Errata to
***Principles of Heating, Ventilating, and Air-Conditioning*, Ninth Edition**
(2021)

March 8, 2023

Shaded items have been added since the previously published errata sheet dated October 12, 2022.

Page 9: At the end of the first paragraph on the page, add the following additional sentence: "**See Section 4.1.1 for more information on SBS and BRI.**"

Page 40: In the equation under Equation (2-47), the final variable reads "W_{hg}" but should read "$\boldsymbol{Wh_g}$".

Page 113: In Problem 3-29, the second and third sentences read "The air is heated with a finned heat exchanger with 78 ft^2 of heat transfer surface area and a UA value of 210 Btu/h·°F. Also, a steam spray system adds moisture to the air from saturated steam at 16 psia" but should read "The air is heated with a finned heat exchanger**, then** a steam spray system adds moisture to the air from saturated steam at 16 psia."

Page 130: In Section 4.2.3, under the heading "Temperatures, Degree-Days, and Degree-Hours (Rows 6–13)," the last sentence of the second bullet reads "Its use is explained in the section on Estimation of Degree-Days." but should read "Its use is explained in the section on Estimation of Degree-Days **in Section 14.5 of the 2021 *ASHRAE Handbook—Fundamentals***."

Page 131: In Section 4.2.3, under the heading "Mean Daily Temperature Range (Rows 35–39)," the first sentence reads "These values are useful in calculating daily dry- and wet-bulb temperature profiles, as explained in the section on Generating Design-Day Data." but should read "These values are useful in calculating daily dry- and wet-bulb temperature profiles, as explained in the section on Generating Design-Day Data **in Section 14.4 of the 2021 *ASHRAE Handbook—Fundamentals***."

Page 135: Example 4-4 concerns weather data for the Philadelphia International Airport in Pennsylvania, and the Solution to this example states this information is available as part of the Design Conditions for Selected Locations in the online supplemental material accompanying this book. The data sheets for Philadelphia International Airport were inadvertently excluded from the first printing of the book; the I-P and SI versions of that data **have now been added to the online supplemental material for this book**.

Page 158: In the second full paragraph, the second sentence reads "Space level refers the load experienced by the individual occupied space or room and the heating and cooling required to maintain its specified conditions (temperature and humidity)" but should read "***Space level*** refers **to** the load experienced by the individual occupied space or room and the heating and cooling required to maintain its specified conditions (temperature and humidity).

Page 164: In the Fenestration paragraph, the second sentence reads "Table 5-6, located in the I-P Resources section at the end of this chapter, lists U-factors for various fenestration products." but should read "Table 5-6, located in the I-P Resources **and SI Resources** section**s** at the end of this chapter, lists U-factors for various fenestration products."

Page 164: In the Fenestration paragraph, the third sentence begins "Tables 5-7 through 5-9, also located in the I-P Resources section at the end of this chapter..." but should read "Tables 5-7 through 5-9, also located in the I-P Resources **and SI Resources** section**s** at the end of this chapter...."

Page 167: In Figure 5-5, the tabular data should match the data shown in the solution to Example 5-3. These data are repeated here, with the corrected values shown in bold:

	Element	***R*** **(Insulated Cavity)**	***R*** **(Studs, Plates, and Headers)**
1	Outdoor air film, 15 mph wind	0.17	0.17
2	Wood bevel lapped siding	0.81	0.81
3	Rigid foam insulating sheathing	**2.5**	**2.5**
4	Mineral fiber batt insulation, 3.5 in.	13.0	—
5	Wood stud, nominal 2 × 4 (est.)	—	**3.47**
6	Gypsum wallboard, 0.5 in.	0.45	0.45
7	Inside air film, still air	0.68	0.68
		R_1 = **17.61**	R_2 = **8.08**

Page 181: In the first paragraph under the heading "Fenestration," the third sentence ends with "but contributes 48% (10,150 Btu/h) of the heat gain to the space per Table 5-13." but should end with "but contributes 48% **(3286 + 668 + 14,589 + 2841 = 21,384; 21,384/43,996 = 48%)** of the heat gain to the space per Table 5-13 **at 4:00 pm**."

Page 183: The last sentence of Section 5.6.3 reads "The methodology is the same as used in the heat loss calculation (Section 5.5.1.4)." but should read "The methodology is the same as used in the heat loss calculation **(in the Floor subsection of Section 5.5.1).**"

Page 193: In the Solution to Example 5-15, in the Sensible column, the items under "Internal heat gain" reference Examples 5-13, 5-14 and 5-15 for People, Lighting, and Equipment, respectively. They should reference Examples **5-11**, **5-13**, and **5-14**, respectively.

