# **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 WSEC. 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:

<b>R-Value</b>	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.

#### TABLE A101.4 R-VALUE OF FIBERGLASS BATTS COMPRESSED WITHIN VARIOUS DEPTH CAVITIES Insulation R-Values at Standard Thickness

Rated F	R-Value	82 71 60 49 38 30 22 21 19 15 13							11				
Standard Thic	kness, 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		Iı	nsulation	R-Valu	es Whe	n Insta	lled in	a Con	fined	Cavity	<u>,</u>	
Truss	26.0	82					—					—	—
Truss	22.5		71			—	—	—	—	—		—	—
Truss	19.0	_	_	60			—					_	—
Truss	15.5	_	_		49		—					_	—
Truss	12.0	_	_			38	—					_	—
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	6.0

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

TABLE A101.5 DEFAULT R-VALUES FOR BUILDING MATERIALS

Material	Nominal Size (in.)	Actual Size (in.)	R-Value (Heat Capacity <sup>3</sup> )
Air cavity (unventilated), between metal studs at 16 inches on center <sup>a</sup>	-	-	0.79
Air cavity (unventilated), all other depths and framing materials <sup>1</sup>	-	-	0.91
Airfilm, exterior surfaces <sup>2</sup>	-	-	0.17

Material	Nominal Size (in.)	Actual Size (in.)	R-Value (Heat Capacity <sup>3</sup> )
Airfilm, interior horizontal surfaces, heat flow up <sup>2</sup>	-	-	0.61
Airfilm, interior horizontal surfaces, heat flow down <sup>2</sup>	-	-	0.92
Airfilm, interior vertical surfaces <sup>2</sup>	-	-	0.68
Brick at R-0.12/in. (face brick, 75% solid/25% core area, 130 lbs/ft <sup>3</sup> )	4	3.5	0.32 (5.9)
Carpet and rubber pad	-	-	1.23
Concrete at R-0.0625/in., heavyweight (144 lbs/ft <sup>3</sup> )	- - - -	2 4 6 8 10	0.13 (HC-4.8) 0.25 (HC-9.6) 0.38 (HC-14.4) 0.50 (HC-19.2) 0.63 (HC-24.0)
	-	12	0.75 (HC-28.8)
Concrete masonry units, solid grouted, lightweight (95 lbs/ft <sup>3</sup> )	6	-	0.80 (HC-11.4)
Concrete masonry units, solid grouted, normal weight (135 lbs/ft <sup>3</sup> )	6	-	0.51 (HC-13.2)
Concrete masonry units, partly grouted, lightweight (95 lbs/ft <sup>3</sup> )	6	-	1.33 (HC-6.7)
Concrete masonry units, partly grouted, normal weight (135 lbs/ft <sup>3</sup> )	6	-	0.82 (HC-9.0)
Concrete masonry units, solid grouted, lightweight (95 lbs/ft <sup>3</sup> )	8	-	1.05 (HC-15.5)
Concrete masonry units, solid grouted, normal weight $(135 \text{ lbs/ft}^3)$	8	-	0.69 (HC-17.9)
Concrete masonry units, partly grouted, lightweight (95 lbs/ft <sup>3</sup> )	8	-	1.44 (HC-9.6)
Concrete masonry units, partly grouted, normal weight (135 lbs/ft <sup>3</sup> )	8	-	0.98 (HC-12.0)
Concrete masonry units, solid grouted, lightweight (95 lbs/ft <sup>3</sup> )	10	-	1.30 (HC-19.7)
Concrete masonry units, solid grouted, normal weight $(135 \text{ lbs/ft}^3)$	10	-	0.87 (HC-22.6)
Concrete masonry units, partly grouted, lightweight (95 lbs/ft <sup>3</sup> )	10	-	1.61 (HC-11.9)
Concrete masonry units, partly grouted, normal weight (135 lbs/ft <sup>3</sup> )	10	-	1.11 (HC-14.8)
Concrete masonry units, solid grouted, lightweight (95 lbs/ft <sup>3</sup> )	12	-	1.53 (HC-23.9)
Concrete masonry units, solid grouted, normal weight (135 lbs/ft <sup>3</sup> )	12	_	1.06 (HC-27.2)
Concrete masonry units, partly grouted, lightweight (95 lbs/ft <sup>3</sup> )	12	_	1.75 (HC-14.2)
Concrete masonry units, partly grouted, normal weight (135 lbs/ft <sup>3</sup> )	12	-	1.23 (HC-17.5)

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# TABLE A101.5—continued DEFAULT R-VALUES FOR BUILDING MATERIALS

0.94

0.75

Flooring, wood subfloor

Material	Nominal Size (in.)	Actual Size (in.)	R-Value (Heat Capacity <sup>3</sup> )
Gypsum board	-	0.5 0.625	0.45 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

#### TABLE A101.5—continued DEFAULT R-VALUES FOR BUILDING MATERIALS

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  $\times$  ft<sup>2</sup>  $\times$  °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 Kvalue of 2.6 h × ft<sup>2</sup> •× °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:

Boof Bitch	U-factor for Sta	andard Framing				
ROOI FIICH	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 1.5 inches 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  $U_0$  for metal framed truss assemblies from approved laboratories shall be used, when such data is acceptable to the building official.

Alternatively, the  $U_0$  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	Ba	ffled
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

#### TABLE A102.1—continued DEFAULT U-FACTORS FOR CEILINGS

	Standard	Advanced					
	Frame	Frame					
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 2x10 joist	0.049	0.048					
R-30 2x12 joist	0.034	0.033					
R-38 2x14 joist	0.027	0.027					
Unvented							
R-30 2x10 joist	0.034	0.033					
R-38 2x12 joist	0.029	0.027					
R-21 + R-21 2x12 joist	0.026	0.025					
Roof Deck	4x Beams	s, 48" O.C.					
R-12.5 2" Rigid insulation	0.0	064					
R-21.9 3.5" Rigid insulation	0.0	040					
R-37.5 6" Rigid insulation	R-37.5 6" Rigid insulation 0.025						
R-50 8" Rigid insulation	0.0	019					

# TABLE A102.2.4(1)STEEL TRUSS<sup>a</sup> FRAMED CEILING UO

Cavity						Tru	iss Span						
R-value	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

# TABLE A102.2.4(2) STEEL TRUSS<sup>a</sup> FRAMED CEILING U<sub>O</sub> WITH R-3 SHEATHING

Cavity	Truss Span (ft)												
R-value	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

