Table 1 .... Data for Determining Operating Characteristics of Snow-Melting Systems[a, 1]

City	Period of No Snowfall: Air Temperature, F[2] Over 32	Below or equal to 32	Mean during freezing period[3]	Wind speed, freezing period,[3] mph	Period of Snowfall[2]: Hours of snowfall[2] Percent	Hr per year	Free area ratio, A_r	Required output, Btu per (sq ft) (hr)[4]: 0 to 49	50 to 99	100 to 149	150 to 199	200 to 249	250 to 299	300 to 349	350 to 399	400- up	Maximum output, Btu/(sq ft) (hr)
	% of winter hours with no snow at above temperatures							Frequency distribution of snowfall hours at above outputs, percent[5]									
Albuquerque, N. M.	74.7	24.7	26.2	8.5	0.6	22	1	62.0	25.4	7.6	4.2	0.0	0.8	—	—	—	259
							0	94.1	5.9	—	—	—	—	—	—	—	82
Amarillo, Tex.	73.1	26.0	24.6	13.3	0.9	33	1	33.7	35.4	15.4	10.7	3.0	1.8	—	—	—	260
							0	88.1	10.1	1.8	—	—	—	—	—	—	143
Boston, Mass.	64.6	31.4	24.7	14.2	4.0	145	1	51.5	30.0	12.3	4.3	1.2	0.6	0.1	—	—	320
							0	83.2	14.0	2.0	0.3	0.3	0.1	—	0.2	—	370*
Buffalo Niagara Falls, N. Y.	46.5	46.9	23.9	10.8	6.6	240	1	50.7	32.6	11.2	3.7	1.4	0.2	0.2	—	—	309
							0	95.9	3.4	0.2	0.5	—	—	—	—	—	192
Burlington, Vt.	39.0	54.5	19.6	10.8	6.5	236	1	53.7	29.9	13.2	2.5	0.6	0.1	—	—	—	280
							0	91.8	7.6	0.6	—	—	—	—	—	—	142
Caribou Limestone, Me.	21.4	70.6	16.5	10.0	8.0	290	1	35.0	39.7	16.0	5.7	2.0	1.0	0.5	0.1	—	378
							0	92.0	7.5	0.5	—	—	—	—	—	—	138
Cheyenne, Wyo.	46.4	49.8	21.5	15.3	3.8	138	1	16.5	26.2	19.4	13.1	8.6	4.7	4.2	4.7	2.6	499
							0	94.3	5.4	0.3	—	—	—	—	—	—	129
Chicago, Ill.	45.4	50.9	21.4	11.5	3.7	134	1	45.8	37.4	11.4	3.1	1.4	0.6	0.2	0.1	—	368
							0	91.5	8.1	0.3	0.1	—	—	—	—	—	165
Colorado Springs, Colo.	54.3	43.6	22.1	11.5	2.1	76	1	26.8	36.3	19.0	7.5	4.4	5.5	0.5	—	—	311
							0	98.4	1.6	—	—	—	—	—	—	—	63
Columbus, Ohio	59.0	38.1	24.5	10.0	2.9	105	1	65.8	22.4	8.0	1.7	1.7	0.4	—	—	—	261
							0	97.7	2.3	—	—	—	—	—	—	—	72
Detroit, Mich.	47.0	49.3	24.1	10.6	3.7	134	1	60.4	27.7	9.3	1.5	0.8	0.3	—	—	—	278
							0	95.9	3.5	0.6	—	—	—	—	—	—	140
Duluth, Minn.	12.6	80.5	14.5	12.0	6.9	250	1	23.7	32.9	20.6	13.7	4.3	2.5	1.7	0.6	—	382
							0	94.8	4.7	0.0	0.3	0.2	—	—	—	—	206
Falmouth, Mass.	68.5	29.5	25.5	12.8	2.0	73	1	50.0	33.9	14.2	1.6	0.3	—	—	—	—	204
							0	91.5	7.4	1.1	—	—	—	—	—	—	144
Great Falls, Mont.	49.0	46.2	16.5	14.4	4.8	174	1	26.2	27.6	16.7	16.4	7.5	4.6	0.3	0.5	0.2	451
							0	94.6	4.8	0.6	—	—	—	—	—	—	138
Hartford, Conn.	56.4	38.9	24.4	8.2	4.7	171	1	48.4	34.6	11.2	4.3	0.8	0.7	—	0.1	—	396
							0	80.4	16.7	2.2	0.5	—	0.1	—	0.1	—	383
Lincoln, Neb.	45.0	52.5	20.8	10.1	2.5	91	1	32.7	26.2	20.0	13.9	5.7	1.5	—	—	—	293
							0	97.2	2.6	0.0	0.0	0.2	—	—	—	—	202
Memphis, Tenn.	87.2	12.5	27.0	11.5	0.3	11	1	48.4	28.3	6.7	13.3	3.3	—	—	—	—	227
							0	85.0	8.3	6.7	—	—	—	—	—	—	144
Minneapolis St. Paul, Minn.	23.6	70.8	16.9	11.1	5.6	203	1	28.4	31.4	21.7	14.1	3.5	0.6	0.3	—	—	313
							0	96.5	3.1	0.3	0.1	—	—	—	—	—	155
Mt. Home, Idaho	56.3	42.6	24.9	9.5	1.1	40	1	74.2	21.9	3.9	—	—	—	—	—	—	143
							0	98.1	1.9	—	—	—	—	—	—	—	90
New York, N. Y.	55.7	42.2	24.2	11.8	2.1	76	1	53.1	31.8	9.4	2.2	1.5	1.7	—	0.3	—	385
							0	87.6	9.6	1.5	0.7	0.3	0.3	—	—	—	298
Ogden, Utah	50.0	45.6	24.3	9.4	4.4	160	1	64.6	29.2	5.8	0.3	0.1	—	—	—	—	216
							0	88.8	9.4	1.4	0.3	0.1	—	—	—	—	216*
Oklahoma City, Okla.	79.0	19.8	24.6	15.8	1.2	44	1	27.8	18.7	17.0	12.6	14.3	5.9	2.7	1.0	—	394
							0	95.7	4.3	—	—	—	—	—	—	—	81
Philadelphia, Pa.	75.8	22.6	26.7	9.7	1.6	58	1	62.3	23.6	10.4	2.3	0.9	0.5	—	—	—	296
							0	84.3	14.0	1.1	0.2	0.4	—	—	—	—	229
Pittsburgh, Pa.	55.2	39.8	24.3	11.6	5.0	182	1	53.6	30.8	8.4	4.6	1.9	0.7	—	—	—	282
							0	93.3	5.9	0.7	0.1	—	—	—	—	—	157
Portland, Ore.	92.9	6.1	28.9	8.4	1.0	36	1	78.0	16.9	5.1	—	—	—	—	—	—	125
							0	91.5	8.5	—	—	—	—	—	—	—	97
Rapid City, S. D.	45.2	51.6	19.3	12.9	3.2	116	1	29.7	29.0	16.0	8.4	6.3	3.6	1.9	2.0	3.1	581
							0	97.6	2.2	0.2	—	—	—	—	—	—	102
Reno, Nev.	56.0	41.6	24.3	5.6	2.4	87	1	82.6	15.4	1.8	0.2	—	—	—	—	—	152
							0	90.2	8.0	1.6	0.2	—	—	—	—	—	154*

