

Table 16.... Determination of U Value Resulting from Addition of Insulation to Uninsulated Building Sections (Continued)
(For use with Tables 13A and 13B)

PART E. FLAT ROOFS AND CEILINGS WITH ROOF-DECK

U Value of Roof without Roof-Deck Insulation ^a	Conductance C of Roof-Deck Insulation					
	0.12	0.15	0.19	0.24	0.36	0.72
	U	U	U	U	U	U
0.10	0.05	0.06	0.07	0.07	0.08	0.09
0.15	0.07	0.08	0.08	0.09	0.11	0.12
0.20	0.08	0.09	0.10	0.11	0.13	0.16
0.25	0.08	0.09	0.11	0.12	0.15	0.19
0.30	0.09	0.10	0.12	0.13	0.16	0.21
0.35	0.09	0.10	0.12	0.14	0.18	0.24
0.40	0.09	0.11	0.13	0.15	0.19	0.26
0.50	0.10	0.12	0.14	0.16	0.21	0.29
0.60	0.10	0.12	0.14	0.17	0.22	0.33
0.70	0.10	0.12	0.15	0.18	0.24	0.35

^a Interpolation or mild extrapolation may be used.

Solution: From Table 11, for heat flow down, the U value for this ceiling G3, without insulation, is 0.40. Referring to Table 16, Part D, with the value 0.40 in Column 1, find $U_i = 0.101$ in Column 4; enter Column 1 at 0.101 and find $U_i = 0.056$ in Column 8. Correct for framing (8 in. joists on 16 in. centers) from Fig. 4, and find corrected ceiling coefficient $U_i = 0.059$; $R_i = 17.0$.

By interpolation in Table 17, Part B, using 95 F ventilation air and 160 F soil-air temperatures, the effective attic resistance R_a is 8.2.

The overall coefficient for the combined ceiling and attic is:

$$U_a = \frac{1}{R_i + R_a} = \frac{1}{17.0 + 8.2} = 0.04$$

$$\text{Heat gain} = U_a A (t_a - t_i) = 0.04 \times 1000 \times (160 - 75) = 3400 \text{ Btu/h}$$

BASEMENT FLOOR, BASEMENT WALL, AND CONCRETE SLAB FLOOR COEFFICIENTS

The heat transfer through basement walls and floors to the ground is dependent on: the temperature difference between the air within the room and that of the ground, on the material constituting the wall or floor, and on the conductivity

Design Heat Transmission Coefficients

of the surrounding earth. The conductivity of the earth will vary with local conditions, and is usually unknown. Tests^a at the ASHRAE Research Laboratory indicate a heat flow of approximately 2.0 Btu per (hr) (sq ft) through an uninsulated concrete basement floor, with a temperature difference of 20 deg between basement floor and the air temperature 6 in. above the floor. The U value of 0.10 is sometimes used for concrete basement floors on ground. For more recent procedures^b, see *National Bureau of Standards Report BMS-103*.

For basement walls below grade only, the temperature difference for winter design conditions will be greater than for the floor. The test results indicate a unit area heat loss, at mid-height of the basement wall portion below grade, of approximately twice that of the same floor area.

For concrete slab floors laid in contact with the ground at grade level, tests^c indicate that, for small floor areas (equal to that of a house 25 feet square), the heat loss may be calculated as proportional to the length of exposed edge rather than total area. This amounts to 0.81 Btu per (hr) (linear foot of exposed edge) (Fahrenheit degree difference between the indoor air temperature and the average outdoor air temperature). It should be noted that this may be appreciably reduced by insulating under the ground slab and along the edges between the floor and the abutting walls. See also sections on Basement Temperatures and Heat Loss, and Floor Heat Loss in Basementless Houses, in Chapter 26. In most calculations, if the perimeter loss is calculated accurately, no other floor loss need be considered.

