

resistance to heat flow inherent in the insulation itself. The maximum increase in heat loss due to air velocity ranges from about 15 per cent in the case of 1-in. thick insulation, to about 5 per cent in the case of 3-in. thick insulation, provided that the insulation is thoroughly sealed so that air can flow only over the surface.

If the conditions are such that the air may circulate through cracks and crevices in the insulation, the increases may be far greater than those given. Therefore, it is essential that insulation be sealed as tightly as

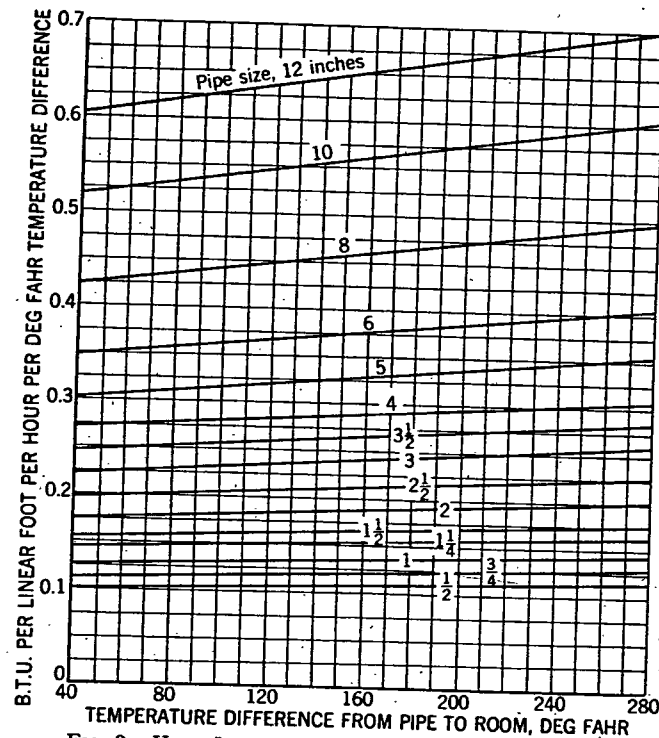


FIG. 3. HEAT LOSS THROUGH 2 IN. THICK 85 PER CENT MAGNESIA TYPE COVERING

possible. Pipe insulation exposed to the elements should be thoroughly waterproofed.

**Example 3.** If the steam line given in *Examples 1 and 2* is covered with 1 in. thick 85 per cent magnesia, determine the resulting total annual loss through the insulation. Also compute the monetary value of the annual saving and the percentage of saving over the heat loss from the bare pipe.

**Solution.** By referring to Fig. 1, the coefficient for 1 in. magnesia on a 2-in. pipe is found to be 0.285 Btu per hour per linear foot of pipe per degree temperature difference at a temperature difference of 169.4 F. The total hourly loss per linear foot of pipe will then be  $0.285 \times 169.4 = 48.3$  Btu. The total annual loss through the insulation =  $48.3 \times 165$  (linear feet)  $\times 4000$  (hours) = 31,900 Mb. The annual bare pipe loss as

determined in the solution of *Example 1* was found to be 181,600 Mb. The saving due to insulation is then  $181,600 - 31,900 = 149,700$  Mb per year.

From the solution of *Example 2*, it was found that the heat supplied to the system cost \$0.804 per thousand Mb. Therefore, the monetary value of the saving =  $0.804$  (dollars)  $\times 149.7$  (thousand Mb) = \$120.36, or 82.4 per cent of the cost when using uninsulated pipe.

TABLE 8. CONDUCTIVITY ( $k$ ) OF VARIOUS TYPES OF INSULATING MATERIALS FOR MEDIUM AND HIGH TEMPERATURE PIPES<sup>a</sup>

Expressed in Btu per hour per square foot per degree Fahrenheit temperature difference per inch thickness

| TYPES OF INSULATING MATERIALS                                  | MEAN TEMPERATURE, DEG F |       |       |       |       |
|----------------------------------------------------------------|-------------------------|-------|-------|-------|-------|
|                                                                | 100                     | 200   | 300   | 400   | 500   |
| 85 per cent Magnesia Type                                      | 0.359                   | 0.403 | 0.448 | 0.493 | 0.539 |
| Corrugated Asbestos Type<br>(4 Plies per 1 in. thick)          | 0.495                   | 0.618 | 0.741 | 0.864 | ----- |
| Corrugated Asbestos Type<br>(8 Plies per 1 in. thick)          | 0.505                   | 0.598 | 0.692 | 0.786 | ----- |
| Laminated Asbestos Type<br>(30-40 Laminations per 1 in. thick) | 0.326                   | 0.380 | 0.434 | 0.488 | 0.543 |
| Laminated Asbestos Type<br>(14-20 Laminations per 1 in. thick) | 0.374                   | 0.445 | 0.518 | 0.589 | 0.662 |
| Mineral Wool Type                                              | 0.350                   | 0.410 | 0.470 | 0.530 | 0.590 |
| High Temperature Type<br>(Diatomaceous Earth and Asbestos)     | 0.576                   | 0.614 | 0.652 | 0.689 | 0.726 |
| Brown Asbestos Type<br>(Felted Fiber)                          | 0.338                   | 0.396 | 0.453 | 0.510 | 0.568 |

<sup>a</sup>From tests conducted at Mellon Institute.

TABLE 9. PIPE COVERING FACTORS

| TYPES OF INSULATING MATERIALS                                  | TEMPERATURE DIFFERENCE, PIPE TO AIR, DEG F |       |       |       |       |       |
|----------------------------------------------------------------|--------------------------------------------|-------|-------|-------|-------|-------|
|                                                                | 100                                        | 200   | 300   | 400   | 500   | 600   |
| 85 per cent Magnesia Type                                      | 1.050                                      | 1.024 | 0.997 | 0.971 | 0.944 | 0.918 |
| Corrugated Asbestos Type<br>(4 Plies per 1 in. thick)          | 1.425                                      | 1.465 | 1.505 | 1.545 | ----- | ----- |
| Corrugated Asbestos Type<br>(8 Plies per 1 in. thick)          | 1.435                                      | 1.437 | 1.438 | 1.440 | ----- | ----- |
| Laminated Asbestos Type<br>(30-40 Laminations per 1 in. thick) | 0.969                                      | 0.960 | 0.951 | 0.942 | 0.933 | 0.924 |
| Laminated Asbestos Type<br>(14-20 Laminations per 1 in. thick) | 1.103                                      | 1.104 | 1.105 | 1.106 | 1.107 | 1.108 |
| Mineral Wool Type                                              | 1.023                                      | 1.028 | 1.033 | 1.038 | 1.043 | 1.048 |
| High Temperature Type<br>(Diatomaceous Earth and Asbestos)     | 1.560                                      | 1.489 | 1.418 | 1.347 | 1.276 | 1.205 |
| Brown Asbestos Type<br>(Felted Fiber)                          | 1.003                                      | 0.997 | 0.990 | 0.984 | 0.977 | 0.971 |

### LOW TEMPERATURE PIPE INSULATION

Surfaces maintained at temperatures lower than the surrounding air are insulated to reduce the flow of heat and to prevent condensation and frost. The insulating material should absorb a minimum amount of moisture, because the absorption of moisture substantially increases the conductivity of the material. This property is particularly important in