upper part of the heater where the water cascading from horizontal baffles comes in direct contact with steam.

The steam in the upper part of the heater serves as the steam cushion for pressurizing the system. The lower part of the heater serves as the expansion tank for the system.

Where the water heater and the boiler operate under the same pressure, the surplus water is usually returned to the boiler through a pipeline connecting the outlet of the high-temperature water circulating pump to the boiler. This system is also applicable where mixed steam and high-temperature water services are required.[7]

Fig. 10 shows a method by which high-temperature water in a heat exchanger heats water for a comfort heating system which uses supply water temperatures of 180 F to 240 F. Fig. 10 is a schematic diagram and is not intended to show exact piping details and safety, or control equipment required. With high-temperature water at 300 to 350 F a temperature differential between entering and leaving water of approximately 100 deg may be used. Automatic control of such generators or converters is preferable and is discussed in a later section, Temperature Control.

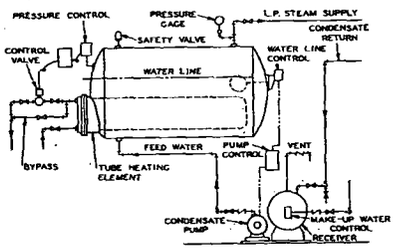


Fig. 11 .... Heat Exchanger Used as Steam Generator

Fig. 11 shows a tubular heat exchanger in which low- or medium-pressure steam is produced by heat transferred from high-temperature water circulated through the tubes. In order to produce the required quantity of steam the mean water temperature in the tubes may need to be within 20 to 30 deg of the original temperature of water in the high temperature system.

Circulating Pumps

Circulating pumps for temperatures above 240 F should be built for continuous operation at high temperature. The preferable types have bearings and stuffing boxes that are water cooled. The bed plate and mountings should be designed to permit expansion and contraction without causing misalignment. Since continuity of service depends upon the circulating pumps, they should be installed in duplicate to provide standby service.

It is good practice to locate the circulating pump in the supply line in order to maintain all parts of the distributing system at pressures exceeding boiler pressure. This location is also preferred since water in the system would flash into steam if the pressure in the piping decreased below the pressure corresponding to the temperature of the water at saturation. Connections which permit some return water to bypass the boiler and enter the supply line as a means of preventing flash steam in the flow main are very important.

With inert gas pressurization the system pressure may be maintained above the saturation pressure. This difference in pressures may be from 10 to 50 psi, depending on system design temperatures and pressure ratings of components and relief devices.

Sufficient net positive suction head (NPSH) should be available at the pump suction flange. Proper design of the pump piping in this respect will avoid *cavitation*.[8] In selecting a pump its pumping head and water circulation rate must be carefully evaluated in order to permit selection of the proper driving motor. The effect of density variation between the high and low temperature must be considered. Pump characteristics as affected by system characteristics, should be given consideration to insure nonoverloading conditions in pump motor operation.

DISTRIBUTION PIPING DESIGN

The arrangement of piping and necessity for zoning will be determined by such factors as the hours of operation, the nature of the space occupancy, and the required water temperature. These factors, together with the heat requirements of the equipment served, will establish the temperature drop which, in common practice, may range from 80 to 150 deg.

Economic considerations require that the savings due to use of small pipe and high velocity circulation be balanced against the cost of valves, pumps, etc., that are suitable for operation at the high friction loss and pressure. The best overall investment will be secured when there is a proper relation between first cost, operating cost (including that of the operating personnel), and the fixed charges.

Fig. 12 shows the relation (based on the Fanning formula in Equation 8 of Chapter 4) of the water flow in thousands of pounds per hour to the friction loss in feet of 62 F water at a mean temperature of 300 F in Schedule 40 commercial steel pipe in sizes ½ to 12 in. The temperature 300 F is a normal mean between flow and return temperatures in the system. Correction of friction loss for other temperatures may be obtained from Fig. 13. Allowance for friction loss in fittings may be obtained from Table 2.

