Table 16 .... Determination of U Value Resulting from Addition of Insulation or Air Spaces to Uninsulated Building Sections* (Continued)

PART C. CEILINGS—HEAT FLOW UP[j] (WINTER CONDITION)

U Value[k] Without Added Insulation	Fibrous Insulation[l] Thickness—Inches				One Air Space of Effective Emissivity[m] E			Two Air Spaces of Effective Emissivity[m] E			Three Air Spaces of Effective Emissivity[m] E		
	½	1	2	3	0.82[n]	0.20	0.05	0.82	0.20	0.05	0.82	0.20	0.05
Col. 1	2	3	4	5	6	7	8	9	10	11	12	13	14
0.70	0.305	0.195	0.113	0.080	0.690	0.472	0.403	0.427	0.262	0.216	0.307	0.180	0.146
0.60	0.284	0.186	0.110	0.078	0.588	0.417	0.362	0.385	0.244	0.204	0.284	0.171	0.139
0.50	0.260	0.175	0.106	0.076	0.488	0.361	0.318	0.339	0.224	0.189	0.258	0.160	0.131
0.45	0.246	0.168	0.104	0.075	0.438	0.331	0.295	0.316	0.212	0.180	0.243	0.154	0.126
0.40	0.230	0.161	0.101	0.074	0.389	0.300	0.270	0.288	0.199	0.170	0.227	0.146	0.121
0.35	0.212	0.152	0.097	0.072	0.340	0.269	0.244	0.260	0.185	0.158	0.209	0.138	0.115
0.30	0.192	0.142	0.093	0.069	0.292	0.237	0.215	0.230	0.168	0.145	0.189	0.129	0.108
0.28	0.184	0.138	0.091	0.068	0.272	0.224	0.203	0.217	0.161	0.140	0.181	0.125	0.104
0.26	0.175	0.133	0.089	0.066	0.253	0.211	0.191	0.204	0.154	0.134	0.172	0.120	0.101
0.24	0.166	0.127	0.087	0.065	0.234	0.199	0.179	0.191	0.146	0.128	0.163	0.115	0.097
0.22	0.156	0.121	0.084	0.064	0.214	0.186	0.166	0.178	0.137	0.120	0.153	0.109	0.093
0.20	0.145	0.115	0.081	0.062	0.195	0.173	0.154	0.164	0.128	0.114	0.143	0.104	0.088
0.18	0.134	0.108	0.078	0.060	0.176	0.159	0.141	0.150	0.119	0.106	0.132	0.097	0.084
0.16	0.123	0.100	0.074	0.057	0.156	0.146	0.128	0.136	0.109	0.098	0.121	0.090	0.079
0.14	0.111	0.092	0.069	0.054	0.137	0.132	0.115	0.120	0.099	0.090	0.109	0.083	0.073
0.12	0.098	0.083	0.064	0.051	0.118	0.118	0.101	0.105	0.088	0.080	0.096	0.075	0.068
0.10	0.085	0.073	0.058	0.047	0.099	0.105	0.088	0.090	0.076	0.071	0.082	0.067	0.062
0.08	0.070	0.062	0.050	0.042	0.079	0.091	0.074	0.073	0.064	0.061	0.067	0.058	0.056

* For construction with air spaces as insulation, coefficients are based on National Bureau of Standards data in *Housing Research Paper* No. 32 (U. S. Government Printing Office, Washington, D. C.).

[j] Based on a temperature difference of 75 deg F from air to air, and a mean temperature of 40 F.

[k] U value taken from Tables 11, 12, 13-A, 14-A, and 15, in which it is assumed that the air space between joists or above the suspended ceiling is nonreflective (E = 0.82), and is 8 in. thick.

[l] Thermal conductivity of fibrous or bulk insulation taken as 0.27 Btu per (hr) (sq ft) (F deg per in.).

[m] For values of effective emissivity E of air space, see Table 3, Section B.

[n] Certain U values in Column 6 differ from Column 1 because they are adjusted to the specific temperature drop across the air space in question as affected by the U value of the construction.

