-fill insulated		
		Perlite	Vermiculite	
Exposed Concrete, Both Sides	NA	NA	NA	0.61
R-5 Interior Insulation, Wood Furring	NA	NA	NA	0.16
R-6 Interior Insulation, Wood Furring	NA	NA	NA	0.15
R-10.5 Interior Insulation, Wood Furring	NA	NA	NA	0.12
R-8 Interior Insulation, Metal Clips	NA	NA	NA	0.12
R-6 Exterior Insulation	NA	NA	NA	0.13
R-10 Exterior Insulation	NA	NA	NA	0.09

For SI: 1 inch = 25.4 mm.

((~~a. Grouted cores at 40″ × 48″ on center vertically and horizontally in partial grouted walls.~~

~~b. Interior insulation values include 1/2″ gypsum board on the inner surface.~~

~~c. Furring and stud spacing is 16″ on center. Insulation is assumed to fill furring space and is not compressed.~~

~~d. Intermediate values may be interpolated using this table. Values not contained in this table may be computed using the procedures listed in the ASHRAE *Fundamentals Handbook*.~~

~~e. Concrete Masonry Unit (CMU) assembly *U*-values are based on local test data for Washington State CMU block material using the ASTM C 236—87 steady state thermal conductance test. Tests included an 8″ × 8″ × 16″ CMU with all cells filled with vermiculite (1995) and 8″ × 8″ × 16″ CMU with all cells filled with polymaster foam in place insulation (1996). Refer to ASHRAE Standard 90.1 for additional nationally recognized data on the thermal performance of CMU block walls.~~))

TABLE A103.3.7.1(((~~(2)~~)) 3
DEFAULT *U*-FACTORS FOR CONCRETE AND MASONRY WALLS[a, b, c, d]

FRAMING TYPE AND DEPTH	RATED *R*-VALUE OF INSULATION ALONE	ASSEMBLY *U*-FACTORS FOR SOLID CONCRETE WALLS	ASSEMBLY *U*-FACTORS FOR CONCRETE BLOCK WALLS: SOLID GROUTED	ASSEMBLY *U*-FACTORS FOR CONCRETE BLOCK WALLS: PARTIALLY GROUTED (cores uninsulated except where specified)
Base Wall only				
No Framing	R-0	U-0.740	U-0.580	U-0.480
	Ungrouted Cores Filled with Loose-Fill Insulation	NA	NA	U-0.350
Continuous Wood Framing				
0.75 in. 1.5 in. 2.0 in.	R-3.0 R-6.0 R-10.0	U-0.247 U-0.160 U-0.116	U-0.226 U-0.151 U-0.111	U-0.210 U-0.143 U-0.107
3.5 in. 3.5 in. 3.5 in.	R-11.0 R-13.0 R-15.0	U-0.094 U-0.085 U-0.079	U-0.091 U-0.083 U-0.077	U-0.088 U-0.080 U-0.075
5.5 in. 5.5 in.	R-19.0 R-21.0	U-0.060 U-0.057	U-0.059 U-0.055	U-0.058 U-0.054
Continuous Metal Framing at 24 in. on center horizontally				
1.0 in. 1.0 in. 1.0 in. 1.0 in.	R-0.0 R-3.8 R-5.0 R-6.5	U-0.414 U-0.325 U-0.314 U-0.305	U-0.359 U-0.290 U-0.281 U-0.274	U-0.318 U-0.263 U-0.255 U-0.249
1.5 in.	R-11.0	U-0.267	U-0.243	U-0.223
2.0 in. 2.0 in. 2.0 in.	R-7.6 R-10.0 R-13.0	U-0.230 U-0.219 U-0.210	U-0.212 U-0.202 U-0.195	U-0.197 U-0.188 U-0.182
3.0 in. 3.0 in. 3.0 in.	R-11.4 R-15.0 R-19.0	U-0.178 U-0.168 U-0.161	U-0.167 U-0.158 U-0.152	U-0.157 U-0.149 U-0.144
3.5 in. 3.5 in. 3.5 in.	R-11.0 R-13.0 R-15.0	U-0.168 U-0.161 U-0.155	U-0.158 U-0.152 U-0.147	U-0.149 U-0.144 U-0.140
4.5 in. 4.5 in. 4.5 in.	R-17.1 R-22.5 R-25.2	U-0.133 U-0.124 U-0.122	U-0.126 U-0.119 U-0.116	U-0.121 U-0.114 U-0.112
5.0 in. 5.0 in. 5.0 in. 5.0 in.	R-19.0 R-25.0 R-28.0 R-32.0	U-0.122 U-0.115 U-0.112 U-0.109	U-0.117 U-0.110 U-0.107 U-0.105	U-0.112 U-0.106 U-0.103 U-0.101
5.5 in. 5.5 in. 5.5 in. 5.5 in. 5.5 in.	R-19.0 R-20.9 R-21.0 R-27.5 R-30.8	U-0.118 U-0.114 U-0.113 U-0.106 U-0.104	U-0.113 U-0.109 U-0.109 U-0.102 U-0.100	U-0.109 U-0.105 U-0.105 U-0.099 U-0.096
6.0 in. 6.0 in. 6.0 in.	R-22.8 R-30.0 R-33.6	U-0.106 U-0.099 U-0.096	U-0.102 U-0.095 U-0.093	U-0.098 U-0.092 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