# TABLE A102.2.4(3)STEEL TRUSS<sup>a</sup> FRAMED CEILING UO WITH R-5 SHEATHING

Cavity		Truss Span (ft)													
R-value	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		

## TABLE A102.2.4(4) STEEL TRUSS<sup>a</sup> FRAMED CEILING U<sub>O</sub> WITH R-10 SHEATHING

Cavity		Truss Span (ft)												
R-value	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	

# TABLE A102.2.4(5) STEEL TRUSS<sup>a</sup> FRAMED CEILING U<sub>O</sub> WITH R-15 SHEATHING

Cavity		Truss Span (ft)												
R-value	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	

#### Footnotes for Tables A102.2.4(1) through A102.2.4(5)

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 2x4 "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 A107.2.5 for the assembly. It is not acceptable to use the U-factors in Tables A102.2.6(1), A102.2.6(2) or A102.2.6(3) 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.

**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(1) through A102.2.6(3): The base assembly is continuous insulation over a structural deck. These tables indicate effective U-factors for tapered roof insulation, sloped from a maximum R-value (Rmax) at the peak of the slope to a minimum R-value (Rmin) at the low point of the slope. The rows of the tables represent the rated R-value of the insulation at the minimum conditions (except at roof drains) and the columns of the table represent the rated R-value of the insulation at the maximum conditions. The slope of the tapered insulation shall be no greater than 1/4 inch per foot.

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							
		Roof Assembly	R-6.5	R-13	R-19.5	R-26	R-32.5	R-39		
Standing Seam	Roofs with Thermal Spacer	Blocks <sup>a,b</sup>								
	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		
Single Lever	R-11	0.107	0.063	0.045	0.035	0.028	0.024	0.021		
Single Layer	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		
	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		
Double Layer	R-13 .+ R-13	0.075	0.050	0.038	0.030	0.025	0.022	0.019		
	R10.+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		
	R-19 .+ R-11	0.035								
Linon System	R-25 .+ R-11	0.031								
Liner System	R-30 .+ R-11	0.029								
	R-25 .+ R-11 .+ R-11	0.026								

## TABLE A102.2.5—continued DEFAULT U-FACTORS FOR METAL BUILDING ROOFS

Insulation System	Rated R-Value of Insulation	Overall U-Factor for Entire Base	Overall U-Factor for Assembly of Base Roof Plus Continuous Insulation (uninterrupted by framing) Rated R-Value of Continuous Insulation							
		Roof Assembly	R-6.5	R-13	R-19.5	R-26	R-32.5	R-39		
Filled Cavity with	n Thermal Spacer Blocks <sup>c</sup>									
	R-10 .+ R-19	0.057	0.042	0.033	0.027	0.023	0.020	0.018		
Standing Seam F	Roofs without Thermal Spa	cer Blocks								
Liner System	R-19 .+ R-11	0.040								
Thru-Fastened R	oofs without Thermal Space	cer Blocks								
	R-10	0.184								
	R-11	0.182								
Single Layer	R-13	0.174								
	R-16	0.157								
	R-19	0.151								
Liner System	R-19 .+ R-11	0.044								

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

a. A standing seam roof clip that provides a minimum 1.5 in. 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.

# TABLE A102.2.6(1)ASSEMBLY U-FACTORS FOR ROOFS WITH TAPERED INSULATION ENTIRELY ABOVE DECK<br/>SINGLE SLOPE RECTANGULAR TO ONE-SIDE,d,f,g,h,i<br/>(UNINTERRUPTED BY FRAMING)

				Ra	ted R-V	alue of	Insulatio	natMa	xim um (	Conditio	n (Rmax	(1)		
		1	5	10	15	20	25	30	35	40	45	50	55	60
E	1	0.562	0.306	0.213	0.168	0.140	0.121	0.107	0.097	0.088	0.081	0.075	0.070	0.066
Ē	5	-	0.173	0.125	0.101	0.086	0.076	0.068	0.062	0.057	0.053	0.049	0.046	0.044
μ.	10	-	E.	0.093	0.076	0.066	0.058	0.053	0.048	0.045	0.042	0.039	0.037	0.035
E.	15	1221	<u>19</u>		0.063	0.055	0.049	0.045	0.041	0.038	0.036	0.034	0.032	0.030
5.5	20	-	-	-	-	0.048	0.043	0.039	0.036	0.034	0.032	0.030	0.028	0.027
ibeli 🖫	25		1		L.		0.039	0.035	0.033	0.031	0.029	0.027	0.026	0.025
nst on	30					-	-	0.032	0.030	0.028	0.026	0.025	0.024	0.023
A iii	35					-	-	H 1	0.028	0.026	0.025	0.023	0.022	0.021
e E	40					-	-	-	<b>1</b> -1	0.025	0.023	0.022	0.021	0.020
-va	45			+		-	-	-	-	-	0.022	0.021	0.020	0.019
ЧP	50					<u>.</u>	14	-	520		12	0.020	0.019	0.018
late	55	-	-	-	-	-	-	-	-	-	-	-	0.018	0.017
<u>L</u>	60		-	1-1	-			-	1-3	-	-	1 (2 <del>.</del> - )	-	0.016

				Ra	ted R-V	alue of I	Ins ulatio	n at M a	xim um C	onditio	n (Rmax	<sup>2</sup> )		
		1	5	10	15	20	25	30	35	40	45	50	55	60
E	1	0.562	0.242	0.146	0.106	0.083	0.068	0.058	0.051	0.045	0.040	0.036	0.033	0.031
Ē	5		0.173	0.112	0.084	0.068	0.057	0.049	0.044	0.039	0.035	0.032	0.030	0.028
μ.	10	-	-	0.093	0.071	0.059	0.050	0.044	0.039	0.035	0.032	0.029	0.027	0.025
E.C.	15		-	-	0.063	0.053	0.045	0.040	0.035	0.032	0.029	0.027	0.025	0.023
E je	20					0.048	0.042	0.037	0.033	0.030	0.027	0.025	0.024	0.022
ilati (B	25		1			-	0.039	0.034	0.031	0.028	0.026	0.024	0.022	0.021
ns(	30			/	d	1		0.032	0.029	0.027	0.025	0.023	0.021	0.020
diti	35					-	-	-	0.028	0.026	0.024	0.022	0.021	0.019
e le	40		→ >	< ←	_   _	15		1.07	-	0.025	0.023	0.021	0.020	0.019
-va	45		/.			-	-	-	- 1		0.022	0.020	0.019	0.018
ЧP	50		/ T					-	- 1	-	-	0.020	0.018	0.017
late	55					1.12		-	21	- <b>-</b>	-		0.018	0.017
H	60					-	-	-	-	-	2		4	0.016