GLASS AND DOOR COEFFICIENTS

The U values given in Table 18 for flat glass, glass block, and plastic panels were obtained from ASHRAE Research Reports in cases where the panels have been tested. In other instances values were computed using procedures outlined earlier in this chapter. Values in Table 19 for doors were calculated. For winter conditions an outdoor surface conductance of 6.0 Btu per (hr) (sq ft) (F deg) was used and for summer conditions 4.0 Btu per (hr) (sq ft) (F deg). The indoor surface conductance was taken as 1.46 Btu per (hr) (sq ft) (F deg) for vertical surfaces, 1.63 for horizontal surfaces with heat flow up, and 1.08 for horizontal surfaces with heat flow down. The outdoor thermal conductances are for wind velocities of 15 and 7½ mph, respectively. Adjustments for other wind velocities may be made using factors in Table 20.

All values should be considered approximate, since some parameters which may have important effects were not considered. For example, in an actual installation the indoor surface of a glazing panel may be exposed to nearby radiating surfaces such as radiant-heating panels or exposed windows in adjacent or opposite walls having much higher or lower temperature than the indoor air. Use of the listed U value assumes that the surface temperature of surrounding bodies is equal to the ambient air temperature. Air movement across the indoor surface of a panel, such as caused by outlet grilles in the sill, will increase the U value.

Shading devices such as venetian blinds, draperies and roller shades will reduce the U value substantially if they fit tight to the window jambs, head, and sill and are made of a non-porous material. As a rough approximation tight-fitting shading devices may be considered to reduce the U value of vertical exterior single glazing by 25 percent, and of vertical exterior double glazing and glass block by 15 percent. These adjustments should not be considered in choosing heating equipment, but may be used for calculating design cooling loads.

Table 18.... Coefficients of Transmission (U) of Windows, Skylights, and Light-Transmitting Partitions
Btu per (hr) (sq ft) (F deg)

PART A—VERTICAL PANELS (EXTERIOR WINDOWS AND PARTITIONS)—FLAT GLASS, GLASS BLOCK, AND PLASTIC SHEET

Description	Exterior ^a		Interior ^b
	Winter	Summer	
Flat Glass single glass	1.13	1.08	0.73
insulating glass—double ^c			
1 in. air space	0.69	0.64	0.51
1 in. air space	0.65	0.61	0.49
1 in. air space	0.58	0.56	0.46
insulating glass—triple ^c			
1 in. air spaces	0.47	0.45	0.38
1 in. air spaces	0.38	0.35	0.30
storm windows			
1 in. air space	0.56	0.54	0.44
Glass Block ^d			
8 × 8 × 4 in. thick	0.60	0.57	0.46
8 × 8 × 4 in. thick	0.56	0.54	0.44
—with cavity divider	0.48	0.46	0.38
12 × 12 × 4 in. thick	0.52	0.50	0.41
—with cavity divider	0.44	0.42	0.36
12 × 12 × 2 in. thick	0.60	0.57	0.46
Single Plastic Sheet	1.09	1.00	0.70

PART B—HORIZONTAL PANELS (SKYLIGHTS)—FLAT GLASS, GLASS BLOCK, AND PLASTIC BUBBLES

Description	Exterior ^a		Interior ^b
	Winter	Summer	
Flat Glass single glass	1.22	0.83	0.96
insulating glass—double ^c			
1 in. air space	0.75	0.49	0.62
1 in. air space	0.70	0.46	0.59
1 in. air space	0.66	0.44	0.56
Glass Block ^d			
11 × 11 × 3 in. thick with cavity divider	0.53	0.35	0.44
12 × 12 × 4 in. thick with cavity divider	0.51	0.34	0.42
Plastic Bubbles ^e			
single walled	1.15	0.80	—
double walled	0.70	0.46	—

PART C—ADJUSTMENT FACTORS FOR VARIOUS WINDOW TYPES (MULTIPLY U VALUES IN PARTS A AND B BY THESE FACTORS)

Window Description	Single Glass	Double or Triple Glass	Storm Windows
All Glass ^a	1.00	1.00	1.00
Wood Sash—80% Glass	0.90	0.95	0.90
Wood Sash—60% Glass	0.80	0.85	0.80
Metal Sash—80% Glass	1.00	1.20	1.20 ^b

^a See Part C for adjustment for various window types.