Page 193:	In the Solution to Example 5-15, the value for People in the Latent column references Example 5-13 but should reference Example **5-11**.
Page 193:	In the Solution to Example 5-15, in the Latent column, the "Example 5-0" referenced for Equipment **should be deleted**.
Page 193:	In the first paragraph of Section 5.7, the first sentence begins "Space loads are need to select..." but should begin "Space loads are **needed** to select...."
Page 193:	In the first paragraph of Section 5.7, the second sentence begins with "Section 3.1.8 of Chapter 3" but should begin with "Section **3.2** of Chapter 3...."
Page 193:	In Section 5.7.1, in both the first paragraph and the first nomenclature line, "Equation (3-22)" is referenced; in both instances, this should read "Equation **(3-21)**".
Page 194:	The first line of nomenclature on this page ends with a reference to "Example 5-16" but should end with a reference to "Example **5-15**".
Page 197:	In Section 5.7.2, the first sentence begins with "Equation (3-22)" but should begin with "Equation (**3-21**)".
Page 199:	Problem 5-16 reads "A 1 hp motor driving a pump is located in a space to be air conditioned. Determine heat dissipated to the space from the motor and pump." but should read "A **small electric** 1 hp motor driving a pump is located in a space to be air conditioned. **The motor is 4-pole enclosed.** Determine heat dissipated to the space from the motor and pump."
Page 210:	Table 5.6 is missing the following source attribution: (**Table 4, Chapter 15, 2021 *ASHRAE Handbook—Fundamentals*)**.
Page 210:	The second page of Table 5-6 was inadvertently excluded from the first printing of the book; **the complete I-P version of Table 5-6 should be included as is shown at the end of this errata sheet.**
Page 223:	The SI version of Table 5-6 was inadvertently excluded from the first printing of the book; **the SI version of Table 5-6 should be included as is shown at the end of this errata sheet.**
Page 239:	The first sentence of Example 6-1 refers to Figures 6-4 and 6-5 but should refer to **Figures 6-3 and 6-4**.
Page 250:	In Problem 6-2, the last sentence of item #2 reads "Provide your answer in MBH" but should read "Provide your answer in **MMBtu**."
Page 251:	In Problem 6-7, item #3 reads "Will this heat gain impact coil sensible load?" but should read "Will this heat gain impact **the** coil sensible load?"

Page 292: In the nomenclature under Equation (8.12), in the definition of the variable C_s, add the following additional text: **Section *s* is taken at the downstream (outlet) of a diverging junction and at the upstream (inlet) junction of a converging junction.**

Page 300: The part of the Solution for Example 8-2 that is included on the top half of this page needs the corrections add additions noted in bold and underline below:

From Equation (8-2),

$$p_{\underline{v,c}} = (2000/4005)^2 = 0.25 \text{ in. of water}$$

For Fitting 5-23, Table 8-5, with θ = 90°, and $V_s/V_c = 0.75$:

$$c_{c,s} = 0.03 \ \underline{\textbf{(We will call this } C_s\textbf{)}}$$

Equation (8-2):

$$\underline{p_{v,s} = (1500/4005)^2 = 0.14 \text{ in. w.g.}}$$

Then, to find straight-through loss by Equation **(8-12),**

$$\Delta p_t = \underline{C_s p_{v,s}}$$

$$\Delta p_t = 0.03 \ (\underline{\textbf{0.14}}) = \underline{\textbf{0.0042}} \text{ in. of water (negligible)}$$

For the branch section**, use the same fitting** with θ = 90° and $A_b/A_c = 0.6$.

In order to determine Q_b/Q_c, we use the knowledge that $A_c = A_s$ ("straight-through section"). From that we know V_s/V_c:

$$\underline{V_s/V_c = Q_s/Q_c = 1500/2000 = 0.75}$$

$$\underline{Q_b = Q_c - Q_s}$$

$$\underline{Q_b = 0.25Q_c \text{ (substitute } Q_s = 0.75Q_c\text{)}}$$

$$\underline{Q_b/Q_c = 0.25}$$

Interpolation gives:

$$\underline{C_{c,b} = 0.985 \text{ (We will call this } C_b\text{)}}$$

$$\underline{p_{v,b} = (1060/4005)^2 = 0.07 \text{ in. w.g.}}$$

By Equation **(8-13)**,

$$\Delta p_t = \underline{C_b p_{v,b}}$$

$$\Delta p_t = \underline{\textbf{0.985(0.07)}} = \underline{\textbf{0.069}} \text{ in. of water}$$

Page 340: In Table 8-5, "Fitting Loss Coefficients for Use with the Problems in this Book," Fittings 1-1 and 1-2 should be labeled as Fittings **1-2** and **1-3**.

Page 344: Above Fitting 5-2, the heading "**5. JUNCTIONS (Tees, Wyes, Crosses)**" should be included.

Table 5-6 U-Factors for Various Fenestration Products in Btu/h·ft^2·°F (I-P)

(Table 4, Chapter 15, 2021 *ASHRAE Handbook—Fundamentals*)

