the temperature of the water in the system must be high enough to produce the required output from that panel.

Room	Available Panel Area, Sq ft	Required Panel Output (q_u), Btu/(hr)(sq ft)
A	132	25.
B	127	19.7
C	306	26.1

Step 3. Panel Surface Temperature

From Fig. 16 find the panel surface temperature needed to yield the required heat output to each room, using the output determined in Step 2 and the design room air temperature.

Floor panel surface temperatures in excess of about 85 F are not recommended because of the probability of discomfort to the feet. If the required heat output cannot be obtained from an 85 F floor panel, heat losses should be reduced or supplementary heating should be provided.

Room	Panel Surface Temperature (t_p)
A	85. F
B	82.5 F
C	85.3 F

Step 4. Downward and Edgewise Heat Flow

a. Determine the temperature of the surface of the concrete slab (t_s) by adding to the panel surface temperature, the temperature difference caused by the thermal resistance of the floor covering, if any:

$$t_s = t_p + (q_u \times r_{uc}) \tag{12}$$

The value of (r_{uc}) for various floor coverings is given in Table 4.

Room	t_p	q_u	r_{uc}	t_s
A	85. F	25.	0.8	105. F
B	82.5 F	19.7	0.8	98.3 F
C	85.3 F	26.1	0.8	106.2 F

b. Determine the downward and edgewise heat loss coefficient C_s from Fig. 17 for the insulation to be used. Insulation with a conductance of 0.4 Btu per (hr)(sq ft)(F deg) extending two feet below the slab results in a slab downward and edgewise heat loss coefficient of 0.97 Btu per (hr)(ft)(F deg)

c. Apportion the downward and edgewise heat loss uniformly across the panel as follows:

$$q_{de} = \frac{P \times C_s(t_s - t_{os})}{A_p} \tag{13}$$

Room	P	$t_s - t_{os}$	A_p	q_{de}
A	23	105. F	132	17.7
B	12	98.3 F	127	9.0
C	21	106.2 F	306	7.1

Table 3. Thermal Resistance of Bare Concrete Floor Panels

Panel Construction	Spacing in.	Thermal Resistance (F deg)(sq ft)(hr)/Btu, Heat Flow Ratio q_u/q_d or q_u/q_{de} = 1		= 3		= 5		= 10	
		up	down	up	down	up	down	up	down
4 in. Concrete Slab—2 in. Cover		r_{us}	r_{ds}	r_{us}	r_{ds}	r_{us}	r_{ds}	r_{us}	r_{ds}
½ in. (nom.) non-ferrous tube	9	0.57	0.52	0.46	0.84	0.43	1.17	0.42	1.97
	12	0.73	0.68	0.58	1.16	0.54	1.65	0.51	2.86
½ in. (nom.) ferrous pipe or ¾ in. (nom.) non-ferrous tube	9	0.49	0.42	0.41	0.66	0.39	0.90	0.38	1.60
	12	0.63	0.55	0.50	0.93	0.48	1.30	0.46	2.35
6 in. Concrete Slab—2 in. Cover									
½ in. (nom.) non-ferrous tube	9	0.59	0.70	0.47	1.05	0.45	1.39	0.43	2.25
	12	0.78	0.90	0.60	1.40	0.56	1.97	0.54	3.21
¾ in. (nom.) non-ferrous tube	9	0.51	0.61	0.43	0.87	0.41	1.13	0.40	1.78
	12	0.68	0.78	0.54	1.23	0.51	1.63	0.49	2.61
¾ in. (nom.) ferrous pipe	9	0.47	0.55	0.40	0.77	0.39	0.98	0.38	1.50
	12	0.63	0.71	0.50	1.07	0.48	1.44	0.46	2.36
1 in. (nom.) non-ferrous tube or 1 in. (nom.) ferrous pipe	12	0.59	0.66	0.48	0.98	0.46	1.30	0.45	2.11
	15	0.73	0.83	0.57	1.21	0.54	1.73	0.51	2.74

Step 5. Upward Panel Resistance

Assume a tentative pipe or tube size and a spacing for each panel, choosing closer spacings and larger pipe or tube when higher heat outputs are required. From Table 3, find the thermal resistance (r_{us}) of the slab of each panel, using heat flow ratios (q_u/q_{de}) calculated from the flow rates determined in Steps 2 and 4, interpolating as required. To the slab resistance (r_{us}), add the resistance of the floor covering (r_{uc}, Step 4) to obtain the panel resistance to upward heat flow (r_u).

Room	Pipe or Tube Spacing	q_u/q_{de}	r_{us}	r_{uc}	r_u
A	9 ins.	$\frac{25}{17.7} = 1.41$	0.47	0.8	1.27
B	12 ins.	$\frac{19.7}{9.0} = 2.19$	0.55	0.8	1.35
C	9 ins.	$\frac{26.1}{7.1} = 3.68$	0.40	0.8	1.20

All rooms: ½-in. pipe or ¾-in. tube; 4-in. concrete slab.

Step 6. Mean Water Temperature

For the required panel output (q_u) found in Step 2, the panel resistance (r_u) found in Step 5, and the room air temperature (t_s), find the mean water temperature (t_{mw}) from Fig. 16.

Room	t_{mw}
A	116.5
B	109.0
C	116.5