^b Double and triple refer to the number of lights of glass.

^c Dimensions are nominal.

^d For heat flow up.

^e For heat flow down.

^f Based on area of coating, not total surface area.

^g Refers to windows with negligible opaque areas.

^h Value becomes 1.00 when storm sash is separated from prime window by thermal break.

Table 17.... Effective Resistance of Ventilated Attics—(Summer Condition)^a
PART A. NON-REFLECTIVE SURFACES

Ventilation Air temp., F	Soil-air temp., F	No Ventilation		Natural Ventilation		Power Ventilation ^a					
		Ventilation rate, cfm/sq ft									
		0		0.1 ^b		0.5		1.0		1.5	
		1/U Ceiling resistance, hr ^c									
		10	20	10	20	10	20	10	20	10	20
80	120	1.9	1.9	2.8	3.4	6.3	9.3	9.8	16	11	20
	140	1.9	1.9	2.8	3.6	6.6	10	9.8	17	12	21
	160	1.9	1.9	2.8	3.6	6.7	11	10	18	15	22
90	120	1.9	1.9	2.6	3.8	4.6	6.7	6.1	10	6.9	13
	140	1.9	1.9	2.6	3.1	5.2	7.9	7.6	12	8.6	16
	160	1.9	1.9	2.7	3.4	5.8	9.0	8.6	14	10	17
100	120	1.9	1.9	2.2	2.3	3.3	4.4	4.0	6.0	4.1	6.9
	140	1.9	1.9	2.4	2.7	4.2	6.1	5.8	8.7	6.5	10
	160	1.9	1.9	2.6	3.2	5.0	7.8	7.8	11	8.3	13

PART B. REFLECTIVE SURFACES^d

80	120	6.5	6.5	8.1	8.8	13	17	17	25	19	30
	140	6.5	6.5	8.2	9.0	14	18	18	26	20	31
	160	6.5	6.5	8.3	9.2	15	18	19	27	21	32
90	120	6.5	6.5	7.5	8.0	10	13	13	17	13	19
	140	6.5	6.5	7.7	8.3	10	14	14	20	16	22
	160	6.5	6.5	7.9	8.6	13	16	16	22	18	25
100	120	6.5	6.5	7.0	7.4	8.0	10	8.5	12	8.8	12
	140	6.5	6.5	7.5	7.8	10	12	11	15	12	16
	160	6.5	6.5	7.6	8.2	11	14	13	18	15	20

^a The term effective resistance is used when there is attic ventilation. A value for no ventilation is also included. The effective resistance of the attic may be added to the resistance (1/ U) of the ceiling (Table 16, Part D) to obtain the effective resistance of the combination based on soil-air (Chapter 27) and room temperature. These values apply to roof frame construction with a roof deck and roofing having a conductance of 1.0 Btu/(sq ft) (hr) (F deg).

^b When attic ventilation meets the requirements of Table 3 in Chapter 23, 0.1 cfm/sq ft may be assumed as the natural summer ventilation rate for design purposes.

^c Resistance Unit, abbreviated ru is one (hr) (sq ft) (F deg) per Btu. Determine ceiling resistance from Tables 11 and 16, and correct for framing by Fig. 4. Do not add the effect of a reflective surface facing the attic to the ceiling resistance from Table 16, Part D, as it is accounted for in Table 17, Part B.

^d Roof surface temperature rather than soil-air temperature (see Chapter 27) may be used if 0.25 is subtracted from the attic resistance shown.

^e Based on air discharging outward from attic.

^f Surfaces with effective emissivity ϵ of 0.05 between ceiling joists facing the attic space.