(continued)

TABLE A103.3.7.1(((~~2~~)) 3—continued
DEFAULT *U*-FACTORS FOR CONCRETE AND MASONRY WALLS[a, b, c, d]

FRAMING TYPE AND DEPTH	RATED *R*-VALUE OF INSULATION ALONE	ASSEMBLY *U*-FACTORS FOR SOLID CONCRETE WALLS	ASSEMBLY *U*-FACTORS FOR CONCRETE BLOCK WALLS: SOLID GROUTED	ASSEMBLY *U*-FACTORS FOR CONCRETE BLOCK WALLS: PARTIALLY GROUTED (cores uninsulated except where specified)
1-in. metal clips at 24 in. on center horizontally and 16 in. vertically (see also Table C402.2, footnote f).				
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-7.6	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-9.5	U-0.109	U-0.104	U-0.101
2.5 in.	R-12.5	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
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-0.367	U-0.324
	R-2.0	U-0.298	U-0.269	U-0.245
	R-3.0	U-0.230	U-0.212	U-0.197
	R-4.0	U-0.187	U-0.175	U-0.164
	R-5.0	U-0.157	U-0.149	U-0.141
No Framing	R-6.0	U-0.136	U-0.129	U-0.124
	R-7.0	U-0.120	U-0.115	U-0.110
	R-8.0	U-0.107	U-0.103	U-0.099
	R-9.0	U-0.097	U-0.093	U-0.090
	R-10.0	U-0.088	U-0.085	U-0.083
No Framing	R-11.0	U-0.081	U-0.079	U-0.076
	R-12.0	U-0.075	U-0.073	U-0.071
	R-13.0	U-0.070	U-0.068	U-0.066
	R-14.0	U-0.065	U-0.064	U-0.062
	R-15.0	U-0.061	U-0.060	U-0.059

(continued)

TABLE A103.3.7.1(((2)) 3—continued
DEFAULT *U*-FACTORS FOR CONCRETE AND MASONRY WALLS[a, b, c, d]