# TABLE A102.2.6(2)ASSEMBLY U-FACTORS FOR ROOFS WITH TAPERED INSULATION ENTIRELY ABOVE DECK<br/>SLOPED TRIANGLE (ROOF WITH CENTER DRAIN)<sup>e,f,g,h,i</sup><br/>(UNINTERRUPTED BY FRAMING)

# TABLE A102.2.6(3)ASSEMBLY U-FACTORS FOR ROOFS WITH TAPERED INSULATION ENTIRELY ABOVE DECK<br/>SLOPED TRIANGLE (ROOF WITH PERIMETER DRAINS)<sup>e,f,g,h,i</sup><br/>(UNINTERRUPTED BY FRAMING)

				Ra	ted R-V	alue of I	ns ulatio	n at M a	xim um C	onditio	n (Rmax	<sup>3</sup> )		
		1	5	10	15	20	25	30	35	40	45	50	55	60
E	1	0.562	0.363	0.273	0.224	0.193	0.170	0.153	0.139	0.128	0.119	0.111	0.105	0.099
Ē	5	-	0.173	0.138	0.118	0.104	0.094	0.086	0.079	0.074	0.070	0.066	0.062	0.059
	10	-	-	0.093	0.081	0.073	0.067	0.062	0.058	0.054	0.051	0.049	0.046	0.044
7	15	-	-	-	0.063	0.058	0.053	0.050	0.047	0.044	0.042	0.040	0.038	0.037
5 j	20					0.048	0.045	0.042	0.040	0.037	0.036	0.034	0.033	0.032
ja E	25			<b>†</b>		-	0.039	0.037	0.035	0.033	0.031	0.030	0.029	0.028
nst D	30					-	-	0.032	0.031	0.029	0.028	0.027	0.026	0.025
Ê Ê	35			1		-	-	-	0.028	0.027	0.026	0.025	0.024	0.023
≞ 5	40	-	-	$\times$ –	-	-	-	-	-	0.025	0.024	0.023	0.022	0.021
e )	45		/			-	-	-	-	-	0.022	0.021	0.020	0.020
ЧР ЧР	50		/			-	-	-	-	-	-	0.020	0.019	0.019
tate	55			÷		-	-	-	-	-	-	-	0.018	0.017
E	60					-	-	-	-	-	-	-	-	0.016

Footnotes to Tables A102.2.6.1, A102.2.6.2, and A102.2.6.3:

a. R<sub>max</sub> and R<sub>min</sub> are determined along the linearly tapered cross section for the respective minimum and maximum thickness values for the roof section being analyzed. For triangular roof sections

b. R<sub>max</sub> refers to the insulation value along the long edge of the triangle and R<sub>min</sub> to the insulation at the point of the triangle which assumes that the insulation slopes to the center.

c. R<sub>max</sub> refers to the insulation value at the point of the triangle and R<sub>min</sub> to the insulation along the long edge of the triangle which assumes that the insulation slopes to the perimeter.

d. Effective U-factor for rectangular tapered insulation is calculated as follows:

$$R_{eff} = \frac{R_{\max} - R_{\min}}{\ln\left[\frac{R_{\max}}{R_{\min}}\right]}$$

e. Effective U-factor for triangular tapered insulation is calculated as follows:

$$R_{eff} = \left[\frac{2}{R_{\max} - R_{\min}} \left[1 + \frac{R_{\min}}{R_{\max} - R_{\min}} \ln\left(\frac{R_{\min}}{R_{\max}}\right)\right]\right]^{-1}$$

f. Assembly U-factors include an exterior air film (R=0.17) and an interior air film, horizontal with heat flow up (R=0.61).

g. For effective U-factors of roof assemblies with different Rmax or Rmin values not listed in the tables interpolation is allowed.

h. This table shall only be applied to tapered insulation that is tapered along only one axis.

i. In areas of differing insulation slopes/configurations, individual U-values shall be calculated and an area weighted U-value calculation shall be used to determine the effective value of the roof.

#### SECTION A103 ABOVE GRADE WALLS

**A103.1 General.** 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 x ft<sup>2</sup> x °F) respectively. 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 A103.3.7.2.

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 g to Table C402.1.3.

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 2x or single 4x 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 2x material with R-10 insulation. Interior partition

wall/exterior wall intersections are fully insulated in the exterior wall.

	Intermediate	framing	weighting	factors:
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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 2x 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

**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 x 4 or 2 x 6 studs framed on 16 or 24 inch centers. Headers are solid for 2 x 4 walls and double 2x for 2 x 6 walls, with either dead-air or rigid-board insulation in the remaining space.

	Siding Material/Framing Type								
	R-value of	Lapped	l Wood	T1-11					
	Foam Board	STD	ADV	STD	ADV				
	0	0.088	0.084	0.094	0.090				
	1	0.080	0.077	0.085	0.082				
<b>NOTE:</b> Nominal Batt R-value: R-11 at 3.5 inch thickness	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				
	5	0.060	0.058	0.063	0.061				
Installed Batt R-value:	6	0.056	0.055	0.059	0.057				
R-11 in 3.5 inch cavity	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(1) 2 x 4 Single Wood Stud: R-11 Batt

# TABLE A103.3.1(2) 2 x 4 Single Wood Stud: R-13 Batt

	Siding Material/Framing Type								
	R-value of	Lapped	l Wood	T1·	·11				
	Foam Board	STD	ADV	STD	ADV				
	0	0.082	0.078	0.088	0.083				
	1	0.075	0.072	0.080	0.076				
<b>NOTE:</b> Nominal Batt R-value: R-13 at 3.63 inch thickness	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				
	5	0.057	0.055	0.059	0.057				
Installed Batt R-value:	6	0.053	0.052	0.056	0.054				
R-12.7 in 3.5 inch cavity	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				