Product Type		Glass Only		Vertical Installation									
				Operable (including sliding and swinging glass doors)					Fixed				
Frame Type		Center of Glass	Edge of Glass	Aluminum Without Thermal Break	Aluminum with Thermal Break	Reinforced Vinyl/ Aluminum Clad Wood	Wood/ Vinyl	Insulated Fiberglass/ Vinyl	Aluminum Without Thermal Break	Aluminum with Thermal Break	Reinforced Vinyl/ Aluminum Clad Wood	Wood/ Vinyl	Insulated Fiberglass/ Vinyl
ID	Glazing Type												
	Single Glazing												
1	1/8 in. glass	1.04	1.04	1.23	1.07	0.93	0.91	0.85	1.12	1.07	0.98	0.98	1.04
2	1/4 in. acrylic/polycarbonate	0.88	0.88	1.10	0.94	0.81	0.80	0.74	0.98	0.92	0.84	0.84	0.88
3	1/8 in. acrylic/polycarbonate	0.96	0.96	1.17	1.01	0.87	0.86	0.79	1.05	0.99	0.91	0.91	0.96
	Double Glazing												
4	1/4 in. air space	0.55	0.64	0.81	0.64	0.57	0.55	0.50	0.68	0.62	0.56	0.56	0.55
5	1/2 in. air space	0.48	0.59	0.76	0.58	0.52	0.50	0.45	0.62	0.56	0.50	0.50	0.48
6	1/4 in. argon space	0.51	0.61	0.78	0.61	0.54	0.52	0.47	0.65	0.59	0.53	0.52	0.51
7	1/2 in. argon space	0.45	0.57	0.73	0.56	0.50	0.48	0.43	0.60	0.53	0.48	0.47	0.45
	Double Glazing, e = 0.60 on surface 2 or 3												
8	1/4 in. air space	0.52	0.62	0.79	0.61	0.55	0.53	0.48	0.66	0.59	0.54	0.53	0.52
9	1/2 in. air space	0.44	0.56	0.72	0.55	0.49	0.48	0.43	0.59	0.53	0.47	0.47	0.44
10	1/4 in. argon space	0.47	0.58	0.75	0.57	0.51	0.50	0.45	0.61	0.55	0.49	0.49	0.47
11	1/2 in. argon space	0.41	0.54	0.70	0.53	0.47	0.45	0.41	0.56	0.50	0.44	0.44	0.41
	Double Glazing, e = 0.40 on surface 2 or 3												
12	1/4 in. air space	0.49	0.60	0.76	0.59	0.53	0.51	0.46	0.63	0.57	0.51	0.51	0.49
13	1/2 in. air space	0.40	0.54	0.69	0.52	0.47	0.45	0.40	0.55	0.49	0.44	0.43	0.40
14	1/4 in. argon space	0.43	0.56	0.72	0.54	0.49	0.47	0.42	0.58	0.52	0.46	0.46	0.43
15	1/2 in. argon space	0.36	0.51	0.66	0.49	0.44	0.42	0.37	0.52	0.46	0.40	0.40	0.36
	Double Glazing, e = 0.20 on surface 2 or 3												
16	1/4 in. air space	0.45	0.57	0.73	0.56	0.50	0.48	0.43	0.60	0.53	0.48	0.47	0.45
17	1/2 in. air space	0.35	0.50	0.65	0.48	0.43	0.41	0.37	0.51	0.45	0.39	0.39	0.35
18	1/4 in. argon space	0.38	0.52	0.68	0.51	0.45	0.43	0.39	0.54	0.47	0.42	0.42	0.38
19	1/2 in. argon space	0.30	0.46	0.61	0.45	0.39	0.38	0.33	0.47	0.41	0.35	0.35	0.30
	Double Glazing, e = 0.10 on surface 2 or 3												
20	1/4 in. air space	0.42	0.55	0.71	0.54	0.48	0.46	0.41	0.57	0.51	0.45	0.45	0.42
21	1/2 in. air space	0.32	0.48	0.63	0.46	0.41	0.39	0.34	0.49	0.42	0.37	0.37	0.32
22	1/4 in. argon space	0.35	0.50	0.65	0.48	0.43	0.41	0.37	0.51	0.45	0.39	0.39	0.35
23	1/2 in. argon space	0.27	0.44	0.59	0.42	0.37	0.36	0.31	0.44	0.38	0.33	0.32	0.27
	Double Glazing, e = 0.05 on surface 2 or 3												
24	1/4 in. air space	0.41	0.54	0.70	0.53	0.47	0.45	0.41	0.56	0.50	0.44	0.44	0.41
25	1/2 in. air space	0.30	0.46	0.61	0.45	0.39	0.38	0.33	0.47	0.41	0.35	0.35	0.30
26	1/4 in. argon space	0.33	0.48	0.64	0.47	0.42	0.40	0.35	0.49	0.43	0.38	0.37	0.33
27	1/2 in. argon space	0.25	0.42	0.57	0.41	0.36	0.34	0.30	0.43	0.36	0.31	0.31	0.25
	Triple Glazing												
28	1/4 in. air spaces	0.38	0.52	0.67	0.49	0.43	0.43	0.38	0.53	0.47	0.42	0.42	0.38
29	1/2 in. air spaces	0.31	0.47	0.61	0.44	0.38	0.38	0.34	0.47	0.41	0.36	0.36	0.31
30	1/4 in. argon spaces	0.34	0.49	0.63	0.46	0.41	0.40	0.36	0.50	0.44	0.38	0.38	0.34
31	1/2 in. argon spaces	0.29	0.45	0.59	0.42	0.37	0.36	0.32	0.45	0.40	0.34	0.34	0.29
	Triple Glazing, e = 0.20 on surface 2, 3, 4, or 5												
32	1/4 in. air spaces	0.33	0.48	0.62	0.45	0.40	0.39	0.35	0.49	0.43	0.37	0.37	0.33
33	1/2 in. air spaces	0.25	0.42	0.56	0.39	0.34	0.33	0.29	0.42	0.36	0.31	0.31	0.25
34	1/4 in. argon spaces	0.28	0.45	0.58	0.41	0.36	0.36	0.31	0.45	0.39	0.33	0.33	0.28
35	1/2 in. argon spaces	0.22	0.40	0.54	0.37	0.32	0.31	0.27	0.39	0.33	0.28	0.28	0.22
	Triple Glazing, e = 0.20 on surfaces 2 or 3 and 4 or 5												
36	1/4 in. air spaces	0.29	0.45	0.59	0.42	0.37	0.36	0.32	0.45	0.40	0.34	0.34	0.29
37	1/2 in. air spaces	0.20	0.39	0.52	0.35	0.31	0.30	0.26	0.38	0.32	0.26	0.26	0.20
38	1/4 in. argon spaces	0.23	0.41	0.54	0.37	0.33	0.32	0.28	0.40	0.34	0.29	0.29	0.23
39	1/2 in. argon spaces	0.17	0.36	0.49	0.33	0.28	0.28	0.24	0.35	0.29	0.24	0.24	0.17
	Triple Glazing, e = 0.10 on surfaces 2 or 3 and 4 or 5												
40	1/4 in. air spaces	0.27	0.44	0.58	0.40	0.36	0.35	0.31	0.44	0.38	0.32	0.32	0.27
41	1/2 in. air spaces	0.18	0.37	0.50	0.34	0.29	0.28	0.25	0.36	0.30	0.25	0.25	0.18
42	1/4 in. argon spaces	0.21	0.39	0.53	0.36	0.31	0.31	0.27	0.38	0.33	0.27	0.27	0.21
43	1/2 in. argon spaces	0.14	0.34	0.47	0.30	0.26	0.26	0.22	0.32	0.27	0.21	0.21	0.14
	Quadruple Glazing, e = 0.10 on surfaces 2 or 3 and 4 or 5												
44	1/4 in. air spaces	0.22	0.40	0.54	0.37	0.32	0.31	0.27	0.39	0.33	0.28	0.28	0.22
45	1/2 in. air spaces	0.15	0.35	0.48	0.31	0.27	0.26	0.23	0.33	0.27	0.22	0.22	0.15
46	1/4 in. argon spaces	0.17	0.36	0.49	0.33	0.28	0.28	0.24	0.35	0.29	0.24	0.24	0.17
47	1/2 in. argon spaces	0.12	0.32	0.45	0.29	0.25	0.24	0.20	0.31	0.25	0.20	0.20	0.12
48	1/4 in. krypton spaces	0.12	0.32	0.45	0.29	0.25	0.24	0.20	0.31	0.25	0.20	0.20	0.12

