

be kept below 285 F which corresponds to about 40 psig steam. Temperatures above 300 F accelerate the deterioration of the inhibitors.

Slab Construction

It has been found satisfactory to use $\frac{3}{4}$ in. pipe or tubing on 12-in. centers as a standard coil. If pumping loads require a reduction in friction the pipe size may be increased to 1-in., but the slab depth must be increased accordingly.

The piping should be supported in such a manner that there is a minimum of 2 in. of concrete above and below the pipe. This requires a 5-in. slab for $\frac{3}{4}$ -in. pipe and 5 $\frac{3}{8}$ -in. for 1-in. pipe.

If an insulating material is used, it is generally good practice to provide a moisture barrier between the insulation and the fill. A roofing material (such as a 55 lb. felt) is often used as a moisture barrier. The joints should be mopped, and the fill made smooth enough so that there will be no holes or gaps for moisture transfer. Also, the edges of the barrier should be flashed to the surface of the slab so that the ends are sealed. See Fig. 16.

If the pipe must pass through an expansion joint, a protective coating should be applied to the pipe for a foot or two on both sides of the joint.

If the pipe is kept dry at all times in both summer and winter, no external corrosion problems will occur.

Draining

Proper drainage is necessary for both the slab surface and the coil.

The slab must be sloped so that the water from the melted snow can run off. Puddles are objectionable on sidewalks or drives. They cause splashing, and they retard heat flow from the embedded pipes.

The pipes must be placed so that they may be drained. If the anti-freeze becomes corrosive it must be drained. It is not good practice to rely entirely on blowing of air through the system.

Drifting Snow

It is quite likely that some drifting will occur on every system that is adjacent to a wall or vertical surface. The designer should try to anticipate this condition and add extra piping in these areas. If possible, coils should be added in the vertical surface. Another expedient is to carry the drainage to the area expected to be drifted. The drainage will tend to wash away some of the snow.

Example 1: Design a snow melting system for an area of 10,000 sq ft in Pittsburgh, Pa. Assume an air temperature of 10 F and a wind velocity of 10 mph.

Solution: From Table 3 select a snowfall rate of 0.08. From Table 4 find the heat output of top of slab as $q_o = 168$ Btu-hr per sq ft and the anti-freeze average circulating temperature as $t_m = 117$ F.

For 10,000 sq ft and 40 percent loss from back of slab, the heat exchanger must deliver $10,000 \times 168 \times 1.40 = 2,352,000$ Btu-hr.

Using a 20 F deg temperature drop, the exit temperature from the exchanger must be 127 F and the entrance temperature must be 107 F.

The anti-freeze solution should be suitable for -20 F minimum temperature for Pittsburgh, and will therefore have a specific heat (see Table 5) of 0.832, and a weight of 65.3 lb per cu ft. The quantity of solution to be circulated with 20 deg temperature drop will then be

$$\frac{2,352,000}{20 \times 0.832} = 141,300 \text{ lb per hr} = 270 \text{ gpm} = 0.601 \text{ cu ft per sec.}$$

Panel Heating

Assume that the coil circuit of longest equivalent length is 250 ft and has a flow of 4 gpm. The coil is $\frac{3}{4}$ in. IPS, having an internal diameter of 0.824 in. or 0.0687 ft. The velocity is therefore

$$\frac{4 \times 231}{60 (0.824)^2 (\pi/4) 12} = 2.41 \text{ fps}$$

From Table 5 the kinematic viscosity μ is 1.46×10^{-5} sq ft per sec.

$$\text{The Reynolds number } N_{Re} = \frac{Vd}{\mu} = \frac{2.41 (0.0687)}{1.46 \times 10^{-5}} = 11340.$$

From Fig. 4 of Chapter 4, using a roughness factor $e = 0.00015$, whence $e/d = 0.00218$, the value of the friction factor f is found to be 0.0335.

Substituting in Equation 14 for f , l , V and d

$$h_f = \frac{0.0335 (250) (2.41)^2}{2(32.2) (0.0687)} = 11 \text{ ft.}$$

The head against which the pump must operate is therefore 11 ft of the circulating liquid.

REFERENCES

- ¹ Standard Specifications for Gypsum Plastering, including Requirements for Lathing and Plastering (American Standards Association, A42.1, 1946).
- ² Code and Manual for the Design and Installation of Warm Air Ceiling Panel Systems (Manual 7-A of the National Warm Air Heating and Air Conditioning Association).
- ³ Various investigations of W. Nusselt (1915-1928) as discussed in Chap. 23 and Chap. 25, and tabulated in Author Index of *Heat Transfer*, by Max Jakob, Vol. I, 1949 (John Wiley and Sons, New York).
- ⁴ The Transmission of Heat by Radiation and Convection, by Ezer Griffiths & A. H. Davis (Special Report No. 9, 1922, Department of Scientific & Industrial Research, His Majesty's Stationery Office, London, England).
- ⁵ Radiation and Convection from Surfaces in Various Positions, by G. B. Wilkes and C. M. F. Peterson (ASHVE TRANSACTIONS, Vol. 44, 1938, page 513).
- ⁶ Design Conditions for Snow Melting, by W. P. Chapman (*Heating and Ventilating*, November, 1952, p. 88).
- ⁷ Design of Snow Melting Systems, by W. P. Chapman (*Heating and Ventilating*, April, 1952, p. 95).
- ⁸ Anti-Freeze Protection for Snow Melting Systems, by P. B. Gordon (*Official Bulletin, Heating, Piping and Air Conditioning Contractors National Association*, February, 1950, p. 21).
- ⁹ Properties of Ethylene Glycol and Its Aqueous Solution, by C. S. Cragoe (National Bureau of Standards CRC Report No. 9, Society of Automotive Engineers).

BIBLIOGRAPHY

- Trend Curves for Estimating Performance of Panel Heating Systems, by B. F. Raber and F. W. Hutchinson (A.S.H.V.E. TRANSACTIONS, Vol. 48, 1942, p. 425).
- A.S.H.V.E. RESEARCH REPORT No. 1192—Panel Heating and Cooling Performance Studies, by B. F. Raber and F. W. Hutchinson (A.S.H.V.E. TRANSACTIONS, Vol. 48, 1942, p. 35).
- A.S.H.V.E. RESEARCH REPORT No. 1193—Radiation as a Factor in the Feeling of Warmth in Convection Radiator and Panel Heated Rooms, by F. C. Houghten, Carl Guterlet and E. C. Hach (A.S.H.V.E. TRANSACTIONS, Vol. 48, 1942, p. 55).
- Panel Heating and Cooling Analysis, by B. F. Raber and F. W. Hutchinson (A.S.H.V.E. TRANSACTIONS, Vol. 47, 1941, p. 285).
- Operating Results of a Residence Radiant Wall Heating System, by E. J. Rodee (A.S.H.V.E. TRANSACTIONS, Vol. 47, 1941, p. 123).
- Performance of a Residential Panel Heating System, by H. F. Randolph and J. B. Wallace (A.S.H.V.E. TRANSACTIONS, Vol. 49, 1943, p. 235).