	Siding Material/Framing Type						
	R-value of	Lapped	d Wood	T1-11			
	Foam Board	STD	ADV	STD	ADV		
	0	0.076	0.071	0.081	0.075		
<b>NOTE:</b> Nominal Batt R-value: R-15 at 3.5 inch thickness	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		
Installed Batt R-value:	6	0.050	0.048	0.052	0.050		
R-15 in 3.5 inch cavity	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(3) 2 x 4 Single Wood Stud: R-15 Batt

# TABLE A103.3.1(4) 2 x 6 Single Wood Stud: R-19 Batt

	Siding Material/Framing Type						
	R-value of	La	pped Wo	od		T1-11	
	Foam Board	STD	INT	ADV	STD	INT	ADV
	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
NOTE:	2	0.054	0.052	0.050	0.056	0.054	0.051
Nominal Batt R-value:	3	0.051	0.049	0.047	0.053	0.051	0.049
R-19 at 6 inch thickness	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
Installed Batt R-value:	6	0.044	0.042	0.041	0.045	0.044	0.042
R-18 in 5.5 inch cavity	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

	Siding Material/Framing Type						
	R-value of	La	pped Wo	od		T1-11	
	Foam Board	STD	INT	ADV	STD	INT	ADV
	0	0.057	0.054	0.051	0.060	0.056	0.053
	1	0.054	0.051	0.048	0.056	0.053	0.050
<b>NOTE:</b> Nominal Batt R-value: 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
	5	0.043	0.041	0.040	0.044	0.042	0.041
Installed Batt R-value:	6	0.041	0.039	0.038	0.042	0.041	0.039
R-21 in 5.5 inch cavity	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(5) 2 x 6 Single Wood Stud: R-21 Batt

# TABLE A103.3.1(6) 2 x 6 Single Wood Stud: R-22 Batt

	Siding Material/Framing Type						
	R-value of	La	pped Wo	od		T1-11	
	Foam Board	STD	INT	ADV	STD	INT	ADV
	0	0.059	0.055	0.052	0.062	0.058	0.054
<b>NOTE:</b> Nominal Batt R-value: R-22 at 6.75 inch thickness	1	0.055	0.052	0.049	0.057	0.054	0.051
	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
	5	0.044	0.042	0.041	0.045	0.043	0.042
Installed Batt R-value:	6	0.042	0.040	0.039	0.043	0.042	0.040
R-20 in 5.5 inch cavity	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

		Siding Material/Framing Type						
	R-value of	La	pped Wo	od		T1-11		
	Foam Board	STD	INT	ADV	STD	INT	ADV	
	0	0.060	0.057	0.054	0.063	0.059	0.056	
	1	0.056	0.053	0.051	0.059	0.056	0.053	
NOTE:	2	0.053	0.050	0.048	0.055	0.052	0.050	
Nominal Batt R-value:	3	0.050	0.048	0.046	0.052	0.049	0.047	
R-22 at 7 inch thickness	4	0.047	0.045	0.044	0.049	0.047	0.045	
	5	0.045	0.043	0.042	0.046	0.045	0.043	
Installed Batt R-value:	6	0.043	0.041	0.040	0.044	0.043	0.041	
R-18.9 in 5.5 inch cavity	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(7) 2 x 6 Single Wood Stud: Two R-11 Batts

## TABLE A103.3.1(8) 2 x 8 Single Stud: R-25 Batt

	Siding Material/Framing Type						
	R-value of	La	oped Wo	od		T1-11	
	Foam Board	STD	INT	ADV	STD	INT	ADV
	0	0.051	0.047	0.045	0.053	0.049	0.046
<b>NOTE:</b> Nominal Batt R-value: R-25 at 8 inch thickness	1	0.048	0.045	0.043	0.049	0.046	0.044
	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
	5	0.039	0.037	0.036	0.040	0.038	0.037
Installed Batt R-value:	6	0.037	0.036	0.035	0.038	0.037	0.036
R-23.6 in 7.25 inch cavity	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  $2 \ge 6$  studs framed on 16 or 24 inch centers.  $2 \ge 3$  or  $2 \ge 4$  strapping is run horizontally along the interior surface of the wall to provide additional space for insulation.

**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 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. TABLE A103.3.2 2 X 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		

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

Batt Configuration			Siding Material/Frame Type					
Datt Configuration		Lapped	d Wood	T1-	T1-11			
Exterior	Middle	Interior	STD	ADV	STD	ADV		
R-19		<b>R-11</b>	0.040	0.037	0.041	0.038		
R-19		R-19	0.034	0.031	0.035	0.032		
R-19	R-8	<b>R-11</b>	0.029	0.028	0.031	0.029		
R-19	R-11	<b>R-11</b>	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 X 4 + 2 X 4: DOUBLE WOOD STUD

Batt Configuration			Siding Material/Frame Type				
			Lapped	d Wood	T1-11		
Exterior	Middle	Interior	STD	ADV	STD	ADV	
R-11		<b>R-11</b>	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-19	<b>R-11</b>	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	<b>R</b> -11	0.026	0.026	0.027	0.026	

## TABLE A103.3.4 LOG WALLS

	Average Log Diameter, Inches	U-factor
	6	0.148
NOTE: R-value of wood: R-1.25 per inch thickness Average wall thickness	8	0.111
	10	0.089
	12	0.074
	14	0.063
90% average log diameter	16	0.056

#### TABLE A103.3.5 STRESS SKIN PANEL

	Panel Thickness, Inches	U-factor				
NOTE:	3 1/2	0.071				
R-value of expanded polystyrene: R-3.85 per inch	5 1/2	0.048				
	7 1/4	0.037				
Framing: 6%	9 1/4	0.030				
Spline: 8%	11 1/4	0.025				
No thermal bridging between interior and exterior splines						

**A103.3.6 Metal stud walls.** The nominal R-values in Tables A103.3.6.1 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 Fundamentals Handbook.

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 25 of the ASHRAE Fundamentals Handbook.

**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.

Metal	<b>R-Value of Continuous</b>	Cavity Insulation						
Framing	Foam Board 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	

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

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).

Metal	R-value of Foam	Z-furring	Cavity Insulation				1	
Framing	<b>Board Insulation</b>	Attachment	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	0.09
	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	0.09
	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

# TABLE A105.3.6.1(2) OVERALL ASSEMBLY U-FACTORS FOR METAL STUD WALLS WITH INSULATION SUPPORTED BY Z-FURRING

Values may in Table A105.3.6.1(2) may not interpolated between. The value of the foam board insulation must meet exceed the value listed in the table in order to use the value shown.