Notes:

1. All heat transmission coefficients in this table include film resistances and are based on winter conditions of 0°F outdoor air temperature and 70°F indoor air temperature, with 15 mph outdoor air velocity and zero solar flux. Except for single glazing, small changes in indoor and outdoor temperatures do not significantly affect overall U-factors. Coefficients are for vertical position except skylight values, which are for 20° from horizontal with heat flow up.
2. Glazing layer surfaces are numbered from outdoor to indoor. Double, triple, and quadruple refer to number of glazing panels. All data are based on 1/8 in. glass, unless otherwise noted. Thermal conductivities are: 0.53 Btu/h·ft·°F for glass, and 0.11 Btu/h·ft·°F for acrylic and polycarbonate.
3. Standard spacers are metal. Edge-of-glass effects are assumed to extend over the 2 1/2 in. band around perimeter of each glazing unit.

Table 5-6 U-Factors for Various Fenestration Products in Btu/h· ft^2· °F (I-P) (*Continued*)

(Table 4, Chapter 15, 2021 *ASHRAE Handbook—Fundamentals*)

Vertical Installation					Sloped Installation									
Garden Windows		Curtain Wall			Glass Only (Skylights)		Manufactured Skylight				Site-Assembled Sloped/Overhead Glazing			
Aluminum Without Thermal Break	Wood/ Vinyl	Aluminum Without Thermal Break	Aluminum with Thermal Break	Structural Glazing	Center of Glass	Edge of Glass	Aluminum Without Thermal Break	Aluminum with Thermal Break	Reinforced Vinyl/ Aluminum Clad Wood	Wood/ Vinyl	Aluminum Without Thermal Break	Aluminum with Thermal Break	Structural Glazing	ID
2.50	2.10	1.21	1.10	1.10	1.19	1.19	1.77	1.70	1.61	1.42	1.35	1.34	1.25	1
2.24	1.84	1.06	0.96	0.96	1.03	1.03	1.60	1.54	1.45	1.31	1.20	1.20	1.10	2
2.37	1.97	1.13	1.03	1.03	1.11	1.11	1.68	1.62	1.53	1.39	1.27	1.27	1.18	3
1.72	1.32	0.77	0.67	0.63	0.58	0.66	1.10	0.96	0.92	0.84	0.80	0.83	0.66	4
1.62	1.22	0.71	0.61	0.57	0.57	0.65	1.09	0.95	0.91	0.84	0.79	0.82	0.65	5
1.66	1.26	0.74	0.63	0.59	0.53	0.63	1.05	0.91	0.87	0.80	0.76	0.80	0.62	6
1.57	1.17	0.68	0.58	0.54	0.53	0.63	1.05	0.91	0.87	0.80	0.76	0.80	0.62	7
1.68	1.28	0.74	0.64	0.60	0.54	0.63	1.06	0.92	0.88	0.81	0.77	0.80	0.63	8
1.56	1.16	0.68	0.57	0.53	0.53	0.63	1.05	0.91	0.87	0.80	0.76	0.80	0.62	9
1.60	1.20	0.70	0.60	0.56	0.49	0.60	1.01	0.87	0.83	0.76	0.72	0.77	0.58	10
1.51	1.11	0.65	0.55	0.51	0.49	0.60	1.01	0.87	0.83	0.76	0.72	0.77	0.58	11
1.63	1.23	0.72	0.62	0.58	0.51	0.61	1.03	0.89	0.85	0.78	0.74	0.78	0.60	12
1.50	1.10	0.64	0.54	0.50	0.50	0.61	1.02	0.88	0.84	0.77	0.73	0.78	0.59	13
1.54	1.14	0.67	0.56	0.52	0.44	0.56	0.96	0.83	0.78	0.72	0.68	0.74	0.54	14
1.44	1.04	0.61	0.50	0.46	0.46	0.58	0.98	0.85	0.80	0.74	0.70	0.75	0.56	15
1.57	1.17	0.68	0.58	0.54	0.46	0.58	0.98	0.85	0.80	0.74	0.70	0.75	0.56	16
1.43	1.03	0.60	0.50	0.45	0.46	0.58	0.98	0.85	0.80	0.74	0.70	0.75	0.56	17
