be raised to ensure that the pressure is always above the equivalent evaporation pressure.

In modern systems, the pressure can be maintained by using steam or a compressed inert gas. With steam, the steam space within the boiler or the steam space in an external drum or tank, which is also used as an expansion vessel, is utilized to produce the required pressure. By using an inert gas, the desired system pressure can be maintained while the water temperature can be regulated to the desired system temperature.

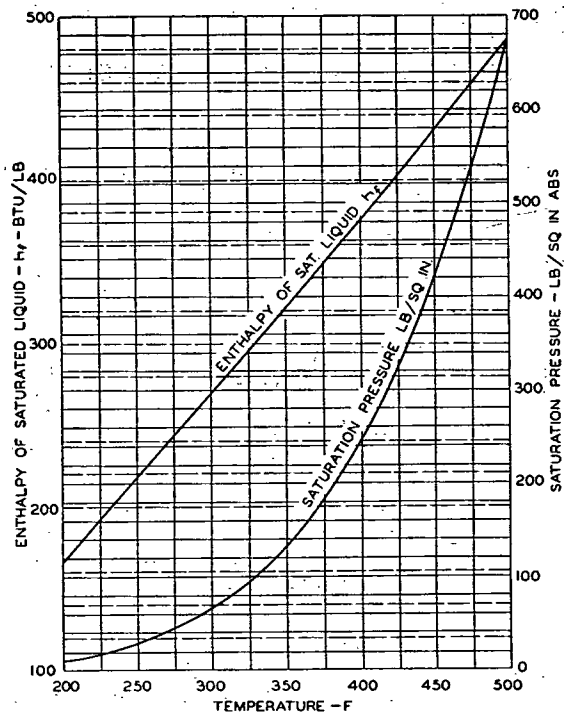


FIG. 22. RELATION OF SATURATION PRESSURE AND ENTHALPY TO WATER TEMPERATURE

The properties of water which must be considered in the design are:

1. Boiling point (t) *vs.* pressure. (See Fig. 22)
2. Density or specific volume (v_s) *vs.* temperature.
3. Enthalpy or sensible heat (h_f) *vs.* temperature.
4. Viscosity (μ) *vs.* temperature.

Boiling point, specific volume and enthalpy are all discussed in Chapter 3, and the data for the normal temperature pressure ranges are given in Table 3 of Chapter 3. As viscosity is reduced materially with increase in temperature, the consequent reduction in pipe friction should be considered a prime asset of high temperature water systems. (See Fig. 23.)

Since the specific heat of water varies only slightly with temperature, it can be ignored in normal design. But as the specific volume varies with

temperature, it has been found more convenient in design to use *pounds per hour* in lieu of gallons per minute, and the accompanying charts are plotted on this basis.

Design and Economics

High temperature water systems differ from conventional systems in that flow main temperatures range from 250 F to 400 F. For flow tempera-

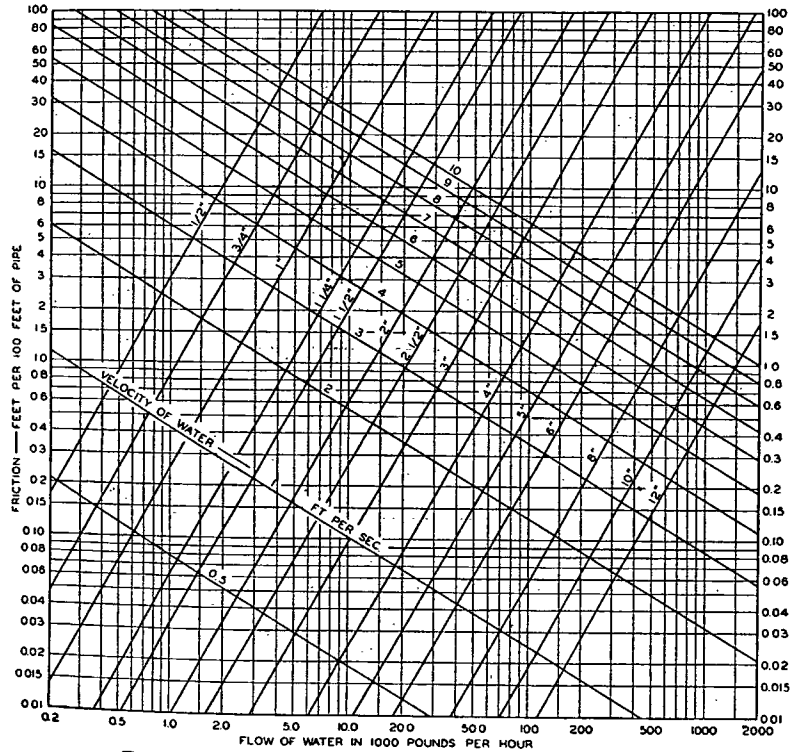


FIG. 23. FRICTION LOSS FOR 300 F WATER IN COMMERCIAL STEEL PIPE (SCHEDULE 40)
(Friction given in feet of 62 F water per 100 ft of pipe.)

tures of 250 to 350 F, temperature drops of 80 deg to 150 deg are in common use. For higher flow temperatures the drop will increase to temperatures dependent upon the requirements of the user and can be as high as 200 deg. With these higher drops and consequent decreased flows, pipe sizes are greatly reduced in comparison with those used for conventional hot water systems.

Fig. 23 is based on a water temperature of 300 F and shows the friction *vs.* flow for water in standard good condition schedule 40 steel pipe. The temperature chosen, 300 F, is the normal mean between flow and return.

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