Cavity			Insulation			
	Nominal	Actual Depth,	Nominal	Effective R-Value		
	Depth, Inches	Inches	R-Value	16" O.C.	24" O.C.	
Air Cavity	Any	Any	R-0.91 (air)	0.79	0.91	
	4	3-1/2	R-11	5.5	6.6	
14/-11	4	3-1/2	R-13	6.0	7.2	
	4	3-1/2	R-15	6.4	7.8	
vvali	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	
			<b>R-11</b>	5.5	6.1	
Roof		Insulation is uncompressed	R-19	7.0	9.1	
			R-30	9.3	11.4	

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

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

Insulation	Rated R-Value of Insulation	Overall U-f Factor for Entire Base Wall Assembly	Overall U-Factor for Assembly of Base Wall Plus Continuous Insulation (Uninterrupted by Framing)						
System			R-6.5	R-13	R-19.5	R-26	R-32.5	R-39	
Single Laye	er 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	

# A103.3.7 Concrete and masonry walls.

**A103.3.7.1 Concrete masonry walls.** The nominal R-values in Table A103.3.7.1(1) 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 Fundamentals Handbook. 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.

8-inch Medium-Weight (115 Ib/CF) CMU									
		Grou	<u>ut @</u>	<u>Grou</u>	<u>ut @</u>	<u>Grout @</u>		No Grout	
Additional	All Cells	<u>16-inch</u>	nes OC	<u>32 inch</u>	<u>es OC</u>	<u>48 inch</u>	es OC	<u>(unrein</u>	forced)
Insulation	Grouted	<u>Cores</u> Empty	<u>Cores</u> <u>Filled</u>	<u>Cores</u> Empty	<u>Cores</u> <u>Filled</u>	<u>Cores</u> Empty	<u>Cores</u> <u>Filled</u>	<u>Cores</u> Empty	<u>Cores</u> <u>Filled</u>
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	<u>0.13</u>	0.14	0.12	0.14	<u>0.10</u>
R-10 continuous insulation	0.09	0.08	<u>0.08</u>	0.08	0.08	0.08	0.08	0.08	0.07
R-15 continuous insulation	0.06	0.06	<u>0.06</u>	<u>0.06</u>	0.06	0.06	0.06	<u>0.06</u>	0.05
R-19 continuous insulation	<u>0.05</u>	<u>0.05</u>	<u>0.05</u>	<u>0.05</u>	0.05	<u>0.05</u>	0.05	<u>0.05</u>	0.04
R-13 insulation 2x4 wood studs	<u>0.08</u>	<u>0.08</u>	<u>0.08</u>	<u>0.08</u>	<u>0.08</u>	<u>0.08</u>	<u>0.07</u>	<u>0.08</u>	<u>0.07</u>
<u>R-21 insulation</u> 2x6 wood studs	<u>0.06</u>	<u>0.06</u>	<u>0.06</u>	<u>0.06</u>	<u>0.06</u>	<u>0.06</u>	<u>0.05</u>	<u>0.06</u>	<u>0.05</u>
<u>R-13 insulation</u> <u>3-5/8" metal studs</u>	<u>0.16</u>	<u>0.15</u>	<u>0.14</u>	<u>0.14</u>	<u>0.13</u>	<u>0.15</u>	<u>0.13</u>	<u>0.14</u>	<u>0.11</u>
<u>R-15 insulation</u> <u>3-5/8" metal studs @24 inches</u>	<u>0.11</u>	<u>0.10</u>	<u>0.09</u>	<u>0.10</u>	<u>0.09</u>	<u>0.10</u>	<u>0.07</u>	<u>0.10</u>	<u>0.07</u>
<u>R-19 insulation</u> 5.5" metal studs	<u>0.11</u>	<u>0.11</u>	<u>0.11</u>	<u>0.11</u>	<u>0.10</u>	<u>0.11</u>	<u>0.10</u>	<u>0.11</u>	<u>0.09</u>
<u>R-21 insulation</u> <u>6" metal studs</u>	<u>0.11</u>	<u>0.11</u>	<u>0.10</u>	<u>0.11</u>	<u>0.10</u>	<u>0.11</u>	<u>0.09</u>	<u>0.11</u>	<u>0.08</u>
<u>R-21 insulation</u> <u>6" metal studs</u>	<u>0.09</u>	<u>0.09</u>	<u>0.09</u>	<u>0.09</u>	<u>0.08</u>	<u>0.09</u>	<u>0.08</u>	<u>0.09</u>	<u>0.07</u>
12-inch Medium-Weight (115 lk	<u>/CF) CMU</u>								
	All Cells	<u>Grou</u>	<u>ut @</u>	<u>Grout @</u>		<u>Grout @</u>		No Grout	
Additional Insulation	Grouted					48 Incr		Coros	
	Filled	Empty	<u>Filled</u>	Empty	<u>Filled</u>	Empty	<u>Filled</u>	Empty	<u>Filled</u>
None	0.47	<u>0.44</u>	<u>0.34</u>	<u>0.42</u>	0.28	<u>0.42</u>	0.25	<u>0.40</u>	<u>0.15</u>
R-5 continuous insulation	<u>0.14</u>	<u>0.14</u>	<u>0.13</u>	<u>0.14</u>	0.12	<u>0.14</u>	<u>0.11</u>	<u>0.13</u>	0.09
R-10 continuous insulation	<u>0.08</u>	<u>0.08</u>	<u>0.08</u>	<u>0.08</u>	0.07	<u>0.08</u>	0.07	<u>0.08</u>	0.06
R-15 continuous insulation	<u>0.06</u>	<u>0.06</u>	<u>0.06</u>	<u>0.06</u>	<u>0.05</u>	<u>0.06</u>	<u>0.05</u>	<u>0.06</u>	<u>0.05</u>
R-19 continuous insulation	<u>0.05</u>	<u>0.05</u>	<u>0.05</u>	<u>0.05</u>	<u>0.04</u>	<u>0.05</u>	<u>0.04</u>	<u>0.05</u>	<u>0.04</u>
<u>R-13 insulation</u> 2x4 wood studs	<u>0.08</u>	<u>0.08</u>	<u>0.08</u>	<u>0.08</u>	<u>0.07</u>	<u>0.08</u>	<u>0.07</u>	<u>0.08</u>	<u>0.06</u>
<u>R-21 insulation</u> 2x6 wood studs	<u>0.06</u>	<u>0.06</u>	<u>0.05</u>	<u>0.06</u>	<u>0.05</u>	<u>0.06</u>	<u>0.05</u>	<u>0.06</u>	<u>0.04</u>
<u>R-13 insulation</u> <u>3-5/8" metal studs</u>	<u>0.15</u>	<u>0.14</u>	<u>0.13</u>	<u>0.14</u>	<u>0.12</u>	<u>0.14</u>	<u>0.11</u>	<u>0.14</u>	<u>0.09</u>
<u>R-15 insulation</u> <u>3-5/8" metal studs @ 24 inches</u>	<u>0.11</u>	<u>0.11</u>	<u>0.10</u>	<u>0.10</u>	<u>0.08</u>	<u>0.10</u>	<u>0.08</u>	<u>0.10</u>	<u>0.06</u>
<u>R-19 insulation</u> <u>6" metal studs</u>	<u>0.11</u>	<u>0.11</u>	<u>0.10</u>	<u>0.11</u>	<u>0.09</u>	<u>0.11</u>	<u>0.09</u>	<u>0.11</u>	0.07
<u>R-21 insulation</u> <u>6" metal studs</u>	<u>0.10</u>	<u>0.10</u>	<u>0.09</u>	<u>0.10</u>	<u>0.09</u>	<u>0.10</u>	<u>0.08</u>	<u>0.10</u>	<u>0.07</u>
R-21 insulation	0.09	0.09	0.08	<u>0.09</u>	0.08	<u>0.09</u>	<u>0.08</u>	<u>0.09</u>	<u>0.06</u>