1.47	1.07	0.62	0.52	0.48	0.39	0.53	0.91	0.78	0.74	0.68	0.64	0.70	0.50	18
1.35	0.95	0.55	0.45	0.41	0.40	0.54	0.92	0.79	0.75	0.68	0.64	0.71	0.51	19
1.53	1.13	0.66	0.56	0.51	0.44	0.56	0.96	0.83	0.78	0.72	0.68	0.74	0.54	20
1.38	0.98	0.57	0.47	0.43	0.44	0.56	0.96	0.83	0.78	0.72	0.68	0.74	0.54	21
1.43	1.03	0.60	0.50	0.45	0.36	0.51	0.88	0.75	0.71	0.65	0.61	0.68	0.47	22
1.30	0.90	0.53	0.43	0.38	0.38	0.52	0.90	0.77	0.73	0.67	0.63	0.69	0.49	23
1.51	1.11	0.65	0.55	0.51	0.42	0.55	0.94	0.81	0.76	0.70	0.66	0.72	0.52	24
1.35	0.95	0.55	0.45	0.41	0.43	0.56	0.95	0.82	0.77	0.71	0.67	0.73	0.53	25
1.40	1.00	0.58	0.48	0.44	0.34	0.49	0.86	0.73	0.69	0.63	0.59	0.66	0.45	26
1.27	0.87	0.51	0.41	0.37	0.36	0.51	0.88	0.75	0.71	0.65	0.61	0.68	0.47	27
see	see	0.61	0.51	0.46	0.39	0.53	0.90	0.75	0.71	0.64	0.62	0.69	0.48	28
note	note	0.55	0.45	0.40	0.36	0.51	0.87	0.72	0.68	0.61	0.60	0.67	0.45	29
7	7	0.58	0.48	0.43	0.35	0.50	0.86	0.71	0.67	0.60	0.59	0.66	0.44	30
		0.53	0.43	0.38	0.33	0.48	0.84	0.69	0.65	0.59	0.57	0.65	0.42	31
see	see	0.57	0.47	0.42	0.34	0.49	0.85	0.70	0.66	0.59	0.58	0.65	0.43	32
note	note	0.50	0.40	0.35	0.31	0.47	0.82	0.67	0.63	0.57	0.56	0.63	0.41	33
7	7	0.53	0.43	0.37	0.28	0.45	0.80	0.64	0.60	0.54	0.53	0.61	0.38	34
		0.47	0.37	0.32	0.27	0.44	0.79	0.63	0.59	0.53	0.52	0.60	0.37	35
see	see	0.53	0.43	0.38	0.29	0.45	0.81	0.65	0.61	0.55	0.54	0.62	0.39	36
note	note	0.46	0.36	0.30	0.27	0.44	0.79	0.63	0.59	0.53	0.52	0.60	0.37	37
7	7	0.48	0.38	0.33	0.24	0.42	0.76	0.60	0.57	0.50	0.49	0.58	0.35	38
		0.43	0.33	0.28	0.22	0.40	0.74	0.58	0.55	0.49	0.48	0.57	0.33	39
see	see	0.52	0.42	0.37	0.27	0.44	0.79	0.63	0.59	0.53	0.52	0.60	0.37	40
note	note	0.44	0.34	0.29	0.25	0.42	0.77	0.61	0.57	0.51	0.50	0.59	0.36	41
7	7	0.46	0.36	0.31	0.21	0.39	0.73	0.57	0.54	0.48	0.47	0.56	0.32	42
		0.40	0.30	0.25	0.20	0.39	0.72	0.56	0.53	0.47	0.46	0.55	0.31	43
		0.47	0.37	0.32	0.22	0.40	0.74	0.58	0.55	0.49	0.48	0.57	0.33	44
see	see	0.41	0.31	0.26	0.19	0.38	0.71	0.55	0.52	0.46	0.45	0.54	0.30	45
note	note	0.43	0.33	0.28	0.18	0.37	0.70	0.54	0.51	0.45	0.44	0.54	0.29	46
7	7	0.39	0.29	0.23	0.16	0.35	0.68	0.52	0.49	0.43	0.42	0.52	0.28	47
		0.39	0.29	0.23	0.13	0.33	0.65	0.49	0.46	0.40	0.40	0.50	0.25	48

4. Product sizes are described in Figure 4, and frame U-factors are from Table 1.
5. Use $U = 0.6$ Btu/(h·ft^2·°F) for glass block with mortar but without reinforcing or framing.
6. Use of this table should be limited to that of an estimating tool for early phases of design.
7. Values for triple- and quadruple-glazed garden windows are not listed, because these are not common products.
8. U-factors in this table were determined using NFRC 100-91. They have not been updated to the current rating methodology in NFRC 100 (2014a).

Table 5-6 U-Factors for Various Fenestration Products in W/(m^2·K)[i] (SI)

(Table 4, Chapter 15, 2021 *ASHRAE Handbook—Fundamentals*)