District Distribution

The conventional conduit or tunnel distribution systems are employed with similar techniques used for installation. Although the mains may be run at different elevations at will, it is important that high points be vented and the low points drained by the air collection and venting arrangement described earlier. Grading is not critical. See Chapter 27, District Heating.

The piping serving each building or process load should have a valved bypass connection between the supply and the return pipe in addition to the usual stop valves as indicated in Fig. 1.

Pipe, Valves, and Fittings

All pipe, valves, and fittings used in high-temperature systems should comply with the requirements of the *American Standard Code for Pressure Piping*, ASA B 31.1—1955. This code states that hot water systems shall be designed for the highest pressure and temperature actually existing in the piping under normal operation. This pressure is the cushion pressure plus pump head plus static pressure.

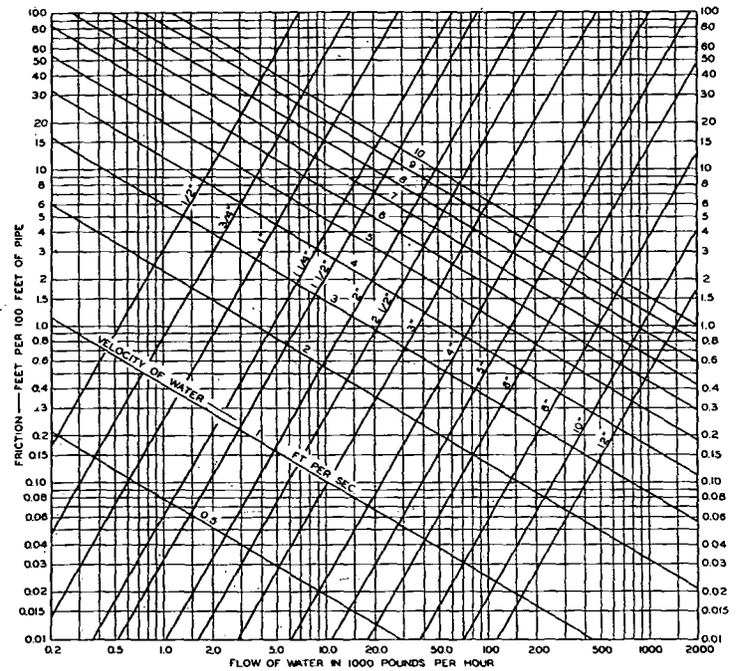
Individual heating equipment units should preferably be installed with a lock-shield valve for balancing the flow and a separate valve for shut-off. These may be placed in the most convenient position for accessibility. If the unit is to be isolated for service, valves will be needed in both the supply and return piping to the unit. Valve trim should be of stainless steel or other alloy that will prevent corrosion.

Thermostatically operated valves in the control equipment should be of the electric-motor-operated or pneumatic type. Their selection is discussed in a later section, Temperature Control. (See also Chapter 43, Automatic Control.)

High points in piping should be provided with chambers and air vents for collecting and removing air and low points should have provision for sludge removal, as illustrated in Fig. 14.

Loop-type expansion joints, in which the expansion is absorbed by deflection of the pipe loop, are preferable to the packed-metal type. If mechanical expansion joints are used, they should be of the guided type.

As high-temperature water is more penetrating than low-temperature water, leakage due partly to capillary action should not be ignored because even a small amount of leakage vaporizes immediately. This slight leakage becomes no-



(Friction given in feet of 62 F water per 100 ft of pipe.)

Fig. 12 .... Friction Loss for 300 F Water in Commercial Steel Pipe (Schedule 40)

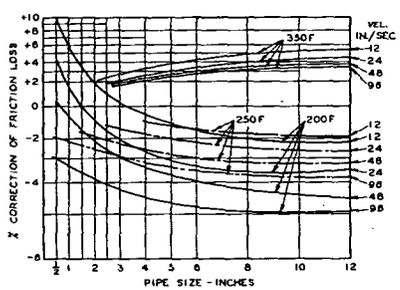


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Fig. 13 .... Correction of 300 F Friction Loss for Other Water Temperatures