Table A105.3.7.1(1) Default U-Factors for Concrete Masonry (CMU) Walls

(( <del>8" Concrete Masonry</del>	CORE TREATMENT				
		Partial Grout with Ungrouted Cores			
Wall Description	Empty	Loose-fill insulated		Solid Grout	
	Empty	Perlite	<b>Vermiculite</b>		
Exposed Block, Both Sides	<del>0.40</del>	<del>0.23</del>	<del>0.24</del>	<del>0.43</del>	
R-5 Interior Insulation, Wood Furring	0.14	0.11	<del>0.12</del>	<del>0.15</del>	
R-6 Interior Insulation, Wood Furring	0.14	0.11	<del>0.11</del>	<del>0.14</del>	
R-10.5 Interior Insulation, Wood Furring	<del>0.11</del>	0.09	<del>0.09</del>	0.11	
R-8 Interior Insulation, Metal Clips	<del>0.11</del>	0.09	<del>0.09</del>	0.11	
R-6 Exterior Insulation	0.12	0.10	<del>0.10</del>	0.12	
R-10 Exterior Insulation	0.08	<del>0.07</del>	<del>0.07</del>	<del>0.08</del>	
R-9.5 Rigid Polystyrene Integral Insulation, Two Webbed Block	<del>0.11</del>	0.09	0.09	0.12	
12" Concrete Masonry		CORI	E TREATMENT		
	Partial Gr	out with Ur	ngrouted Cores		
Wall Description	Empty	Loose fill insulated		Solid Grout	
	Empty	Perlite	<b>Vermiculite</b>		
Exposed Block, Both Sides	<del>0.35</del>	<del>0.17</del>	<del>0.18</del>	<del>0.33</del>	
R-5 Interior Insulation, Wood Furring	<del>0.14</del>	<del>0.10</del>	<del>0.10</del>	<del>0.13</del>	
R-6 Interior Insulation, Wood Furring	<del>0.13</del>	<del>0.09</del>	<del>0.10</del>	<del>0.13</del>	
R-10.5 Interior Insulation, Wood Furring	<del>0.11</del>	<del>0.08</del>	<del>0.08</del>	<del>0.10</del>	
R-8 Interior Insulation, Metal Clips	<del>0.10</del>	<del>0.08</del>	<del>0.08</del>	<del>0.09</del>	
R-6 Exterior Insulation	<del>0.11</del>	<del>0.09</del>	<del>0.09</del>	<del>0.11</del>	
R-10 Exterior Insulation	<del>0.08</del>	<del>0.06</del>	<del>0.06</del>	<del>0.08</del>	
R-9.5 Rigid Polystyrene Integral Insulation, Two Webbed Block	<del>0.11</del>	<del>0.08</del>	<del>0.09</del>	0.12	
8" Clay Brick		CORI	E TREATMENT		
	Partial Gr	out with Ur	ngrouted Cores		
Wall Description	Empty	Loose	fill insulated	Solid Grout	
		Perlite	Vermiculite		
Exposed Block, Both Sides	<del>0.50</del>	<del>0.31</del>	0.32	0.56	
R 5 Interior Insulation, Wood Furring	<del>0.15</del>	0.13	<del>0.13</del>	<del>0.16</del>	
R 6 Interior Insulation, Wood Furring	<del>0.15</del>	0.12	<del>0.12</del>	<del>0.15</del>	
R 10.5 Interior Insulation, Wood Furring	<del>0.12</del>	<del>0.10</del>	<del>0.10</del>	<del>0.12</del>	
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	<del>0.09))</del>	

Table A103.3.7.1(((4)) <u>2</u>) Default U-factors for Concrete ((and Masonry)) Walls

6" Concrete Poured or Precast	CORE TREATMENT				
	Partial G	out with U	ngrouted Cores		
Wall Description	Empty	Loose	fill insulated	Solid Grout	
	Empty	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	

## Table A103.3.7.1(((4)) <u>2)</u> Default U-factors for Concrete ((<del>and Masonry</del>)) Walls

Footnotes for Table A105.3.7.1(2):

(( 1. Grouted cores at 40" x 48" on center vertically and horizontally in partial grouted walls.

2. Interior insulation values include 1/2" gypsum board on the inner surface.

3. Furring and stud spacing is 16" on center. Insulation is assumed to fill furring space and is not compressed.

4. 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.