Product Type		Glass Only		Vertical Installation									
				Operable (including sliding and swinging glass doors)					Fixed				
Frame Type		Center of Glass	Edge of Glass	Aluminum Without Thermal Break	Aluminum With Thermal Break	Reinforced Vinyl/ Aluminum Clad Wood	Wood/ Vinyl	Insulated Fiberglass/ Vinyl	Aluminum Without Thermal Break	Aluminum With Thermal Break	Reinforced Vinyl/ Aluminum Clad Wood	Wood/ Vinyl	Insulated Fiberglass/ Vinyl
ID	Glazing Type												
	Single Glazing												
1	3.2 mm glass	*5.91*	*5.91*	7.01	6.08	5.27	5.20	4.83	6.38	6.06	5.58	5.58	5.40
2	6 mm acrylic/polycarb	*5.00*	*5.00*	6.23	5.35	4.59	4.52	4.18	5.55	5.23	4.77	4.77	4.61
3	3.2 mm acrylic/polycarb	*5.45*	*5.45*	6.62	5.72	4.93	4.86	4.51	5.96	5.64	5.18	5.18	5.01
	Double Glazing												
4	6 mm airspace	*3.12*	*3.63*	4.62	3.61	3.24	3.14	2.84	3.88	3.52	3.18	3.16	3.04
5	13 mm airspace	*2.73*	*3.36*	4.30	3.31	2.96	2.86	2.58	3.54	3.18	2.85	2.83	2.72
6	6 mm argon space	*2.90*	*3.48*	4.43	3.44	3.08	2.98	2.69	3.68	3.33	3.00	2.98	2.86
7	13 mm argon space	*2.56*	*3.24*	4.16	3.18	2.84	2.74	2.46	3.39	3.04	2.71	2.69	2.58
	Double Glazing, e = 0.60 on surface 2 or 3												
8	6 mm airspace	*2.95*	*3.52*	4.48	3.48	3.12	3.02	2.73	3.73	3.38	3.04	3.02	2.90
9	13 mm airspace	*2.50*	*3.20*	4.11	3.14	2.80	2.70	2.42	3.34	2.99	2.67	2.65	2.53
10	6 mm argon space	*2.67*	*3.32*	4.25	3.27	2.92	2.82	2.54	3.49	3.13	2.81	2.79	2.67
11	13 mm argon space	*2.33*	*3.08*	3.98	3.01	2.68	2.58	2.31	3.20	2.84	2.52	2.50	2.39
	Double Glazing, e = 0.40 on surface 2 or 3												
12	6 mm airspace	*2.78*	*3.40*	4.34	3.35	3.00	2.90	2.61	3.59	3.23	2.90	2.88	2.77
13	13 mm airspace	*2.27*	*3.04*	3.93	2.96	2.64	2.54	2.27	3.15	2.79	2.48	2.46	2.35
14	6 mm argon space	*2.44*	*3.16*	4.07	3.09	2.76	2.66	2.38	3.30	2.94	2.62	2.60	2.49
15	13 mm argon space	*2.04*	*2.88*	3.75	2.79	2.48	2.38	2.11	2.95	2.60	2.29	2.27	2.16
	Double Glazing, e = 0.20 on surface 2 or 3												
16	6 mm airspace	*2.56*	*3.24*	4.16	3.18	2.84	2.74	2.46	3.39	3.04	2.71	2.69	2.58
17	13 mm airspace	*1.99*	*2.83*	3.70	2.75	2.44	2.34	2.07	2.91	2.55	2.24	2.22	2.12
18	6 mm argon space	*2.16*	*2.96*	3.84	2.88	2.56	2.46	2.19	3.05	2.70	2.38	2.36	2.26
19	13 mm argon space	*1.70*	*2.62*	3.47	2.53	2.24	2.14	1.88	2.66	2.30	2.00	1.98	1.88
	Double Glazing, e = 0.10 on surface 2 or 3												
20	6 mm airspace	*2.39*	*3.12*	4.02	3.05	2.72	2.62	2.34	3.25	2.89	2.57	2.55	2.44
21	13 mm airspace	*1.82*	*2.71*	3.56	2.62	2.32	2.22	1.96	2.76	2.40	2.10	2.08	1.98
22	6 mm argon space	*1.99*	*2.83*	3.70	2.75	2.44	2.34	2.07	2.91	2.55	2.24	2.22	2.12
23	13 mm argon space	*1.53*	*2.49*	3.33	2.40	2.12	2.02	1.76	2.51	2.16	1.86	1.84	1.74
	Double Glazing, e = 0.05 on surface 2 or 3												
24	6 mm airspace	*2.33*	*3.08*	3.98	3.01	2.68	2.58	2.31	3.20	2.84	2.52	2.50	2.39
25	13 mm airspace	*1.70*	*2.62*	3.47	2.53	2.24	2.14	1.88	2.66	2.30	2.00	1.98	1.88
26	6 mm argon space	*1.87*	*2.75*	3.61	2.66	2.36	2.26	2.00	2.81	2.45	2.15	2.12	2.02
27	13 mm argon space	*1.42*	*2.41*	3.24	2.31	2.04	1.94	1.69	2.42	2.06	1.76	1.74	1.65
	Triple Glazing												
28	6 mm airspace	*2.16*	*2.96*	3.78	2.78	2.46	2.42	2.17	3.02	2.68	2.36	2.36	2.25
29	13 mm airspace	*1.76*	*2.67*	3.46	2.47	2.18	2.14	1.90	2.68	2.34	2.03	2.03	1.92
30	6 mm argon space	*1.93*	*2.79*	3.60	2.60	2.30	2.26	2.02	2.82	2.49	2.17	2.17	2.06
31	13 mm argon space	*1.65*	*2.58*	3.36	2.39	2.10	2.06	1.83	2.58	2.24	1.93	1.93	1.83
	Triple Glazing, e = 0.20 on surface 2, 3, 4, or 5												
32	6 mm airspace	*1.87*	*2.75*	3.55	2.56	2.26	2.22	1.98	2.78	2.44	2.12	2.12	2.01
33	13 mm airspace	*1.42*	*2.41*	3.18	2.21	1.94	1.90	1.67	2.38	2.05	1.74	1.74	1.64
34	6 mm argon space	*1.59*	*2.54*	3.32	2.34	2.06	2.02	1.79	2.53	2.20	1.89	1.89	1.78
35	13 mm argon space	*1.25*	*2.28*	3.04	2.08	1.82	1.78	1.55	2.24	1.90	1.60	1.60	1.50
	Triple Glazing, e = 0.20 on surfaces 2 or 3 and 4 or 5												
36	6 mm airspace	*1.65*	*2.58*	3.36	2.39	2.10	2.06	1.83	2.58	2.24	1.93	1.93	1.83
37	13 mm airspace	*1.14*	*2.19*	2.95	1.99	1.74	1.69	1.48	2.14	1.80	1.50	1.50	1.40
38	6 mm argon space	*1.31*	*2.32*	3.09	2.12	1.86	1.82	1.59	2.29	1.95	1.65	1.65	1.55
39	13 mm argon space	*0.97*	*2.05*	2.81	1.86	1.62	1.57	1.36	1.99	1.65	1.36	1.36	1.26
	Triple Glazing, e = 0.10 on surfaces 2 or 3 and 4 or 5												
40	6 mm airspace	*1.53*	*2.49*	3.27	2.30	2.02	1.98	1.75	2.48	2.15	1.84	1.84	1.73
41	13 mm airspace	*1.02*	*2.10*	2.85	1.90	1.66	1.61	1.40	2.04	1.70	1.41	1.41	1.31
42	6 mm argon space	*1.19*	*2.23*	2.99	2.04	1.78	1.73	1.52	2.19	1.85	1.55	1.55	1.45
43	13 mm argon space	*0.80*	*1.92*	2.67	1.73	1.49	1.45	1.24	1.84	1.51	1.22	1.22	1.12
	Quadruple Glazing, e = 0.10 on surfaces 2 or 3 and 4 or 5												
44	6 mm airspaces	*1.25*	*2.28*	3.04	2.08	1.82	1.78	1.55	2.24	1.90	1.60	1.60	1.50
45	13 mm airspaces	*0.85*	*1.96*	2.71	1.77	1.54	1.49	1.28	1.89	1.55	1.26	1.26	1.17
46	6 mm argon spaces	*0.97*	*2.05*	2.81	1.86	1.62	1.57	1.36	1.99	1.65	1.36	1.36	1.26
47	13 mm argon spaces	*0.68*	*1.83*	2.57	1.64	1.41	1.37	1.16	1.74	1.41	1.12	1.12	1.03
48	6 mm krypton spaces	*0.68*	*1.83*	2.57	1.64	1.41	1.37	1.16	1.74	1.41	1.12	1.12	1.03