PART D. CEILINGS—HEAT FLOW DOWN[o] (SUMMER CONDITION)

U Value[p] Without Added Insulation	Fibrous Insulation[q] Thickness—Inches				One Air Space of Effective Emissivity[r] E			Two Air Spaces of Effective Emissivity[r] E			Three Air Spaces of Effective Emissivity[r] E		
	½	1	2	3	0.82	0.20	0.05	0.82	0.20	0.05	0.82	0.20	0.05
Col. 1	2	3	4	5	6	7	8	9	10	11	12	13	14
0.70	0.305	0.195	0.113	0.080	0.704	0.269	0.119	0.423	0.144	0.061	0.306	0.103	0.046
0.60	0.284	0.186	0.110	0.078	0.602	0.252	0.116	0.384	0.139	0.060	0.284	0.100	0.046
0.50	0.260	0.175	0.106	0.076	0.501	0.231	0.112	0.340	0.133	0.059	0.260	0.097	0.045
0.45	0.246	0.168	0.104	0.075	0.450	0.220	0.108	0.316	0.128	0.058	0.246	0.095	0.044
0.40	0.230	0.161	0.101	0.074	0.400	0.206	0.105	0.291	0.123	0.057	0.230	0.092	0.044
0.35	0.212	0.152	0.097	0.072	0.350	0.192	0.100	0.264	0.118	0.056	0.213	0.090	0.043
0.30	0.192	0.142	0.093	0.069	0.300	0.175	0.095	0.234	0.112	0.055	0.193	0.086	0.042
0.28	0.184	0.138	0.091	0.068	0.280	0.168	0.093	0.222	0.109	0.054	0.185	0.085	0.042
0.26	0.175	0.133	0.089	0.066	0.260	0.160	0.090	0.209	0.105	0.054	0.176	0.083	0.041
0.24	0.166	0.127	0.087	0.065	0.240	0.152	0.087	0.195	0.102	0.053	0.167	0.080	0.040
0.22	0.156	0.121	0.084	0.064	0.220	0.144	0.084	0.182	0.098	0.052	0.157	0.078	0.040
0.20	0.145	0.115	0.081	0.062	0.200	0.135	0.081	0.168	0.094	0.050	0.146	0.075	0.039
0.18	0.134	0.108	0.078	0.060	0.180	0.125	0.077	0.154	0.089	0.049	0.135	0.072	0.038
0.16	0.123	0.100	0.074	0.057	0.160	0.115	0.073	0.139	0.084	0.047	0.124	0.068	0.038
0.14	0.111	0.092	0.069	0.054	0.140	0.104	0.069	0.124	0.078	0.045	0.111	0.064	0.037
0.12	0.098	0.083	0.064	0.051	0.120	0.093	0.063	0.108	0.072	0.042	0.098	0.059	0.035
0.10	0.085	0.073	0.058	0.047	0.099	0.080	0.056	0.091	0.064	0.039	0.084	0.054	0.033
0.08	0.070	0.062	0.050	0.042	0.079	0.068	0.048	0.074	0.054	0.034	0.070	0.046	0.030

* Based on a temperature difference of 35 F deg from air to air, and a mean temperature of 100 F.

[p] U value taken from Tables 11, 12, 13-B, 14-B, and 15, in which it is assumed that the air space between joists or above the suspended ceiling is nonreflective (E = 0.82), and is 8 in. thick.

[q] Thermal conductivity of fibrous or bulk insulation taken as 0.27 Btu per (hr) (sq ft) (F deg per in.).

[r] For values of effective emissivity E of air space, see Table 3, Section B.

Table 16 .... Determination of U Value Resulting from Addition of Insulation to Uninsulated Building Sections (Concluded)

(For use with Tables 13A and 13B)

PART E. FLAT ROOFS AND CEILINGS WITH ROOF DECK

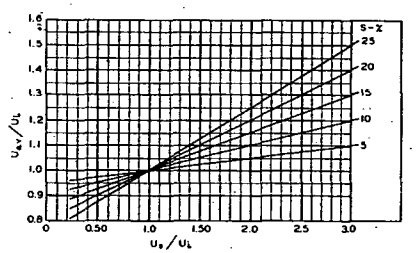
U Value of Roof without Roof-Deck Insulation*	Conductance C of Roof-Deck Insulation					
	0.12	0.15	0.19	0.24	0.36	0.72
	U	U	U	U	U	U
0.10	0.05	0.06	0.07	0.07	0.08	0.09
0.15	0.07	0.08	0.08	0.09	0.11	0.12
0.20	0.08	0.09	0.10	0.11	0.13	0.16
0.25	0.08	0.09	0.11	0.12	0.15	0.19
0.30	0.09	0.10	0.12	0.13	0.16	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

* Interpolation or mild extrapolation may be used.