Table 1 .... Data for determining Operating Characteristics of Snow-Melting Systems[a, 1] (Concluded)

City	Period of No Snowfall: Air Temperature, F[2] Over 32	Below or equal to 32	Mean during freezing period[3]	Wind speed freezing period,[3] mph	Period of Snowfall[2]: Hours of snowfall[2] Percent	Hr per year	Free area ratio, A_r	Required output, Btu per (sq ft) (hr)[4]: 0 to 49	50 to 99	100 to 149	150 to 199	200 to 249	250 to 299	300 to 349	350 to 399	400- up	Maximum output Btu/(sq ft) (hr)
	% of winter hours with no snow at above temperatures							Frequency distribution of snowfall hours at above outputs, percent[5]									
St. Louis, Mo.	68.7	30.4	25.0	11.5	0.9	33	1	42.9	31.4	16.7	7.1	1.9	—	—	—	—	225
							0	85.2	11.6	2.6	0.6	—	—	—	—	—	152
Salina, Kan.	60.0	38.5	23.3	10.9	1.5	54	1	44.9	31.9	12.7	7.6	2.2	0.7	—	—	—	286
							0	93.5	6.2	0.3	—	—	—	—	—	—	120
Sault Ste. Marie, Mich.	21.3	69.2	18.6	9.4	9.5	345	1	45.7	32.8	14.3	5.7	1.4	0.1	—	—	—	262
							0	97.9	2.0	0.1	—	—	—	—	—	—	144
Seattle Tacoma, Wash.	88.0	10.8	28.5	5.9	1.2	44	1	86.3	12.3	1.4	—	—	—	—	—	—	137
							0	91.0	8.1	0.9	—	—	—	—	—	—	128
Spokane, Wash.	48.5	46.1	25.7	10.7	5.4	196	1	62.6	28.7	7.4	1.1	2.0	—	—	—	—	205
							0	92.0	7.8	0.2	—	—	—	—	—	—	127
Washington, D. C.	77.9	21.2	26.8	9.6	0.9	33	1	59.0	29.8	10.6	0.6	—	—	—	—	—	154
							0	85.7	11.8	2.5	—	—	—	—	—	—	121

