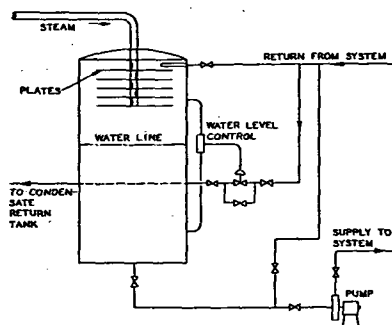




Used by permission from Reference 6.

Fig. 8 Direct Contact Heater for Generating High-Temperature Water

into the boiler through a pipe connecting the outlet of the high-temperature water circulating pump to the boiler. This system is also applicable where both steam and high-temperature water services are required.¹ Where heat and power production are combined, the direct contact heater becomes the mixing condenser.¹

System Circulating Pumps

Forced circulation boiler systems may be either of the one-pump or two-pump type. These terms do not refer to the number of pumps, but to the number of groups of pumps employed. In the former (see Fig. 9) a single group of pumps

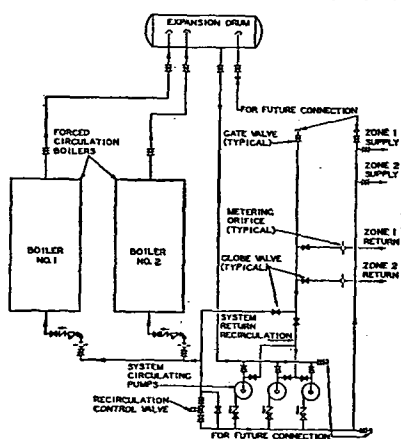


Fig. 9 High-Temperature Water Piping for Combined (One-Pump) System

assures both generator and distribution system circulation. In this system both the distribution system and the generators are in series.¹

However, to assure the minimum flow through the boiler at all times, a bypass around the district must be provided. This applies generally only to systems in which the total friction head is relatively low, since the energy loss of available circulating head due to throttling in the bypass at times of reduced flow requirements in the district may substantially increase the operating cost.

The two-pump system (see Fig. 10) employs an additional group of recirculating pumps solely for the purpose of providing circulation for the generators.¹ One pump is normally used for each generator to draw water from the expansion drum or the system return and pump it through the generator into the expansion drum. The system circulating pumps draw water from the expansion drum and circulate it through the distribution system only. This system provides full flexibility. The supply temperature to the distribution system can be varied by mixing water from the return into the supply on the pump suction side. Where zoning is required, several groups of pumps can be employed with a different head and different temperature in each zone. The flow rate can also be varied without affecting the generator circulation, and without the use of a system bypass.

In steam-pressurized systems the circulating pump is installed in the supply line in order to maintain all parts of the distributing system at pressures exceeding boiler pressure, and thus minimize the danger of flashing into steam. Special care must be exercised in the design of the suction line from the expansion drum to the pump in order to avoid flashing in the line, and to provide the net positive suction head (NPSH) required by the pump at the inlet to the impeller.

It is common practice to install a mixing connection from the return to the pump suction which bypasses the high-temperature water generator. This connection is used for

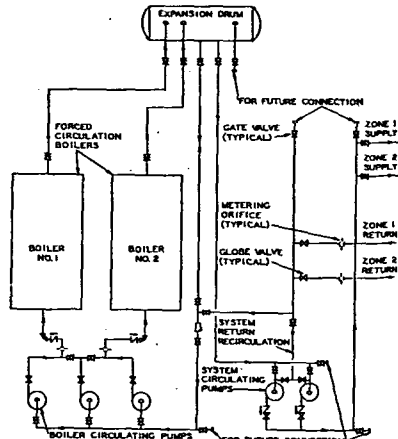


Fig. 10 High-Temperature Water Piping for Separate (Two-Pump) System

High-Temperature Water Systems

startup and for modulating the supply temperature. This mixing connection should not be relied on for increasing NPSH at the pump inlet. Where it is impossible to provide the required submergence by proper design, a separate small-bore premixing line should be provided.

In selecting a pump, the pumping head and water circulation rate must be carefully evaluated in order to permit selection of a proper 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 assure non-overloading conditions in pump motor operation.

Most pump applications today are of the vertical, split-case, centerline-mounted type with mechanical seals. Care must be taken to keep the shaft seal and sleeves clean during the initial startup of the system. Many manufacturers recommend the use of water cooling chambers for both seal and bearing cooling in HTW applications. Also available today are hermetically sealed pumps which eliminate the shaft sealing problem by putting the motor into the water circuit.

DISTRIBUTION PIPING DESIGN

Fig. 11 shows the relation of the flow of water in thousands of pounds per hour to the friction loss in feet per 100 ft of Schedule 40 pipe in sizes from 1/2 in. to 12 in. Fig. 12 shows a correction curve to be used with Fig. 11 to correct the friction loss according to the water temperature. For example, with 17,000 lb per hr of water at 400 F flowing through a 2 in., Schedule 40 pipe, the friction loss is found from Fig. 11 as 2.25 ft per 100 ft. The correction for temperature, from Fig. 12, is 1.185, and the corrected friction loss is $2.25 \times 1.185 = 2.67$ ft per 100 ft of pipe.

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.

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 7, 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.

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. Schedule 40 steel pipe is applicable to most HTW systems with welded steel fittings and steel valves. It is desirable to minimize the number of joints in the system and many installations are

welding or brazing all valves in the piping system. Flange connections generally used at major equipment may be of the serrated, raised flange facing or of the ring joint type. It is desirable to have all valves of the back-seating type and provided with special packing suitable for this service.

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.

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.

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 noticeable only on the outside of the gland and stem of the valve where thin deposits of salt are left after evaporation.

HEAT EXCHANGERS

Heat exchangers or converters generally use steel shells with stainless steel, admiralty metal, or cupro-nickel tubes. The choice of material needs careful consideration in relation to the pressure-temperature characteristics of the particular system. All connections should either be flanged or welded. On larger exchangers, water-box type construction is desirable to facilitate removal of the tube bundle without breaking piping connections.

AIR HEATING COILS

In HTW systems over 400 F, it is recommended that coils be of all-steel construction. Below this point other materials may be used after careful checking of their suitability for the temperatures involved. Coils in outdoor air connections need careful freeze-up protection. This may take the form of damper closure or fan shut down from a freeze-up thermostat. It is also possible to set the control valve on the preheat coil to a minimum position. This may protect against freeze-up as long as no unbalance takes place in the tube circuits where parallel paths of HTW flow exist. Special coil design of a tube-within-a-tube construction is available. A further alternative is the use of a HTW heat exchanger bundle in the base of a vertical tube section which then operates as a gravity steaming heat exchanger surface.

Pressure gauges should be installed in the pump discharge and suction and at locations where pressure readings will assist operation and maintenance. Thermometers (preferably dial type) or thermometer wells should be installed in the flow and return pipes, the pump suction and discharge, and at any other points of major temperature change or where temperatures are of importance in operating the system. Thermometers and gages are desirable in the piping at the entrance to each building converter.

SPACE HEATING EQUIPMENT

In industrial areas, space heating equipment may often be operated with high-temperature water due to its availability. Convectors and radiators may require water temperatures in the low and medium temperature ranges (120 to