Notes:

1. All heat transmission coefficients in this table include film resistances and are based on winter conditions of –18°C outdoor air temperature and 21°C indoor air temperature, with 6.7 m/s outdoor air velocity and zero solar flux. Except for single glazing, small changes in the indoor and outdoor temperatures do not significantly affect overall U-factors. Coefficients are for vertical position except skylight values, which are for 20° from horizontal with heat flow up.
2. Glazing layer surfaces are numbered from outdoor to indoor. Double, triple, and quadruple refer to number of glazing panels. All data are based on 3 mm glass, unless otherwise noted. Thermal conductivities are: 0.917 W/(m·K) for glass, and 0.19 W/(m·K) for acrylic and polycarbonate.
3. Standard spacers are metal. Edge-of-glass effects are assumed to extend over the 63.5 mm band around perimeter of each glazing unit.

Table 5-6 U-Factors for Various Fenestration Products in W/(m^2·K)^i (SI) (*Continued*)

(Table 4, Chapter 15, 2021 *ASHRAE Handbook—Fundamentals*)

Vertical Installation					Sloped Installation									
Garden Windows		Curtainwall			Glass Only (Skylights)		Manufactured Skylight				Site-Assembled Sloped/Overhead Glazing			
Aluminum Without Thermal Break	Wood/ Vinyl	Aluminum Without Thermal Break	Aluminum With Thermal Break	Structural Glazing	Center of Glass	Edge of Glass	Aluminum Without Thermal Break	Aluminum With Thermal Break	Reinforced Vinyl/ Aluminum Clad Wood	Wood/ Vinyl	Aluminum Without Thermal Break	Aluminum With Thermal Break	Structural Glazing	ID
14.21	11.94	6.86	6.27	6.27	*6.76*	*6.76*	10.03	9.68	9.16	8.05	7.66	7.64	7.10	1
12.70	10.42	6.03	5.44	5.44	*5.85*	*5.85*	9.09	8.74	8.23	7.45	6.83	6.80	6.27	2
13.45	11.18	6.44	5.86	5.86	*6.30*	*6.30*	9.56	9.21	8.70	7.89	7.24	7.22	6.68	3
9.78	7.50	4.38	3.79	3.56	*3.29*	*3.75*	6.23	5.46	5.21	4.79	4.54	4.71	3.75	4
9.19	6.92	4.03	3.45	3.22	*3.24*	*3.71*	6.17	5.41	5.16	4.74	4.49	4.68	3.70	5
9.44	7.17	4.18	3.60	3.37	*3.01*	*3.56*	5.96	5.19	4.94	4.54	4.30	4.52	3.51	6
8.94	6.67	3.89	3.30	3.07	*3.01*	*3.56*	5.96	5.19	4.94	4.54	4.30	4.52	3.51	7
9.53	7.25	4.23	3.65	3.41	*3.07*	*3.60*	6.01	5.24	4.99	4.59	4.35	4.56	3.55	8
8.86	6.58	3.84	3.25	3.02	*3.01*	*3.56*	5.96	5.19	4.94	4.54	4.30	4.52	3.51	9
9.11	6.84	3.99	3.40	3.17	*2.78*	*3.40*	5.74	4.97	4.72	4.34	4.10	4.37	3.31	10
8.61	6.33	3.69	3.11	2.88	*2.78*	*3.40*	5.74	4.97	4.72	4.34	4.10	4.37	3.31	11
9.28	7.00	4.08	3.50	3.27	*2.90*	*3.48*	5.85	5.08	4.83	4.44	4.20	4.45	3.41	12
8.52	6.25	3.64	3.06	2.83	*2.84*	*3.44*	5.79	5.02	4.78	4.39	4.15	4.41	3.36	13
8.77	6.50	3.79	3.21	2.97	*2.50*	*3.20*	5.46	4.69	4.45	4.09	3.86	4.18	3.07	14
8.18	5.91	3.45	2.86	2.63	*2.61*	*3.28*	5.57	4.80	4.56	4.19	3.96	4.25	3.17	15
8.94	6.67	3.89	3.30	3.07	*2.61*	*3.28*	5.57	4.80	4.56	4.19	3.96	4.25	3.17	16
8.10	5.82	3.40	2.81	2.58	*2.61*	*3.28*	5.57	4.80	4.56	4.19	3.96	4.25	3.17	17
