

## CHAPTER 18

### Pipe Insulation

*Heat Losses from Bare and Insulated Pipes, Low Temperature Pipe Insulation, Insulation of Pipes to Prevent Freezing, Economical Thickness of Pipe Insulation, Underground Pipe Insulation*

THE heat transfer through uninsulated pipes may be of considerable magnitude if the temperature of the surrounding medium differs appreciably from that of the fluid conveyed. Careful consideration must, therefore, be given to this factor in a properly designed system and adequate insulation provided, if necessary.

#### HEAT LOSSES FROM BARE PIPES

Heat losses from horizontal bare steel pipes, based on tests at *Mellon Institute* and calculated from the fundamental radiation and convection equations (Chapter 3), are given in Table 1. Heat losses from horizontal copper tubes and pipes with bright, lacquered and tarnished surfaces, are given in Tables 2, 3 and 4<sup>1</sup>.

The area in square feet per linear foot of pipe is given in Table 5 for various standard pipe sizes, and Table 6 for copper tubing, while Table 7 gives the area in square feet of flanges and fittings for various standard pipe sizes. These tables can be used to advantage in estimating the amount of insulation required.

Very often, when pipes are insulated, flanges and fittings are left bare so as to allow for easy access to the fittings in case of repairs. The fact that a pair of 8-in. standard flanges having an area of 2.41 sq ft would lose, at 100 lb steam pressure, an amount of heat equivalent to more than a ton of coal per year shows the necessity for insulating such surfaces.

Examples 1 and 2 show how the annual heat loss from uncovered pipe and its dollar value may be computed from the data in Table 1.

**Example 1.** Compute the total annual heat loss from 165 ft of 2 in. bare pipe in service 4000 hours per year. The pipe is carrying steam at 10 lb pressure and is exposed to an average air temperature of 70 F.

**Solution.** The pipe temperature is taken as the steam temperature, which is 239.4 F, obtained by interpolation from Table 8, Chapter 1. The temperature difference between the pipe and air =  $239.4 - 70 = 169.4$  F. By interpolation of Table 1 between temperature differences of 157.1 and 227.7 F, the heat loss from a 2-in. pipe at a temperature difference of 169.4 F is found to be 1.624 Btu per hour per linear foot per degree temperature difference. The total annual heat loss from the entire line =  $1.624 \times 169.4 \times 165$  (linear feet)  $\times 4000$  (hours) = 181,600 Mb.

<sup>1</sup>Heat Loss from Copper Piping, by R. H. Heilman (*Heating, Piping and Air Conditioning*, September, 1933, p. 458).

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**Example 2.** Coal costing \$11.50 per ton and having a calorific value of 13,000 Btu per pound is being burned in the furnace supplying steam to the pipe line given in the previous example. If the system is operating at an overall efficiency of 55 per cent, determine the monetary value of the annual heat loss from the line.

**Solution.** The cost of heat per 1000 Mb supplied to the system =  $1,000,000 \times 11.5$

TABLE 1. HEAT LOSSES FROM HORIZONTAL BARE STEEL PIPES  
Expressed in Btu per hour per linear foot per degree Fahrenheit difference in temperature between the pipe and surrounding still air at 70 F