5. 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"x8"x16" CMU with all cells filled with vermiculite (1995) and 8"x8"x16" 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 ((<del>A103.3.7.1(<u>2</u>))) <u>A103.3.7.1(4)</u> Default U-factors for Concrete and Masonry Walls <sup>a, b, c, d</sup></del>

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 or	nly			
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 V	Vood Framing			
0.75 in.	R-3.0	U-0.247	U-0.226	U-0.210
1.5 in.	R-6.0	U-0.160	U-0.151	U-0.143
2.0 in.	R-10.0	U-0.116	U-0.111	U-0.107
3.5 in.	R-11.0	U-0.094	U-0.091	U-0.088
3.5 in.	R-13.0	U-0.085	U-0.083	U-0.080
3.5 in.	R-15.0	U-0.079	U-0.077	U-0.075
5.5 in.	R-19.0	U-0.060	U-0.059	U-0.058
5.5 in.	R-21.0	U-0.057	U-0.055	U-0.054
Continuous N	Metal Framing at 24	in. on center horizonta	lly	
1.0 in.	R-0.0	U-0.414	U-0.359	U-0.318
1.0 in.	R-3.8	U-0.325	U-0.290	U-0.263
1.0 in.	R-5.0	U-0.314	U-0.281	U-0.255
1.0 in.	R-6.5	U-0.305	U-0.274	U-0.249
1.5 in.	R-11.0	U-0.267	U-0.243	U-0.223

Table (( <del>A103.3.7.1(2)</del> )) <u>A103.3.7.1(4)—continued</u>
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)
2.0 in.	R-7.6	U-0.230	U-0.212	U-0.197
2.0 in.	R-10.0	U-0.219	U-0.202	U-0.188
2.0 in.	R-13.0	U-0.210	U-0.195	U-0.182
3.0 in.	R-11.4	U-0.178	U-0.167	U-0.157
3.0 in.	R-15.0	U-0.168	U-0.158	U-0.149
3.0 in.	R-19.0	U-0.161	U-0.152	U-0.144
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
5.0 in.	R-32.0	U-0.109	U-0.105	U-0.101
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

(also, where allowed by Section C402.1.3, for assemblies with a ratio of metal penetration area/ mass wall area of <0.0004 or <0.04% of the mass wall area)<sup>5</sup>

	,			
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

# Table ((<del>A103.3.7.1(2)</del>)) <u>A103.3.7.1(4)—continued</u> Default U-factors for Concrete and Masonry Walls <sup>a, b, c, d</sup>

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)
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 I	nsulation Uninterrup	oted 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
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

# Table ((<del>A103.3.7.1(2)</del>)) <u>A103.3.7.1(4)—continued</u> Default U-factors for Concrete and Masonry Walls <sup>a, b, c, d</sup>

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)
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-3.0	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 continuou	is 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 I	nsulation Uninterrup	ted by Framing with S	tucco and Continuous Meta	l 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
3.5 in.	R-11.0 + R-19 c.i.	U-0.040	U-0.039	U-0.039
3.5 in.	R-13.0 + R-19 c.i.	U-0.040	U-0.039	U-0.038

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)
5.0 in.	R-19.0 + R-19 c.i.	U-0.037	U-0.036	U-0.036
5.0 in.	R-25.0 + R-19 c.i.	U-0.036	U-0.035	U-0.035
5.0 in.	R-32.5 + R-19 c.i.	U-0.035	U-0.035	U-0.034
5.5 in.	R-19.0 + R-19 c.i.	U-0.036	U-0.036	U-0.035
5.5 in.	R-21.0 + R-19 c.i.	U-0.035	U-0.035	U-0.035

#### Table ((<del>A103.3.7.1(2)</del>)) <u>A103.3.7.1(4)—continued</u> Default U-factors for Concrete and Masonry Walls <sup>a, b, c, d</sup>

#### Notes for Default Table A103.3.7.1(4):

a. It is acceptable to use the U-factors in Table A103.3.7.1(4) 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(4), 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<sup>3</sup>.
  - 2. Solid grouted concrete block wall: 8-in. medium weight ASTM C90 concrete block with a density of 115 lb/ft<sup>3</sup> and solid grouted cores.
  - 3. Partially grouted concrete block wall: 8-in. medium weight ASTM C90 concrete block with a density of 115 lb/ft<sup>3</sup> 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(4) 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 four-inch metal stud containing insulation that is nominally six inches thick and therefore extends two inches beyond the back of the metal stud).
- d. Except for wall assemblies qualifying for note 3, 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

Slab Edgo Troatmont	Average Thickness of Wall Above and Below						
Sidd Euge Treatment	6 inches	8 inches	10 inches	12 inches			
Exposed Concrete	0.816	0.741	0.678	0.625			
<b>R-5</b> Exterior Insulation	0.161	0.157	0.154	0.152			
<b>R-6</b> Exterior Insulation	0.138	0.136	0.134	0.132			
<b>R-7</b> Exterior Insulation	0.122	0.120	0.118	0.116			
<b>R-8</b> Exterior Insulation	0.108	0.107	0.106	0.104			
<b>R-9</b> Exterior Insulation	0.098	0.097	0.095	0.094			
<b>R-10</b> 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			
<b>R-14</b> Exterior Insulation	0.066	0.065	0.065	0.064			
<b>R-15</b> Exterior Insulation	0.062	0.061	0.061	0.060			

#### Notes for Table A103.3.7.2:

- 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 x ft2 x °F of wall area). Coefficients for below-grade slabs are listed as F-factors (Btu/h x ft x °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 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 of concrete wall extending above grade.

Interior insulation is assumed to be fiberglass batts placed in the cavity formed by  $2 \ge 4$  framing on 24 inch centers with 1/2 inch 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, 3-1/2 and 7 feet below grade. Basements shallower than two feet 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.

#### 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

#### TABLE A104.1—continued DEFAULT WALL U-FACTORS AND SLAB F-FACTORS FOR BASEMENTS

	Below Grade Wall U-factor	Below Grade Slab F-factor					
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					

TB = Thermal Break

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

- 1. Uninsulated: No insulation or interior finish.
- 2. **Interior insulation:** Interior 2 x 4 insulated wall without a thermal break between concrete wall and slab.
- 3. Interior insulation with thermal break: Interior 2 x 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.

#### 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 x ft<sup>2</sup> x  $^{\circ}$ F.

They are derived from procedures listed in the ASHRAE Fundamentals Handbook, assuming an average outdoor temperature of  $45^{\circ}$ F, an average indoor temperature of  $65^{\circ}$ F and a crawlspace area of 1350 ft<sup>2</sup> and 100 feet of perimeter. The crawlspace is assumed to be 2.5 feet high, with 24 inches below grade and 6 inches above grade.

