best advantage by combining a high temperature insulation near the pipe with a moderate or low temperature insulation around it as an outer layer. By this method an efficient material may be used for each of the two temperature ranges encountered. In calculating the heat loss through such a combination the mean temperature of each layer must be determined along with the thickness of each. This is readily done in three or four calculations performed as a series of approximations, in which assumptions

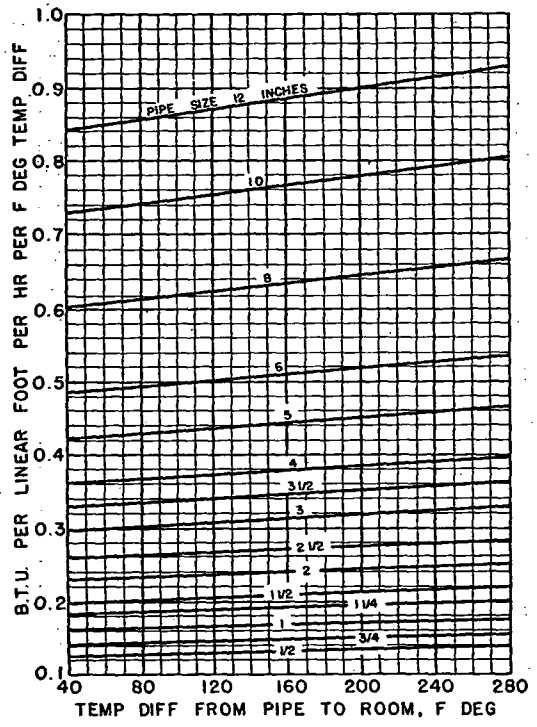

FIG. 2. HEAT LOSS THROUGH 1½ IN. THICK 85 PERCENT MAGNESIA TYPE COVERING

of thickness and mean temperature are adjusted as indicated in the discussion which follows.

In the case of a single thickness of pipe covering, the quantity of heat transferred per square foot of outer surface of the insulation is given by the equation:

$$q_o = \frac{k(t_1 - t_2)}{r_2 \log_e \frac{r_2}{r_1}} \qquad (1)$$

where

q_o = Btu per (hour) (square foot of outer surface of insulation).

r_1 = outer radius of pipe or inner radius of insulation, inches.

r_2 = outer radius of insulation, inches.

k = thermal conductivity of insulation, Btu per (hour) (square foot) (Fahrenheit degree per inch).

t_1 = temperature of inner surface of insulation, Fahrenheit degrees.

t_2 = temperature of outer surface of insulation, Fahrenheit degrees.

It is convenient to work from the outer surface of the insulation, since the loss through the covering must be determined from the outer surface loss by means of surface loss curves such as given in Fig. 4.

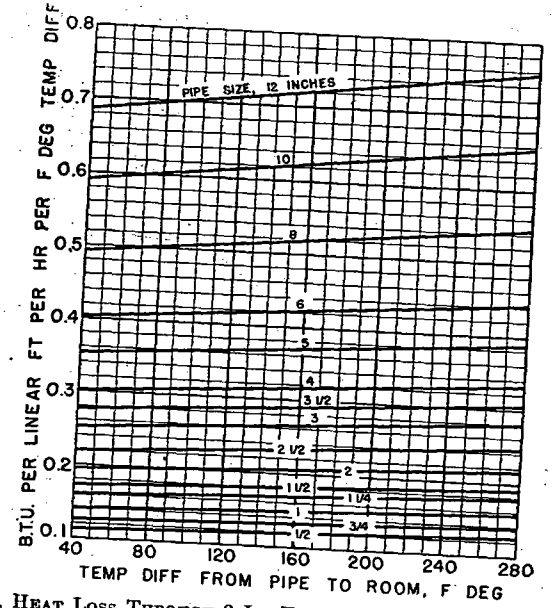

FIG. 3. HEAT LOSS THROUGH 2 IN. THICK 85 PERCENT MAGNESIA TYPE COVERING

After the true heat loss is obtained, the loss per square foot of pipe surface can be calculated from the relationship:

$$q_i = q_o(r_2/r_1)$$

where q_i = Btu per (hour) (square foot outer surface of pipe).

The heat loss through two or more thicknesses of insulation applied to a pipe can be calculated by means of the equation:

$$q_o = \frac{t_1 - t_2}{\frac{r_2 \log_e \frac{r_2}{r_1}}{k_1} + \frac{r_3 \log_e \frac{r_3}{r_2}}{k_2} + \cdots} \qquad (2)$$

where r_2 = outer radius of second layer of insulation, inches.

r_3 = outer radius of last layer of insulation, inches.