

maximum water temperature of 130 F giving a surface temperature of about 115 F.

The area in square feet of each type or different surface temperature, horizontal or vertical, is multiplied by the emission value corresponding to its actual surface temperature. These products are added together to give the total radiant heat effect inside the room from all surfaces.

The difference between the desired and the actual total radiant emission represents the additional heating effect which must be supplied by the hot surfaces to be installed. The temperature of the proposed hot surface must then be selected from Table 2, and its emission per square foot at that temperature determined from Table 1. The difference between this emission and that of the unheated surface replaced by the panel is divided into the total amount of additional heat needed, and the quotient will be the area of the required heating surfaces.

These calculations depend on the accuracy of estimating the ultimate surface temperatures of the walls, windows, ceiling and floor surfaces

TABLE 3. ROOM DATA FOR SOLVING EXAMPLE

SURFACE	AREA Sq Ft	U	ESTIMATED INSIDE SURFACE TEMP DEG F	EMISSIVITY ϵ	HEAT EMISSION BTU PER SQ FT PER HOUR	TOTAL HEAT EMISSION FROM AREA BTU PER HOUR
Outside Wall.....	297	0.25	55.0	0.95	115.1	34,200
Glass.....	279	1.13	33.6	0.92	94.3	26,300
Inside Wall.....	480		60.0 ^a	0.95	119.5	57,300
Ceiling.....	480	0.20	60.4	0.95	119.8	57,500
Floor.....	480	0.10	60.0	0.93	117.0	56,200
Total.....	2,016			Avg. 0.93		231,500

^aNo heat loss through inside wall; assume wall surface temperature 60 F.

under comfort conditions. Some unheated surfaces will absorb a large number of heat rays from the heated panels and thereby become warmer, giving off rays of longer wave length, while other surfaces will reflect a large percentage of rays and become simple reflectors of heat. Windows will be affected largely by curtains, shades or venetian blinds and floors will be affected by rugs and carpets.

Example 1. The surface areas and over-all heat transmission coefficient for a residence room having a volume of 5760 cu ft are given in Table 3. Determine the amount of radiating surface to maintain a room air temperature of 65 F and an MRT of 71 F, with an outside temperature of zero, utilizing ceiling panels with circulating hot water at 130 F which will maintain a surface temperature of approximately 115 F as given in Table 2.

Solution. From Fig. 7 determine the estimated inside surface temperature for the various surfaces. In the case of the outside wall having a $U = 0.25$, it is found from the chart, that the intersection of this line with the zero outside temperature, that the surface temperature is 55 F.

Since the glass temperature will depend on whether or not shades or curtains are provided, it may be assumed in offices and similar rooms that the whole glass surface will be exposed, whereas in residences, curtains may cover all or part of the window thus increasing the room MRT and reducing the human body heat loss. For this example it is assumed that the windows are partly covered with side curtains to the extent of about

one-third. From Fig. 7 the surface temperature of the exposed glass corresponding to a $U = 1.13$, is 19 F. Assuming about a 2 F differential between the room air temperature and curtain surface temperature or 63 F, then one-third the difference between this value and the glass temperature results in a calculated average of 33.6 F.

With a ceiling $U = 0.20$, the surface temperature for an unheated ceiling from Fig. 7 is 57 F; multiplied by a factor $1.06 \times 57 = 60.4$ F. The surface temperature of the floor with a $U = 0.10$ is from Fig. 7 a value of 62 F; multiplied by a factor $0.968 \times 62 = 60$ F.

The emissivities are selected from Table 6, Chapter 3. The glass emissivity of 0.92 in Table 3 was determined by taking one-third of 0.95 (curtain) and two-thirds of 0.90 (glass). The heat emission in Btu per square foot per hour are taken from Table 1.

The approximate natural mean radiant emission of the room from data in Table 3 is $231,500 \div 2016 = 114.8$ Btu per square foot per hour which from Table 1 corresponds

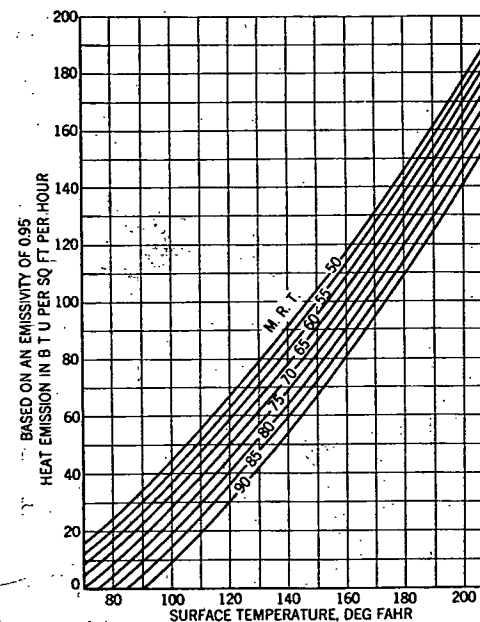


FIG. 8. HEAT EMISSION BY RADIATION FROM PANELS WHEN SURROUNDED BY SURFACES OF VARIOUS TEMPERATURES GIVING AN AVERAGE MRT ACCORDING TO CURVES

to an MRT of 57 F for an average emissivity of 0.93. With a ceiling surface temperature of 115 F and an emissivity of 0.95 from Table 1 the emission is 179.0 Btu per square foot per hour. The difference between 179 and 119.8 used in Table 3 is the additional heat emitted per square foot of warmed ceiling.

For an MRT of 71 F having a heat emission of 127 Btu corresponding to an average emissivity of 0.93, the total emission for all the room surfaces is $2016 \times 127 = 256,000$ Btu per hour. Or an additional $(256,000 - 231,500) = 24,500$ Btu per hour will be required. The heated ceiling at 115 F and 0.95 emissivity releases 179 Btu or $(179 - 119.8) = 59.2$ Btu per square foot per hour more heat than that allowed for an unheated ceiling. Therefore the surface required to be heated is approximately $24,500 \div 59.2 = 415$ sq ft.

Since the total ceiling area is 480 sq ft it is only necessary to utilize 415 sq ft to satisfy the necessary heating requirements. An alternative would be to heat the whole ceiling