FRAMING TYPE AND DEPTH	RATED *R*-VALUE OF INSULATION ALONE	ASSEMBLY *U*-FACTORS FOR SOLID CONCRETE WALLS	ASSEMBLY *U*-FACTORS FOR CONCRETE BLOCK WALLS: SOLID GROUTED	ASSEMBLY *U*-FACTORS FOR CONCRETE BLOCK WALLS: PARTIALLY GROUTED (cores uninsulated except where specified)
Continuous insulation uninterrupted by framing—*continued*				
No Framing	R-16.0	U-0.058	U-0.056	U-0.055
	R-17.0	U-0.054	U-0.053	U-0.052
	R-18.0	U-0.052	U-0.051	U-0.050
	R-19.0	U-0.049	U-0.048	U-0.047
	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
	R-22.0	U-0.043	U-0.042	U-0.042
	R-23.0	U-0.041	U-0.040	U-0.040
	R-24.0	U-0.039	U-0.039	U-0.038
	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
	R-35.0	U-0.028	U-0.027	U-0.027
	R-40.0	U-0.024	U-0.024	U-0.024
	R-45.0	U-0.022	U-0.021	U-0.021
	R-50.0	U-0.019	U-0.019	U-0.019
	R-55.0	U-0.018	U-0.018	U-0.018
	R-60.0	U-0.016	U-0.016	U-0.016
Brick cavity wall with continuous insulation				
No Framing	R-0.0	U-0.337	U-0.299	U-0.270
No Framing	R-3.8	U-0.148	U-0.140	U-0.133
No Framing	R-5.0	U-0.125	U-0.120	U-0.115
No Framing	R-6.5	U-0.106	U-0.102	U-0.098
No Framing	R-7.6	U-0.095	U-0.091	U-0.088
No Framing	R-10.0	U-0.077	U-0.075	U-0.073
No Framing	R-10.5	U-0.079	U-0.077	U-0.075
No Framing	R-11.4	U-0.070	U-0.068	U-0.066
No Framing	R-15.0	U-0.056	U-0.055	U-0.053
No Framing	R-16.5	U-0.054	U-0.053	U-0.052
No Framing	R-19.0	U-0.046	U-0.045	U-0.044
No Framing	R-22.5	U-0.041	U-0.040	U-0.039
No Framing	R-28.5	U-0.033	U-0.032	U-0.032
Continuous insulation uninterrupted by framing with stucco and continuous metal framing at 24 in. on center horizontally				
1.0 in.	R-0.0 + R-19 c.i.	U-0.047	U-0.046	U-0.045
1.0 in.	R-3.8 + R-19 c.i.	U-0.045	U-0.044	U-0.044
1.0 in.	R-5.0 + R-19 c.i.	U-0.045	U-0.044	U-0.043
1.0 in.	R-6.5 + R-19 c.i.	U-0.045	U-0.044	U-0.043
1.5 in.	R-11.0 + R-19 c.i.	U-0.044	U-0.043	U-0.043
2.0 in.	R-7.6 + R-19 c.i.	U-0.043	U-0.042	U-0.041
2.0 in.	R-10.0 + R-19 c.i.	U-0.042	U-0.041	U-0.041
2.0 in.	R-13.0 + R-19 c.i.	U-0.042	U-0.041	U-0.041
3.0 in.	R-11.4 + R-19 c.i.	U-0.041	U-0.040	U-0.039
3.0 in.	R-15.0 + R-19 c.i.	U-0.040	U-0.039	U-0.039
3.0 in.	R-19.0 + R-19 c.i.	U-0.040	U-0.039	U-0.038

(continued)

TABLE A103.3.7.1(((2)) 3—continued
DEFAULT *U*-FACTORS FOR CONCRETE AND MASONRY WALLS[a, b, c, d]

FRAMING TYPE AND DEPTH	RATED *R*-VALUE OF INSULATION ALONE	ASSEMBLY *U*-FACTORS FOR SOLID CONCRETE WALLS	ASSEMBLY *U*-FACTORS FOR CONCRETE BLOCK WALLS: SOLID GROUTED	ASSEMBLY *U*-FACTORS FOR CONCRETE BLOCK WALLS: PARTIALLY GROUTED (cores uninsulated except where specified)
Continuous insulation uninterrupted by framing with stucco and continuous metal framing at 24 in. on center horizontally—*continued*				
3.5 in. 3.5 in.	R-11.0 + R-19 c.i. R-13.0 + R-19 c.i.	U-0.040 U-0.040	U-0.039 U-0.039	U-0.039 U-0.038
5.0 in. 5.0 in. 5.0 in.	R-19.0 + R-19 c.i. R-25.0 + R-19 c.i. R-32.5 + R-19 c.i.	U-0.037 U-0.036 U-0.035	U-0.036 U-0.035 U-0.035	U-0.036 U-0.035 U-0.034
5.5 in. 5.5 in.	R-19.0 + R-19 c.i. R-21.0 + R-19 c.i.	U-0.036 U-0.035	U-0.036 U-0.035	U-0.035 U-0.035

For SI: 1 inch = 25.4 mm.

a. It is acceptable to use the *U*-factors in Table A103.3.7.1(2) for all concrete and masonry walls, provided that the grouting is equal to or less than that specified.
   - For ungrouted walls, use the partially grouted column.
   - For metal studs and z-furring, use the continuous-metal-framing category.
   - For discontinuous metal clips 1 inch square or smaller, use the metal-clip category.
   - For insulation that is attached without any framing members (e.g., glued), use the continuous-insulation uninterrupted-by-framing category. Continuous insulation may be installed on the interior or exterior of masonry walls, or between stand-alone walls in multilayer masonry walls, or on the interior or exterior of the concrete.