8.35	6.08	3.54	2.96	2.73	*2.22*	*3.00*	5.19	4.42	4.18	3.84	3.61	3.98	2.83	18
7.67	5.39	3.15	2.56	2.33	*2.27*	*3.04*	5.24	4.47	4.24	3.89	3.66	4.02	2.88	19
8.69	6.42	3.74	3.16	2.92	*2.50*	*3.20*	5.46	4.69	4.45	4.09	3.86	4.18	3.07	20
7.84	5.57	3.25	2.66	2.43	*2.50*	*3.20*	5.46	4.69	4.45	4.09	3.86	4.18	3.07	21
8.10	5.82	3.40	2.81	2.58	*2.04*	*2.88*	5.02	4.25	4.02	3.69	3.46	3.86	2.68	22
7.41	5.14	3.00	2.42	2.18	*2.16*	*2.96*	5.13	4.36	4.13	3.79	3.56	3.94	2.78	23
8.61	6.33	3.69	3.11	2.88	*2.39*	*3.12*	5.35	4.58	4.34	3.99	3.76	4.10	2.97	24
7.67	5.39	3.15	2.56	2.33	*2.44*	*3.16*	5.41	4.64	4.40	4.04	3.81	4.14	3.02	25
7.93	5.65	3.30	2.71	2.48	*1.93*	*2.79*	4.91	4.14	3.91	3.58	3.37	3.77	2.58	26
7.24	4.96	2.90	2.32	2.09	*2.04*	*2.88*	5.02	4.25	4.02	3.69	3.46	3.86	2.68	27
see	see	3.48	2.91	2.62	*2.22*	*3.00*	5.13	4.24	4.03	3.63	3.55	3.92	2.70	28
note	note	3.14	2.57	2.27	*2.04*	*2.88*	4.96	4.07	3.87	3.48	3.40	3.80	2.56	29
7	7	3.28	2.71	2.42	*1.99*	*2.83*	4.91	4.01	3.81	3.43	3.35	3.76	2.51	30
		3.04	2.47	2.17	*1.87*	*2.75*	4.80	3.90	3.70	3.33	3.25	3.68	2.41	31
see	see	3.23	2.66	2.37	*1.93*	*2.79*	4.85	3.96	3.76	3.38	3.30	3.72	2.46	32
note	note	2.84	2.27	1.97	*1.76*	*2.67*	4.68	3.79	3.59	3.22	3.16	3.59	2.31	33
7	7	2.99	2.42	2.12	*1.59*	*2.54*	4.52	3.63	3.43	3.07	3.01	3.47	2.17	34
		2.69	2.12	1.83	*1.53*	*2.49*	4.46	3.57	3.37	3.02	2.96	3.43	2.12	35
see	see	3.04	2.47	2.17	*1.65*	*2.58*	4.57	3.68	3.48	3.12	3.06	3.51	2.22	36
note	note	2.59	2.02	1.73	*1.53*	*2.49*	4.46	3.57	3.37	3.02	2.96	3.43	2.12	37
7	7	2.74	2.17	1.87	*1.36*	*2.36*	4.29	3.40	3.21	2.86	2.81	3.30	1.97	38
		2.44	1.87	1.58	*1.25*	*2.28*	4.18	3.29	3.10	2.76	2.71	3.22	1.87	39
see	see	2.94	2.37	2.07	*1.53*	*2.49*	4.46	3.57	3.37	3.02	2.96	3.43	2.12	40
note	note	2.49	1.92	1.63	*1.42*	*2.41*	4.35	3.46	3.27	2.91	2.86	3.34	2.02	41
7	7	2.64	2.07	1.78	*1.19*	*2.23*	4.13	3.24	3.04	2.71	2.66	3.18	1.82	42
		2.29	1.72	1.43	*1.14*	*2.19*	4.07	3.18	2.99	2.66	2.61	3.13	1.77	43
		2.69	2.12	1.83	*1.25*	*2.28*	4.18	3.29	3.10	2.76	2.71	3.22	1.87	44
see	see	2.34	1.77	1.48	*1.08*	*2.14*	4.02	3.12	2.93	2.60	2.56	3.09	1.72	45
note	note	2.44	1.87	1.58	*1.02*	*2.10*	3.96	3.07	2.88	2.55	2.51	3.05	1.67	46
7	7	2.19	1.62	1.33	*0.91*	*2.01*	3.85	2.96	2.77	2.45	2.41	2.96	1.58	47
		2.19	1.62	1.33	*0.74*	*1.87*	3.68	2.79	2.60	2.29	2.26	2.83	1.43	48

4. Product sizes are described in Figure 4, and frame U-factors are from Table 1.
5. Use $U = 3.40$ W/(m^2·K) for glass block with mortar but without reinforcing or framing.
6. Use of this table should be limited to that of an estimating tool for early phases of design.
7. Values for triple- and quadruple-glazed garden windows are not listed, because these are not common products.
8. U-factors in this table were determined using NFRC 100-91. They have not been updated to the current rating methodology in NFRC 100 (2014a).