

The relation between flow in thousands of pounds per hour and friction loss in feet per 100 ft of pipe as shown in Fig. 20 is based on the Fanning formula:

$$h_f = \frac{4flv^2}{2gd\rho}$$

where

h_f = head loss in feet of water at 62 F per foot of pipe.

f = friction factor.³

l = length, feet.

v = average flow velocity, feet per second.

g = gravitational acceleration, in feet per (second) (second).

d = inside diameter of pipe, feet.

ρ = density, pounds per cubic foot.

$$f = \frac{0.0650}{N_{Re}^{0.25}} \quad N_{Re} = \frac{dv}{\nu}$$

N_{Re} = Reynolds number.

ν = kinematic viscosity = $\frac{\mu}{\rho}$

ν = 0.215×10^{-5} square feet per second.

μ = absolute viscosity, pounds per foot second.

When corrections are desirable Fig. 21 may be used to correct the friction loss as found in Fig. 20.

The friction loss in fittings expressed in equivalent feet of pipe is given in Table 8.

Circuits

High temperature water is used directly in unit heaters, air heating coils, steel heating panels, and process equipment. Evaporators or steam generators are used for generating steam where required for steam heating systems and equipment. Converters or heat exchangers are also used for building heating and domestic hot water service systems.

Smaller district heating systems which are pressurized to 30 psig with distribution at 250 F are in common use. In such installations the water is drawn into the individual building systems and recirculated by means of a conventional circulator. Temperature is controlled in each system by a control valve at the high temperature line. The control is usually of the indoor-outdoor type, but many variations are used. Sufficient pressure head is usually available to permit circulation of the high temperature water through domestic water heaters for individual supply in each building.

Pumps for High Temperature Systems

Circulating pumps form one of the most important components of the system, and are installed in the flow main to increase the static pressure in the main and thereby maintain a satisfactory temperature-pressure relationship. It is common practice to use single-inlet single-stage centrifugal pumps operating at 1750 rpm and having water-cooled bearings and glands (although mechanical seals are coming into use). With pumps of this type the total differential head should not exceed 150 ft.

Pumps for high temperature must be specially designed and constructed to withstand the high pressure and temperature, at which they will

operate, and the higher stresses involved. For space heating loads where the flow varies greatly, it is common practice to use two or more pumps, although care should be taken in motor sizing to avoid overloading when one or more pumps may not be in operation. By use of multiple pumps light loads during off peak periods can be handled economically.

When selecting the size of the pump, consideration should be given to the temperature conditions under which the pump will operate. To illustrate this, at 212 F the density of water is 59.88 lb per cu ft, whereas at 380 F it has dropped to 54.36. Therefore, as the weight of a gallon of water is considerably less, the pump will have to handle a much larger volume of water. On large installations the pump sizes can be kept down to practical limits by the use of multiple pumps connected in parallel to a common header.

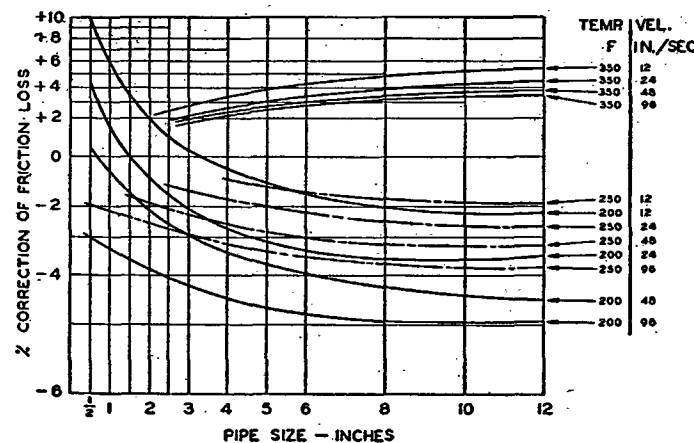


FIG. 21. CORRECTION OF 300 F FRICTION LOSS FOR OTHER WATER TEMPERATURES

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To prevent flashing to steam at the pump suction line, a by-pass is fitted between the supply and return lines to allow a small quantity of the return water to mix with the supply water from the boiler. This by-pass line is manually controlled, and connects into the supply line as near to the suction inlet of the pump as possible.

Pipe, Fittings, and Insulation

Steel pipe and fittings are generally used. An effort should be made to avoid the use of non-ferrous materials, since the action of the water at elevated temperatures on these materials is difficult to predict.

Steel pipe should be used throughout, and piping external to the boiler house should be welded. Within the boiler house flanges are recommended to facilitate inspection and provide ready access. Branches should take off with easy sweeps and full radius bends be used for all changes of direction. Provision for expansion is as important as for steam at the same