b. For Table A103.3.7.1(2), 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 0.5 in. gypsum board. *U*-factors are provided for the following configurations:
   1. Concrete wall: 8-in. normal weight concrete wall with a density of 145 lb/ft^3.
   2. Solid grouted concrete block wall: 8-in. medium weight ASTM C 90 concrete block with a density of 115 lb/ft^3 and solid grouted cores.
   3. Partially grouted concrete block wall: 8-in. medium weight ASTM C 90 concrete block with a density of 115 lb/ft^3 having reinforcing steel every 32 in. vertically and every 48 in. horizontally, with cores grouted in those areas only. Other cores are filled with insulating material only if there is no other insulation.

c. For walls with insulation contained in a framing layer, the *U*-factors in Table A103.3.7.1(2) assume contact (and thermal bridging) between the mass wall and other framing. For wall assemblies with multiple layers where the wood or metal framing layer does not contact the concrete or masonry layer (i.e., walls with an airspace between the stud wall layer and the mass wall layer), it is acceptable to use the appropriate wood or metal frame wall default *U*-factors in Tables A103.3.1 or A103.3.6.1. Note: It is acceptable to use this approach where the insulation extends beyond the framing and is in contact with the mass wall layer (e.g., a nominal 4-inch metal stud containing insulation that is nominally 6 inches thick and therefore extends 2 inches beyond the back of the metal stud).

d. Except for wall assemblies qualifying for Note c, if not taken from Table A103.3.7.1(2), mass wall *U*-factors shall be determined in accordance with ASHRAE 90.1, Appendix A, Section A3.1 and Tables A3.1A to A3.1D, or Section A9.4.

TABLE A103.3.7.2
DEFAULT *U*-FACTORS FOR PERIPHERAL EDGES OF INTERMEDIATE CONCRETE FLOORS[a, b, c]

SLAB EDGE TREATMENT	AVERAGE THICKNESS OF WALL ABOVE AND BELOW			
	6 inches	8 inches	10 inches	12 inches
Exposed Concrete	0.816	0.741	0.678	0.625
R-5 Exterior Insulation	0.161	0.157	0.154	0.152
R-6 Exterior Insulation	0.138	0.136	0.134	0.132
R-7 Exterior Insulation	0.122	0.120	0.118	0.116
R-8 Exterior Insulation	0.108	0.107	0.106	0.104
R-9 Exterior Insulation	0.098	0.097	0.095	0.094
R-10 Exterior Insulation	0.089	0.088	0.087	0.086
R-11 Exterior Insulation	0.082	0.081	0.080	0.079
R-12 Exterior Insulation	0.076	0.075	0.074	0.074
R-13 Exterior Insulation	0.070	0.070	0.069	0.068
R-14 Exterior Insulation	0.066	0.065	0.065	0.064
R-15 Exterior Insulation	0.062	0.061	0.061	0.060

For SI: 1 inch = 25.4 mm.

a. Exterior insulation values listed above are continuous *R*-values on the exterior side of the concrete floor.

b. For conditions with an exterior wall above the peripheral edge of intermediate concrete floor but with no wall below the intermediate concrete floor, this table may be used as long as the code minimum insulation is applied to the floor slab below the concrete floor.

c. Typical conditions where conditioned space building envelope wall thermal insulation values are broken concrete floors include, but are not limited to, the following examples:
   1. Elevator hoistway shafts that serve the conditioned building and pass through unconditioned floors such as parking garage levels;
   2. Stairwell enclosures that serve the conditioned building and pass through unconditioned floors such as parking garage levels;
   3. Walls between interior and exterior building envelope that separate the interior conditioned space from an exterior courtyard or roofdeck;
   4. Walls between interior and exterior building envelope that separate the interior conditioned space from an exterior unconditioned space on parking garage levels.

SECTION A104
BELOW-GRADE WALLS AND SLABS

A104.1 General. Table A104.1 lists heat loss coefficients for below-grade walls and floors.

Coefficients for below-grade walls are given as *U*-factors (Btu/h × ft^2 × °F of wall area). Coefficients for below-grade slabs are listed as *F*-factors (Btu/h × ft × °F per lineal foot of slab perimeter).

Below-grade wall *U*-factors are only valid when used with the accompanying below-grade slab *F*-factor, and vice versa.

A104.2 Component description. All below-grade walls are assumed to be 8-inch (203 mm) concrete. The wall is assumed to extend from the slab upward to the top of the mud sill for the distance specified in Table A104.1, with 6 inches (152 mm) of concrete wall extending above grade.