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

Nomin	al 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 WOOD-FRAMED 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% 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			

#### TABLE A105.1(3)—continued DEFAULT U-FACTORS FOR EXPOSED FLOORS

U-Factor							
Nominal R-Value	Concrete	Wood Joist	Metal Joist				
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 ft<sup>2</sup> of netfree ventilation in the foundation for every 300 ft<sup>2</sup> 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. Assume to have 1.5 air changes per hour, with less than 1.0  $\text{ft}^2$  of net-free ventilation in the foundation for every 300  $\text{ft}^2$  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 centers, or post and beam on 4 foot by 8 foot 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.

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 x °F per lineal foot of perimeter.

Insulation type	R-0	R-5	R-10	R-15
		Unheat	ted 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	
Hea				
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	

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

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

Soil is assumed to have a conductivity of 0.75 Btu/h x ft<sup>2</sup> x  $^{\circ}$ F. Slabs 2 feet or more below grade should use basement coefficients.

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

- 1. **Two foot (or four foot) vertical:** Insulation is applied directly to the slab exterior, extending downward from the top of the slab to a depth of 2 feet (or 4 feet) below grade.
- 2. Two foot (or four foot) horizontal: Insulation is applied directly to the underside of the slab, and run

horizontally from the perimeter inward for 2 feet (or 4 feet). 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 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).

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. x 82 in.)						
Slab Doors							
Wood slab in wood frame <sup>a</sup>	0.46						
6% glazed fenestration (22 in. x 8 in. lite)	_	0.48	0.47	0.46	0.44		
25% glazed fenestration (22 in.x36 in. lite)	_	0.58	0.48	0.46	0.42		
45% glazed fenestration (22 in.x64 in. lite)	_	0.69	0.49	0.46	0.39		
More than 50% glazed fenestration		Us	e Table C303.1.3(1)/R3	03.1.3(1) as appropriate			

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

# TABLE A107.1(1)—continued 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	
Insulated steel slab with wood edge in wood frame <sup>a</sup>	0.16					
6% glazed fenestration (22 in. x 8 in. lite)	_	0.21	0.20	0.19	0.18	
25% glazed fenestration (22 in.x36 in. lite)	—	0.39	0.28	0.26	0.23	
45% glazed fenestration (22 in.x64 in. lite)	_	0.58	0.38	0.35	0.26	
More than 50% g glazed fenestration		Us	e Table C303.1.3(1)/R3	03.1.3(1) as appropriate		
Foam insulated steel slab with metal edge in steel frame <sup>b</sup>	0.37					
6% glazed fenestration (22 in. x 8 in. lite)	_	0.44	0.42	0.41	0.39	
25% glazed fenestration (22 in.x36 in. lite)	_	0.55	0.50	0.48	0.44	
45% glazed fenestration (22 in.x64 in. lite)	_	0.71	0.59	0.56	0.48	
More than 50% glazed fenestration		Us	e Table C303.1.3(1)/R3	03.1.3(1) as appropriate		
Cardboard honeycomb slab with metal edge in steel frame <sup>b</sup>	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	

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

b. Non-thermally broken sill

c. Nominal U-factors are through the center of the insulated panel before consideration of thermal bridges around the edges of the door section and due to the frame.

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

Revolving Doors						
Size (W x H)	U-Factor					
3-wing						
8 ft x 7 ft	0.79					
10 ft x 8 ft	0.80					
4-wing						
7 ft x 6.5 ft	0.63					
7 ft x 7.5 ft	0.64					
Open						
82 in x 84 in	1.32					

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

Double-Skin Steel Emergency Exit Doors			
Core Insulation	3 ft x 6 ft 8 in	6 ft x 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	

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

Double-Skin Steel Garage and Aircraft Hangar Doors					
Insulation <sup>e</sup>	One-piece tilt-up <sup>a</sup>		Sectional tilt-up <sup>b</sup>	Aircraft hangar	
	8 ft. x 7 ft.	16 ft. x 7 ft.	9 ft. x 7 ft.	72 ft. x 12 ft. <sup>c</sup>	240 ft. x 50 ft. <sup>d</sup>
1-3/8 in. thickness	0.26	0.22	0.24.0.20		
XPS, steel ribs	0.36	0.33	0.34-0.39		
2 in. thickness					
EPS, steel ribs XPS, steel ribs	0.31 0.29	0.28 0.26	0.29-0.33 0.27-0.31		
3 in. thickness					
EPS, steel ribs XPS, steel ribs	0.26 0.24	0.23 0.21	0.25-0.28 0.24-0.27		
4 in. thickness					
EPS, steel ribs XPS, steel ribs	0.23 0.21	0.20 0.19	$\begin{array}{c} 0.23 \text{-} 0.25 \\ 0.21 \text{-} 0.24 \end{array}$		
6 in. thickness					
EPS, steel ribs XPS, steel ribs	0.20 0.19	0.16 0.15	0.20-0.21 0.19-0.21		
4 in. thickness					
Non-insulated Expanded polystyrene Mineral wool, steel ribs Extruded polystyrene				$ \begin{array}{c} 1.10 \\ 0.25 \\ 0.25 \\ 0.23 \end{array} $	$     \begin{array}{r}       1.23 \\       0.16 \\       0.16 \\       0.15     \end{array} $
6 in. thickness					
Non-insulated Expanded polystyrene Mineral wool, steel ribs Extruded polystyrene				1.10 0.21 0.23 0.20	1.23 0.13 0.13 0.12

Double-Skin Steel Garage and Aircraft Hangar Doors					
Insulation <sup>e</sup>	One-piece tilt-up <sup>a</sup>		Sectional tilt-up <sup>b</sup>	Aircraft hangar	
	8 ft. x 7 ft.	16 ft. x 7 ft.	9 ft. x 7 ft.	72 ft. x 12 ft. <sup>c</sup>	240 ft. x 50 ft. <sup>d</sup>
Uninsulated					
All products	1.15				

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

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. EPS is extruded polystyrene, XPS 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:

 $Q_{infil} = ACH_{eff} * HCP$ 

Where:

Q<sub>infil</sub> = Heat loss due to air infiltration.

- ACH<sub>eff</sub> = The effective air infiltration rate in Table A108.1(1)
- HCP = The Heat Capacity Density Product for the appropriate elevation or climate zone as given below.

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

Air-l eakage Control Package	Air Changes per Hour		
All-Leakage Control 1 ackage	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