temperature drop is used in determining water flow rates, and a total pump head of more than 30 ft is undesirable due to noise caused by high water velocity.

Panel systems involving several rooms and panels comprising a single zone, require that all coils be selected for the same inlet water temperatures. Panel areas and pipe spacing must be selected to make this possible.

INSTALLATION DETAILS, ACCESSORIES, AND CONTROLS

Installation details, as given in Chapter 22, Hot Water Systems, also apply to piping systems for panel heating. Control problems of panel heating systems are discussed in Chapter 39, Automatic Control.

Efficient venting of air from the coils may be obtained by arranging the circulation so that the air moves in the direction of water flow to a high point in the system where an automatic float-type vent or connection to expansion tank should be provided for its release. Coils should be installed as nearly level as possible or, if they are on sloping surfaces due to structural conditions, they should be arranged to vent air at their high points. Arrangements of pumps, expansion tanks, drainage, and flow and return mains may be generally the same as for conventional hot water heating systems.

SNOW MELTING

The practicability of melting snow by means of heated coils has been demonstrated in a large number of installations in sidewalks, roadways, ramps, and runways. In addition to eliminating the need for snow removal, other advantages gained are greater safety to pedestrians and vehicles, and reduction of labor in removal of slush from floors.

The design of a snow-melting system involves primarily (1) a determination of the heat requirement which depends on snow fall and atmospheric conditions, (2) the coil and piping design which depends on heat transfer from a panel and on friction loss in piping due to the circulating medium used, and (3) the selection or design of a heat exchanger for heating the circulating medium.

DESIGN

Heating Requirements

The heating requirements for snow melting are affected by four atmospheric factors: (1) rate of snowfall, (2) air temperature, (3) wind velocity, and (4) humidity. The effects of these factors can be evaluated by consideration of the action of snow falling on a warmed surface.

The first flakes fall on a dry, warm surface, and are then warmed to 32 F and melted. The water from the melted snow soon forms a film over the entire area and starts to evaporate. The evaporation of the film is a *mass* transfer from the surface to the atmosphere. In addition, there is a *heat* transfer from the film to the ambient air and surfaces.

Both the mass and heat transfers attain a maximum only when the film is entirely free of snow. Theoretically this is impossible because some time will elapse while the snow is warmed to 32 F. For all practical purposes, however, it is permissible to assume the snow to be melted as fast as it falls so that the surface may be considered entirely free of snow. The ratio of free area to total area is known as the *free area ratio*, A_r. When $A_r = 1$, there is no snow on the surface and the mass and heat transfers are at a maximum. When $A_r = 0$; the snow covers the entire area and there is no mass or heat transfer.

TABLE 3. SNOWFALL DATA FOR VARIOUS CITIES[a]

City	Number of Readings with Maximum Temperature in 6-Hour Period below Freezing at Various Snowfall Rates — Snowfall Rate in Equivalent Inches of Water per Six Hours.				Total Readings Taken	Assumed Design Rate of Snowfall[b]
	0.00 to 0.24	0.25 to 0.49	0.50 to 0.74	0.75 to 0.99		s
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7
Albany, N. Y.	2052	29	5	1	3720	0.16
Asheville, N. C.	463	5	1	0	3536	0.08
Billings, Mont.	1640	4	0	0	3532	0.08
Bismarck, N. D.	2838	0	0	0	3720	0.08
Boise, Idaho	1300	3	0	0	3720	0.08
Boston, Mass.	1323	11	4	2	3720	0.16
Buffalo, N. Y.	1871	23	3	1	3720	0.16
Burlington, Vt.	2390	9	0	0	3720	0.08
Caribou, Maine	1363	19	1	0	1672	0.16
Chicago, Ill.	1498	3	0	1	2976	0.08
Cincinnati, Ohio	1045	3	0	0	3720	0.08
Cleveland, Ohio	1569	2	0	0	3720	0.08
Columbus, Ohio	1351	4	1	0	3720	0.08
Denver, Col.	1207	4	0	0	3720	0.08
Detroit, Mich.	1830	5	2	0	3720	0.08
Evansville, Ind.	916	5	1	1	3720	0.08
Hartford, Conn.	1514	44	9	3	3720	0.25
Kansas City, Mo.	1189	12	2	1	3720	0.16
Madison, Wisc.	2370	5	2	0	3720	0.08
Minneapolis, Minn.	2703	7	0	0	3720	0.08
Oklahoma City, Okla.	613	8	4	0	3720	0.16
Omaha, Neb.	1795	8	1	0	3720	0.16
Philadelphia, Pa.	891	10	2	1	3720	0.16
Pittsburgh, Pa.	1365	6	2	0	3720	0.08
Portland, Maine	2054	33	4	1	3720	0.16
St. Louis, Mo.	1088	5	0	1	3720	0.08
Salt Lake City, Utah	1482	5	0	0	3720	0.08
Spokane, Wash.	1545	11	1	0	3720	0.16
Washington, D. C.	533	7	2	1	3348	0.16
New York, N. Y.[c]						0.16

[a] Data from *U. S. Weather Bureau*. Based on readings taken 1:30 a.m., 7:30 a.m., 1:30 p.m., and 7:30 p.m. daily from November 15 to February 15 from 1940 to 1949. (Where the total readings are less than 3720 the period of record is less than 10 years). The difference between Col. 6 and the sum of readings in Cols. 2, 3, 4, and 5 is the number of readings with a maximum temperature (in the 6-hr period) above freezing.

[b] The design rate is found as follows: Proceed to left (on line from any city) from Column 5 until the column containing the tenth reading is found. Assume that the larger value in the heading of the selected column is an *average maximum* value, and should be multiplied by 2 to obtain the maximum rate for a 6-hour period. This maximum rate divided by 6 is the design rate per hour. This is equivalent to dividing the larger value in the heading of the selected column by 3.

For example: For Albany, N. Y. Columns 5 and 4 total six readings, and consequently the tenth reading is in Column 3, which has the larger value of 0.49 in the column heading. Dividing 0.49 by 3, the design water equivalent of 0.16 inches per hour is found, as listed in Column 7.

[c] New York City record was not used in this tabulation since the records for that station were not comparable with those of the other stations.

Research on the insulating effects of snow indicate that there are just three practical values for the free area ratio, A_r; they are 1, 0.5, and 0. A general rule to follow is that emergency areas should be designed with