Interior insulation is assumed to be fiberglass batts placed in the cavity formed by 2 × 4 framing on 24-inch (610 mm) centers with $^1/_2$-inch (12.7 mm) gypsum board as the interior finish material. Exterior insulation is assumed to be applied directly to the exterior of the below-grade wall from the top of the wall to the footing. The exterior case does not assume any interior framing or sheetrock.

In all cases, the entire wall surface is assumed to be insulated to the indicated nominal level with the appropriate framing and insulation application. Coefficients are listed for wall depths of 2 (610 mm), $3^1/_2$ (1067 mm) and 7 feet (2134 mm) below grade. Basements shallower than 2 feet (610 mm) should use on-grade slab coefficients.

Heat-loss calculations for wall areas above-grade should use above-grade wall *U*-factors, beginning at the mudsill.

A104.3 Insulation description. Coefficients are listed for the following four configurations:

1. Uninsulated: No insulation or interior finish.
2. Interior insulation: Interior 2 × 4 insulated wall without a thermal break between concrete wall and slab.
3. Interior insulation with thermal break: Interior 2 × 4 insulated wall with R-5 rigid board providing a thermal break between the concrete wall and the slab.
4. Exterior insulation: Insulation applied directly to the exterior surface of the concrete wall.

TABLE A104.1
DEFAULT WALL *U*-FACTORS AND SLAB *F*-FACTORS FOR BASEMENTS

	BELOW-GRADE WALL *U*-FACTOR	BELOW-GRADE SLAB *F*-FACTOR
2-Foot Depth Below Grade		
Uninsulated	0.350	0.59
R-11 Interior	0.066	0.68
R-11 Interior w/TB	0.070	0.60
R-19 Interior	0.043	0.69
R-19 Interior w/TB	0.045	0.61
R-10 Exterior	0.070	0.60
R-12 Exterior	0.061	0.60
3.5-Foot Depth Below Grade		
Uninsulated	0.278	0.53
R-11 Interior	0.062	0.63
R-11 Interior w/TB	0.064	0.57
R-19 Interior	0.041	0.64
R-19 Interior w/TB	0.042	0.57
R-10 Exterior	0.064	0.57
R-12 Exterior	0.057	0.57
7-Foot Depth Below Grade		
Uninsulated	0.193	0.46
R-11 Interior	0.054	0.56
R-11 Interior w/TB	0.056	0.42
R-19 Interior	0.037	0.57
R-19 Interior w/TB	0.038	0.43
R-10 Exterior	0.056	0.42
R-12 Exterior	0.050	0.42

For SI: 1 foot = 304.8 mm.
TB = Thermal Break

SECTION A105
FLOORS OVER UNCONDITIONED SPACE

A105.1 General. Tables A105.1(1), A105.1(2) and A105.1(3) list heat-loss coefficients for floors over unconditioned spaces in units of Btu/h × ft² × °F.

They are derived from procedures listed in the ASHRAE *Handbook of Fundamentals,* assuming an average outdoor temperature of 45°F (7.2°C), an average indoor temperature of 65°F (18.3°C) and a crawlspace area of 1,350 square feet (125.4 m^2) and 100 feet (30 480 mm) of perimeter. The crawlspace is assumed to be $2^1/_2$ feet (762 mm) high, with 24 inches (610 mm) below grade and 6 inches (152 mm) above grade.

TABLE A105.1(1)
DEFAULT U-FACTORS FOR FLOORS OVER VENTED CRAWLSPACE OR UNHEATED BASEMENT

NOMINAL *R*-VALUE		*U*-FACTOR	
Floor	Perimeter	Post & Beam	Joists
0	0	0.112	0.134
	11	0.100	0.116
	19	0.098	0.114
	30	0.093	0.107
11	0	0.052	0.056
	11	0.048	0.052
19	0	0.038	0.041
	11	0.036	0.038
22	0	0.034	0.037
	11	0.033	0.035
25	0	0.032	0.034
	11	0.031	0.033
30	0	0.028	0.029
	11	0.027	0.028
38	0	0.024	0.025
	11	0.024	0.024

TABLE A105.1(2)
DEFAULT *U*-FACTORS FOR FLOORS OVER HEATED PLENUM CRAWLSPACES

NOMINAL *R*-VALUE PERIMETER	*U*-FACTOR
11	0.085
19	0.075
30	0.069

Note: Crawlspaces used as heated plenums have approximately 30 percent higher heat-loss rate than unvented crawlspaces with the same assumed ACH. Default *U*-factors in Table A105.1(2) reflect this higher rate of heat loss.