| NOMINAL PIPE SIZE (INCHES) | HOT WATER              |       |       |       | STEAM          |                 |                  |
|----------------------------|------------------------|-------|-------|-------|----------------|-----------------|------------------|
|                            | 120 F                  | 150 F | 180 F | 210 F | 227.1 F (5 Lb) | 239.7 F (50 Lb) | 337.9 F (100 Lb) |
|                            | TEMPERATURE DIFFERENCE |       |       |       |                |                 |                  |
|                            | 50 F                   | 80 F  | 110 F | 140 F | 157.1 F        | 227.7 F         | 267.9 F          |
| 1/2                        | 0.455                  | 0.495 | 0.546 | 0.584 | 0.612          | 0.706           | 0.760            |
| 3/4                        | 0.555                  | 0.605 | 0.666 | 0.715 | 0.748          | 0.866           | 0.933            |
| 1                          | 0.684                  | 0.743 | 0.819 | 0.877 | 0.919          | 1.065           | 1.147            |
| 1 1/4                      | 0.847                  | 0.919 | 1.014 | 1.086 | 1.138          | 1.324           | 1.425            |
| 1 1/2                      | 0.958                  | 1.041 | 1.148 | 1.230 | 1.288          | 1.492           | 1.633            |
| 2                          | 1.180                  | 1.281 | 1.412 | 1.512 | 1.578          | 1.840           | 1.987            |
| 2 1/2                      | 1.400                  | 1.532 | 1.683 | 1.796 | 1.883          | 2.190           | 2.363            |
| 3                          | 1.680                  | 1.825 | 2.010 | 2.153 | 2.260          | 2.630           | 2.840            |
| 3 1/2                      | 1.900                  | 2.064 | 2.221 | 2.433 | 2.552          | 2.974           | 3.215            |
| 4                          | 2.118                  | 2.302 | 2.534 | 2.717 | 2.850          | 3.320           | 3.590            |
| 5                          | 2.580                  | 2.804 | 3.084 | 3.303 | 3.470          | 4.050           | 4.385            |
| 6                          | 3.036                  | 3.294 | 3.626 | 3.886 | 4.074          | 4.765           | 5.160            |
| 8                          | 3.880                  | 4.215 | 4.638 | 4.960 | 5.210          | 6.100           | 6.610            |
| 10                         | 4.760                  | 5.180 | 5.680 | 6.090 | 6.410          | 7.490           | 8.115            |
| 12                         | 5.590                  | 6.070 | 6.670 | 7.145 | 7.500          | 8.800           | 9.530            |

TABLE 2. HEAT LOSS FROM HORIZONTAL BARE BRIGHT COPPER PIPE  
Expressed in Btu per hour per linear foot per degree Fahrenheit difference between the pipe and surrounding still air at 70 F

| NOMINAL PIPE SIZE (INCHES) | HOT WATER (Type K Copper Tube) |       |       |       | STEAM (Standard Pipe Size Pipe) |                 |                  |
|----------------------------|--------------------------------|-------|-------|-------|---------------------------------|-----------------|------------------|
|                            | 120 F                          | 150 F | 180 F | 210 F | 227.1 F (5 Lb)                  | 239.7 F (50 Lb) | 337.9 F (100 Lb) |
|                            | TEMPERATURE DIFFERENCE         |       |       |       |                                 |                 |                  |
|                            | 50 F                           | 80 F  | 110 F | 140 F | 157.1 F                         | 227.7 F         | 267.9 F          |
| 1/2                        | 0.180                          | 0.210 | 0.218 | 0.229 | 0.299                           | 0.338           | 0.355            |
| 3/4                        | 0.236                          | 0.275 | 0.291 | 0.307 | 0.357                           | 0.408           | 0.418            |
| 1                          | 0.290                          | 0.338 | 0.354 | 0.373 | 0.440                           | 0.492           | 0.523            |
| 1 1/4                      | 0.340                          | 0.400 | 0.418 | 0.443 | 0.510                           | 0.571           | 0.598            |
| 1 1/2                      | 0.390                          | 0.463 | 0.473 | 0.507 | 0.598                           | 0.671           | 0.710            |
| 2                          | 0.490                          | 0.525 | 0.600 | 0.628 | 0.719                           | 0.813           | 0.851            |
| 2 1/2                      | 0.580                          | 0.675 | 0.709 | 0.750 | 0.840                           | 0.953           | 1.008            |
| 3                          | 0.680                          | 0.788 | 0.848 | 0.871 | 0.987                           | 1.107           | 1.165            |
| 3 1/2                      | 0.760                          | 0.888 | 0.946 | 1.000 | 1.114                           | 1.235           | 1.307            |
| 4                          | 0.940                          | 1.000 | 1.045 | 1.107 | 1.210                           | 1.361           | 1.456            |
| 4 1/2                      | ...                            | ...   | ...   | ...   | 1.335                           | 1.495           | 1.488            |
| 5                          | 1.020                          | 1.200 | 1.255 | 1.320 | 1.465                           | 1.670           | 1.755            |
| 6                          | 1.160                          | 1.375 | 1.410 | 1.500 | 1.685                           | 1.890           | 1.942            |
| 8                          | 1.460                          | 1.725 | 1.820 | 1.890 | 2.100                           | 2.373           | 2.510            |