[a] From *Air Conditioning, Heating and Ventilating*, August, 1957, p. 87.

[1] The period covered by this table is from No. 1 to March 31, incl. with February taken as a 28¼ day month. Total hours in period = 3632. [2] The percentage in Columns 2 and 3 plus the percent under hours of snowfall total 100 percent. Note that *Hours of Snowfall* does not include idling time, and is not actual operating time. See text. [3] Snowfalls of trace amounts are not included; hence, *Hours of Snowfall* includes only those hours of 0.01 inches water equivalent per hour snowfall. [4] Output does not include allowance for back or edge losses since these depend on slab construction. [5] Percentages total 100 percent of the number of hours of snowfall. [6] *Freezing Period* is that during No Snowfall when the air temperature is 33 F or below. * When heat output for $A_r = 0$ equals or exceeds the heat output for $A_r = 1$, the heat transfer q_h is *from* the air *to* the slab. This occurs when snowfall is at temperatures above 33 F.

The sensible heat, q_s, to raise the temperature of the snow to 32 F is

$$q_s = 2.6s\,(32 - t_a) \qquad (3)$$

where

s = rate of snowfall, inches of water equivalent per hour.
t_a = air temperature, Fahrenheit.

The heat of fusion, q_m, to melt the snow is

$$q_m = 74\delta s \qquad (4)$$

The heat of evaporation, q_e, (mass transfer) is

$$q_e = h_{fg}(0.0201v + 0.055)(0.185 - p_{aw}) \qquad (5)$$

where

h_{fg} = heat of evaporation at the film temperature, Btu per pound.
v = wind speed, miles per hour.
p_{aw} = vapor pressure of moist air, inches of mercury.

The heat transfer, q_h, (convection and radiation) is

$$q_h = 11.4(0.0201v + 0.055)(t_f - t_a) \qquad (6)$$

where

t_f = water film temperature, Fahrenheit.

In addition to determining the four heating requirements, it is necessary to make allowance for back and edge losses. These losses vary from 30 to 50 percent, depending upon the slab construction and fluid temperature.

The equation for the required fluid temperature to provide an output q_o has been derived in Reference 2. For construction similar to Fig. 1, the equation is

$$t_m = 0.5q_o + t_f \qquad (7)$$

where

t_m = mean fluid temperature (antifreeze solution), Fahrenheit.

Equation 7 will apply to 1 in. as well as ¾ in. IPS pipe—see Fig. 1.

Equations 2 to 7 permit the designer to determine the heating requirement of a snow-melting system. The solutions of these equations, however, require the *simultaneous consideration* of the four climatic factors: (1) wind speed, (2) air temperature, (3) relative humidity, and (4) rate of snowfall. It is not satisfactory to use annual averages or maximums for the climatic factors. If averages or maximums are used there is no assurance that they will *ever* occur simultaneously. It is necessary, therefore, to make a frequency analysis of the solutions to Equation 2 for all the occurrences of snowfall for a period of several years. Such an analysis for 33 cities appears in Table 1 which contains the operating information for a snow-melting system. For freezing temperatures (32 F and below) without snowfall the system may be *idling* which means that some heat is supplied to the slab so that there will be immediate melting when snow starts to fall. Column 4 of Table 1 gives the average temperature during freezing periods. This temperature is used in calculating the *idling load*. The other term needed to calculate *idling load* is the wind speed during the period of freezing temperatures.

The column, Hours of Snowfall, indicates the number of hours that snow is falling at rates equal to or greater than 0.01 in. of water equivalent per hour. There are snowfalls of