TABLE A105.1(3)
DEFAULT *U*-FACTORS FOR EXPOSED FLOORS

U-FACTOR			
Nominal *R*-Value	Concrete	Wood Joist	Metal Joist
R-11	0.077	0.088	0.14
R-15	0.059	0.076	0.12
R-19	0.048	0.062	0.11
R-21	0.043	0.057	0.11
R-25	0.037	0.051	0.10
R-30	0.031	0.040	0.09
R-38	0.025	0.034	0.08

A105.2 Crawlspace description. Four configurations are considered: naturally ventilated crawlspace, mechanically vented crawlspace, heated plenum crawlspace and exposed floor.

A105.2.1 Naturally ventilated crawlspaces. Assumed to have 3.0 air changes per hour, with at least 1.0 square feet of net-free ventilation in the foundation for every 300 square feet (7742 mm^2 per 27.9 m^2) of crawlspace floor area. The crawlspace is not actively heated. Floors over unheated areas, such as garages, may only use those values which have R-0 perimeter insulation.

A105.2.2 Mechanically ventilated crawlspaces. Assumed to have 1.5 air changes per hour, with less than 1.0 square feet of net-free ventilation in the foundation for every 300 square feet (7742 mm^2 per 27.9 m^2) of crawlspace floor area. The crawlspace is not actively heated. Floors over unheated basements may only use those values which have R-0 perimeter insulation.

A105.2.3 Heated plenum crawlspaces. Assumed to have 0.25 air changes per hour, with no foundation vents. Heated supply air from central furnace is blown into a crawlspace and allowed to enter the living space unducted via holes cut into the floor.

A105.2.4 Exposed floors. Assumes no buffer space, and a covering of $^1/_2$-inch T1-11 on the exterior of the cavity exposed to the outside air or rigid insulation below a concrete floor, such as over parking garages.

A105.3 Construction description. Floors are assumed to be either joisted floors framed on 16-inch (406 mm) centers, or post and beam on 4-foot by 8-foot (1219 × 2438 mm) squares. Insulation is assumed to be installed under the subflooring between the joists or beams with no space between the insulation and the subfloor. Insulation is assumed to be uncompressed. Exposed floors also include concrete with continuous rigid insulation assumed.

Perimeter insulation is assumed to extend from the top of the rim joist to the crawlspace floor and then inward along the ground (on top of the ground cover) for at least 24 inches (610 mm).

Floor coverings are assumed to be light carpet with rubber pad.

SECTION A106
ON-GRADE SLAB FLOORS

A106.1 General. Table A106.1 lists heat-loss coefficients for heated on-grade slab floors, in units of Btu/h × °F per lineal foot of perimeter.

A106.2 Component description. All on-grade slab floors are assumed to be 6-inch (152 mm) concrete poured directly onto the earth. The bottom of the slab is assumed to be at grade line. Monolithic and floating slabs are not differentiated.

Soil is assumed to have a conductivity of 0.75 Btu/h × ft^2 × °F. Slabs 2 feet (610 mm) or more below grade should use basement coefficients.

A106.3 Insulation description. Coefficients are provided for the following three configurations:

1. Two-foot (610 mm) [or 4-foot (1219 mm)] vertical: Insulation is applied directly to the slab exterior, extending downward from the top of the slab to a depth of 2 feet (610 mm) [or 4-foot (1219 mm)] below grade.
2. Two-foot (610 mm) [or 4-foot (1219 mm)] horizontal: Insulation is applied directly to the underside of the slab, and run horizontally from the perimeter inward for 2 feet (610 mm) [or 4-foot (1219 mm)]. The slab edge is exposed in this configuration.

   Note: A horizontal installation with a thermal break of at least R-5 at the slab edge should use the vertical-case *F*-factors.
3. Fully insulated slab: Insulation extends from the top of the slab, along the entire perimeter, and completely covers the area under the slab. Thicker perimeter insulation covers the slab edge and extends 2 feet (610 mm) under the slab.

SECTION A107
DEFAULT *U*-FACTORS FOR DOORS

A107.1 Doors without NFRC certification. Doors that do not have NFRC certification shall be assigned the appropriate *U*-factor from Tables A107.1(1) through A107.1(4).