CORRECTION FOR FRAMING

Correction for parallel heat flow through framing and insulated areas may be made by use of Fig. 6. Correction for the effect of framing should be applied after final U_i and U_s values have been obtained for a given construction. In many cases this correction may be omitted.

Example 7: Consider a frame wall with 2-in. blanket insulation which has a U_i value of 0.08. By calculation it is found that heat loss from the area backed by framing members (U_s) is 0.13. U_s/U_i is 1.63. From Fig. 6 if 15 percent of wall area is backed by framing, the value $U_{as}/U_i = 1.1$. U_{as} is therefore $1.1 \times 0.08 = 0.088$.



U_{av} = average U value for building section.
U_i = U value for area between framing members.
U_s = U value for area backed by framing members.
S = percentage of area backed by framing members.

Fig. 6 .... Correction for Effect of Framing in Insulated Building Sections

VENTILATED ATTICS—HOW TO USE TABLE 17

Table 17 is intended to be used with Table 11, Part D of Table 16, and Fig. 6, or when ceiling resistance is known. Its purpose is to determine the resistance to heat flow of the attic space under various conditions of ventilating air temperatures and rates, ceiling resistance, roof or sol-air temperatures, and surface emissivities.[11] Ventilating air temperature is the outdoor design temperature.

The total resistance, $1/U$, obtained by adding the ceiling and attic resistances can be converted to a U value so that the heat gain may be calculated. The applicable temperature difference is that difference between room air and sol-air temperature or between room air and roof temperatures. (See footnote d, Table 17.)

Table 17 may be used for both pitched and flat residential roofs over attic spaces. When there is an attic floor, the ceiling resistance should be that which applies to the complete ceiling-floor construction.

All values in Table 16, Part D, include the resistance of a non-reflective surface facing the attic space. Therefore, if separate calculations are made, include only the value of a non-reflective surface and not the value of a reflective surface in determining ceiling resistance. The use of Table 17, Part B, will account for this reflection surface.

Example 8: Determine the heat gain for a 1000 sq ft ceiling of ⅜-in. gypsum board and ½-in. light weight aggregate plaster, with no flooring above, when insulated with a 2-in. foil-enclosed fibrous blanket. The blanket is installed so as to form a reflective air space between the ceiling and the blanket. The attic has a gable roof which meets the ventilation requirements in Table 3, Chapter 10. (Use ventilation rate of 0.1 cfm per sq ft.)

Design temperatures are: indoor air = 75 F, outdoor air = 95 F, and sol-air = 160 F.

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. 6 and find corrected ceiling coefficient U_c = 0.059; R_c = 17.0.

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

The overall coefficient for the combined ceiling and attic is:

$$U_o = \frac{1}{R_c + R_a} = \frac{1}{17.0 + 8.2} = 0.04$$

Heat gain $= U_o A (t_o - t_i) = 0.04 \times 1000 \times (160-75) = 3400$ Btuh

COMBINED CEILING AND ROOF COEFFICIENTS

If the attic space between the ceiling and roof is unheated and *not ventilated*, the combined coefficient from room air below the ceiling to exterior air can be calculated from the following formula:

$$R_T = \frac{1}{U_{ce}} + \frac{1}{nU_r} \qquad (4)$$

The combined coefficient U is the reciprocal of R_T, or

$$U = 1/R_T \qquad (5)$$

where

U = combined coefficient to be used with ceiling area.
R_T = total resistance of ceiling and roof.
U_{ce} = coefficient of transmission of ceiling.
U_r = coefficient of transmission of roof.
n = ratio of roof area to ceiling area.

It should be noted that the overall coefficient U should be multiplied by the ceiling area to determine heat loss, and not