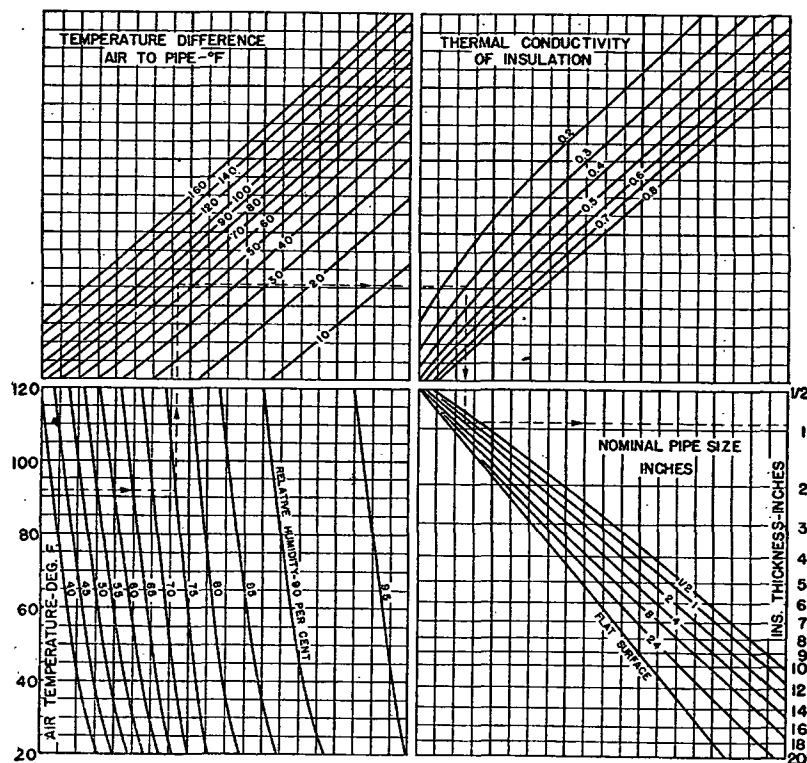


1.65, was used in calculating the curves. This value provides a slight factor of safety and its use is known to give satisfactory field results. In using the chart it is advisable to specify the next thicker, rather than the next thinner, commercial insulation in cases where an intermediate thickness is indicated.

Heat gains for pipes insulated with a material having an installed conductivity of 0.30 Btu per (square foot) (hour) (Fahrenheit degree per inch) are given in Table 8. This table may be used for any of the com-



*Solve problems as indicated by dotted line, entering chart at lower left-hand scale.

FIG. 5. THICKNESS OF PIPE INSULATION TO PREVENT CONDENSATION ON OUTER SURFACE*

mercial insulations offered for this purpose since they have conductivities very near the 0.3 value used.

INSULATION OF PIPES TO PREVENT FREEZING

If the surrounding air temperature remains sufficiently low for an ample period of time, insulation cannot prevent the freezing of still water, or of water flowing at such a velocity that the quantity of heat carried in the water is not sufficient to take care of the heat losses which will result and cause the temperature of the water to be lowered to the freezing point.

Insulation can materially prolong the time required for the water to give up its heat, and if the velocity of the water flowing in the pipe is maintained at a sufficiently high rate, freezing may be prevented.

Table 9 may be used for making estimates of the thickness of insulation necessary to take care of still water in pipes at various water and surrounding air temperature conditions. Because of the damage and service interruptions which may result from frozen water in pipes, it is essential that an efficient insulation be utilized. This table is based on the use of a material having a conductivity of 0.30. The initial water temperature is assumed to be 10 F above, and the surrounding air temperature 50 F below the freezing point of water (temperature difference, 60 F).

The last column of Table 9 gives the minimum quantity of water at initial temperature of 42 F which should be supplied every hour for each

TABLE 9. DATA FOR ESTIMATING REQUIREMENTS TO PREVENT FREEZING OF WATER IN PIPES WITH SURROUNDING AIR AT -18 F

NOMINAL PIPE SIZE (INCHES)	NUMBER OF HOURS TO COOL 42 F WATER TO FREEZING POINT	WATER FLOW REQUIRED AT 42 F TO PREVENT FREEZING, POUNDS PER LINEAR FOOT OF PIPE PER HOUR					
		Thickness of Insulation in Inches (Conductivity, $k = 0.30$)					
		2	3	4	2	3	4
1/2		0.42	0.50	0.57	0.54	0.45	0.40
1		0.83	1.02	1.16	0.68	0.55	0.48
1 1/2		1.40	1.74	2.02	0.84	0.68	0.58
2		1.94	2.48	2.90	0.95	0.75	0.64
3		3.25	4.27	5.08	1.24	0.94	0.79
4		4.55	6.02	7.20	1.47	1.11	0.93
5		5.92	7.96	9.69	1.73	1.29	1.06
6		7.35	9.88	12.20	1.98	1.46	1.19
8		10.05	13.90	17.25	2.46	1.78	1.43
10		13.00	18.10	22.70	2.96	2.12	1.70
12		15.80	22.20	28.10	3.43	2.45	1.93

linear foot of pipe, in order to prevent the temperature of the water from being lowered to the freezing point. The weights given in this column should be multiplied by the total length of the exposed pipe line expressed in feet. As an additional factor of safety, and in order to provide against temporary reductions in flow occasioned by reduced pressure, it is advisable to double the rates of flow listed in the table. It must be emphasized that the flow rates and periods of time designated apply only for the conditions stated. To estimate for other service conditions the following method of procedure may be used.

If water enters the pipe at 52 F instead of 42 F, the time required to cool it to the freezing point will be prolonged to twice that given in the table, or the rate of flow of water may be reduced so that the quantity required will be one-half that shown in the last column of Table 9. However, if the water enters the pipe at 34 F it will be cooled to 32 F in one-fifth of the time given in the table. It will then be necessary to increase the rate of flow so that five times the specified quantity of water will have to be supplied in order to prevent freezing.

If the minimum air temperature is -38 F (temperature difference 80 F) instead of -18 F, the time required to cool the water to the freezing point will be 60/80 of the time given in the table, or the necessary quantity of water to be supplied will be 80/60 of that given.