TABLE A106.1
DEFAULT *F*-FACTORS FOR ON-GRADE SLABS

INSULATION TYPE	R-0	R-5	R-10	R-15
	Unheated Slab			
Uninsulated slab	0.73	—	—	—
2 ft Horizontal (No thermal break)	—	0.70	0.70	0.69
4 ft Horizontal (No thermal break)	—	0.67	0.64	0.63
2 ft Vertical	—	0.58	0.54	0.52
4 ft Vertical	—	0.54	0.48	0.45
Fully insulated slab	—	—	0.36	—
	Heated Slab			
Uninsulated slab	0.84	—	—	—
Fully insulated slab	—	0.74	0.55	0.44
R-5 Center (With perimeter insulation)	—	—	0.66	0.62
R-10 Center (With perimeter insulation)	—	—	—	0.51
3 ft Vertical	—	—	0.78	—

For SI: 1 foot = 304.8 mm.

TABLE A107.1(1)
DEFAULT *U*-FACTORS FOR DOORS

DOOR TYPE	NO GLAZED FENESTRATION	SINGLE GLAZING	DOUBLE GLAZING WITH 1/4 IN. AIRSPACE	DOUBLE GLAZING WITH 1/2 IN. AIRSPACE	DOUBLE GLAZING WITH *e* = 0.10, 1/2 IN. ARGON
SWINGING DOORS (Rough opening — 38 in. × 82 in.)					
Slab Doors					
Wood slab in wood frame[a]	0.46	—	—	—	—
6% glazed fenestration (22 in. × 8 in. lite)	—	0.48	0.47	0.46	0.44
25% glazed fenestration (22 in. × 36 in. lite)	—	0.58	0.48	0.46	0.42
45% glazed fenestration (22 in. × 64 in. lite)	—	0.69	0.49	0.46	0.39
More than 50% glazed fenestration	Use Table C303.1.3(1)/R303.1.3(1) as appropriate				
Insulated steel slab with wood edge in wood frame[a]	0.16	—	—	—	—
6% glazed fenestration (22 in. × 8 in. lite)	—	0.21	0.20	0.19	0.18
25% glazed fenestration (22 in. × 36 in. lite)	—	0.39	0.28	0.26	0.23
45% glazed fenestration (22 in. × 64 in. lite)	—	0.58	0.38	0.35	0.26
More than 50% glazed fenestration	Use Table C303.1.3(1)/R303.1.3(1) as appropriate				
Foam-insulated steel slab with metal edge in steel frame[b]	0.37	—	—	—	—
6% glazed fenestration (22 in. × 8 in. lite)	—	0.44	0.42	0.41	0.39
25% glazed fenestration (22 in. × 36 in. lite)	—	0.55	0.50	0.48	0.44
45% glazed fenestration (22 in. × 64 in. lite)	—	0.71	0.59	0.56	0.48
More than 50% glazed fenestration	Use Table C303.1.3(1)/R303.1.3(1) as appropriate				
Cardboard honeycomb slab with metal edge in steel frame[b]	0.61	—	—	—	—
Style and Rail Doors					
Sliding glass doors/French doors	Use Table C303.1.3(1)/R303.1.3(1) as appropriate				
Site-Assembled Style and Rail Doors					
Aluminum in aluminum frame	—	1.32	0.99	0.93	0.79
Aluminum in aluminum frame with thermal break	—	1.13	0.80	0.74	0.63

For SI: 1 inch = 25.4 mm.

a. Thermally broken sill (add 0.03 for non-thermally broken sill).

b. Nonthermally broken sill.

TABLE A107.1(2)
DEFAULT *U*-FACTORS FOR REVOLVING DOORS

REVOLVING DOORS	
Size (W × H)	***U*-Factor**
3-wing	
8 ft. × 7 ft.	0.79
10 ft. × 8 ft.	0.80
4-wing	
7 ft. × 6.5 ft.	0.63
7 ft. × 7.5 ft.	0.64
Open	
82 in. × 84 in.	1.32

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

TABLE A107.1(3)
DEFAULT *U*-FACTORS FOR STEEL EMERGENCY DOORS

DOUBLE-SKIN STEEL EMERGENCY EXIT DOORS		
Core Insulation	**3 ft. × 6 ft. 8 in.**	**6 ft. × 6 ft. 8 in.**
$1^3/_8$ in. thickness		
Honeycomb kraft paper	0.57	0.52
Mineral wool, steel ribs	0.44	0.36
Polyurethane foam	0.34	0.28
$1^3/_4$ in. thickness		
Honeycomb kraft paper	0.57	0.54
Mineral wool, steel ribs	0.41	0.33
Polyurethane foam	0.31	0.26
$1^3/_8$ in. thickness		
Honeycomb kraft paper	0.60	0.55
Mineral wool, steel ribs	0.47	0.39
Polyurethane foam	0.37	0.31
$1^3/_4$ in. thickness		
Honeycomb kraft paper	0.60	0.57
Mineral wool, steel ribs	0.44	0.37
Polyurethane foam	0.34	0.30

For SI: 1 inch = 25.4 mm.

TABLE A107.1(4)
DEFAULT *U*-FACTORS FOR STEEL GARAGE AND HANGAR DOORS

Double-skin Steel Garage And Aircraft Hangar Doors					
INSULATION[e]	**ONE-PIECE TILT-UP[a]**		**SECTIONAL TILT-UP[b]**	**AIRCRAFT HANGAR**	
	8 ft. × 7 ft.	**16 ft. × 7 ft.**	**9 ft. × 7 ft.**	**72 ft. × 12 ft.[c]**	**240 ft. × 50 ft.[d]**
$1^3/_8$-in. thickness					
XPS, steel ribs	0.36	0.33	0.34-0.39	—	—
EPS, steel ribs	0.33	0.31	0.31-0.36		
2-in. thickness					
XPS, steel ribs	0.31	0.28	0.29-0.33	—	—
EPS, steel ribs	0.29	0.26	0.27-0.31		
3-in. thickness					
XPS, steel ribs	0.26	0.23	0.25-0.28	—	—
EPS, steel ribs	0.24	0.21	0.24-0.27		
4-in. thickness					
XPS, steel ribs	0.23	0.20	0.23-0.25	—	—
EPS, steel ribs	0.21	0.19	0.21-0.24		
6-in. thickness					
XPS, steel ribs	0.20	0.16	0.20-0.21	—	—
EPS, steel ribs	0.19	0.15	0.19-0.21		
4-in. thickness					
Noninsulated				1.10	1.23
Expanded polystyrene	—	—	—	0.25	0.16
Mineral wool, steel ribs				0.25	0.16
Extruded polystyrene				0.23	0.15
6-in. thickness					
Noninsulated				1.10	1.23
Expanded polystyrene	—	—	—	0.21	0.13
Mineral wool, steel ribs				0.23	0.13
Extruded polystyrene				0.20	0.12
Uninsulated	1.15	—	—	—	—
All products					

For SI: 1 inch = 25.4 mm.

a. Values are for thermally broken or thermally unbroken doors.

b. Lower values are for thermally broken doors; upper values are for doors with no thermal break.

c. Typical size for a small private airplane (single-engine or twin).

d. Typical hangar door for a midsize commercial jet airliner.

e. XPS is extruded polystyrene, EPS is expanded polystyrene.

SECTION A108
AIR INFILTRATION

A108.1 General. Tables A108.1(1) and A108.1(2) list effective air change rates and heat capacities for heat loss due to infiltration for Single-Family Residential.

The estimated seasonal average infiltration rate in air changes per hour (ACH) is given for standard air leakage control (see Section R402.4 for air leakage requirements for Single-Family Residential). The effective air change rate shall be used in calculations for compliance under either the Component Performance or Systems Analysis approaches.

Heat loss due to infiltration shall be computed using the following equation:

$$Q_{infil} = ACH_{eff} \times HCP$$

where:

Q_{infil} = Heat loss due to air infiltration.

ACH_{eff} = The effective air infiltration rate in Table A108.1(1)

HCP = The Heat Capacity Density Product for the appropriate elevation or climate zone as shown in Table A108.1(2).

TABLE A108.1(1)
ASSUMED EFFECTIVE AIR CHANGES PER HOUR

AIR LEAKAGE CONTROL PACKAGE	AIR CHANGES PER HOUR	
	Natural	Effective
Standard	0.35	0.35

TABLE A108.1(2)
DEFAULT HEAT CAPACITY/DENSITY PRODUCT FOR AIR

ZONE	AVERAGE ELEVATION	HEAT CAPACITY/ DENSITY
1	Mean Sea Level	0.0180 Btu/h × °F
2	2000	0.0168 Btu/h × °F
3	3000	0.0162 Btu/h × °F