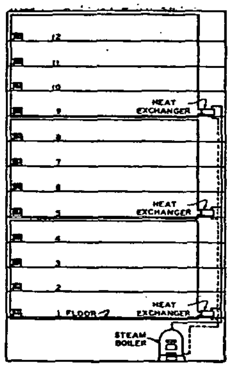
tures by room thermometers, and the determination of the temperature drop of water flowing through a heating unit or zone by means of surface contact thermometers or thermometers installed in the piping. When adjustment is made by means of water temperature drop, the capacity of the units after adjustment must equal the heat delivery actually required. Control is then accomplished by making the temperature drop through all units equal.



(Provision should be made for expansion in each closed circuit)

Fig. 20 .... Vertical Zoning of Hot Water Heating System in a 12-Story Building

The procedure for making a permanent adjustment of heat distribution in a larger system should be as follows:

1. Select a time or day when conditions of heat gain are minimum; i.e., nighttime or an overcast day. Outdoor temperatures should be such as to require at least 50 percent of the system capacity to maintain the design indoor temperature.
2. Place the system in operation and make certain that all valves, adjusting fittings, and dampers are in the open position. Automatic control which might reduce the flow or capacity of any unit should be rendered inoperative. Doors and openings between rooms should be closed.
3. Prepare a form for recording data on temperatures in spaces or at the supply and return of heating elements or of zones.
4. After the system has reached equilibrium a complete record should be made of temperatures throughout the system.
5. An initial adjustment of flow regulating devices in the system should be made on the basis of the record of the original readings. A new set of temperature readings should be recorded after sufficient time has been allowed to establish a new equilibrium throughout the building.
6. Continue adjustments of flow control devices until a satisfactory condition is obtained.
7. When a satisfactory adjustment has been accomplished, it is advisable to *mark the position of each of the adjusting fittings or valves*. This facilitates return to proper control settings if the flow controls are disturbed by accidental or emergency changes at any time.

CARE AND MAINTENANCE OF SYSTEMS

A hot water heating system should last during the life of the building if it is designed, installed, and maintained properly. Maintenance instructions for individual elements of the system such as burners, motors, pumps, and accessories may be obtained from the manufacturers who supply this equipment. Two factors contribute in a most important way to the satisfactory operation and life of the hot water heating system: (1) the proper cleaning of the system when installed; and (2) a minimum change of water in the system, except as required by periodic maintenance of the boiler or draining of the expansion tank.

INITIAL CLEANING OF SYSTEM

Rules that should be followed for the initial cleaning of the system are:

1. All equipment and piping should be thoroughly cleaned of iron cuttings and other refuse during assembly and installation.
2. When installation is complete, the system should be filled with a solution of 1 lb of trisodium phosphate per 50 gal of water and should be operated for 24 hr at maximum temperature with all pumps operating. The system should then be drained and thoroughly flushed with water before refilling.

In order to minimize the addition of water to the heating system, the operation of air-vent valves, relief valves, and the tightness of the system generally should be subject to continuous inspection. Drips from automatic air-vent valves should discharge in places where leakage is readily detected. Continual operation of the pressure relief valve should be a signal for the inspection, repair, or replacement of the relief valve, or a check on the operation of the expansion tank or the automatic water feeder, if one is provided.

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CHAPTER 9

HIGH-TEMPERATURE WATER SYSTEMS

Features; Basic System; Design Considerations: Direct-Fired High-Temperature Water Generators, Pressurization, Direct-Contact Heaters, System Circulating Pumps; Distribution Piping Design; Heat Exchangers, Air Heating Coils; Space Heating Equipment; Temperature Control; Water Treatment; Storage; Safety Considerations

HIGH-TEMPERATURE water systems have been classified as those operating with supply water temperatures above 350 F, and medium-temperature water systems as those with operating temperatures above 250 F and below 350 F. The usual practicable limit of temperature is approximately 450 F, due to pressure limitations on pipe fittings, equipment, and accessories. The general design principles are basically the same for both medium-temperature and high-temperature systems. Both require water under considerable pressure, and therefore require special pumps, boilers, and equipment. The basic differences are in the pressure, temperature drops and average temperatures, with resulting differences in cost. In this chapter, the abbreviation HTW will be used to refer to both medium-temperature and high-temperature systems.

This chapter is intended to give a broad general idea of principles and practices that apply to high-temperature systems and distinguish these systems from the systems operating below 250 F.

FEATURES OF SYSTEMS

The following are among the outstanding features of HTW systems as compared to steam distribution systems or low-temperature water systems:

1. The system is generally a completely closed circuit with supply and return mains maintained under pressure. There are no losses due to flashing, and the heat not utilized in the terminal heat transfer equipment is returned to the high-temperature water generator. Corrosion within the system is minimized.
2. In general, all mechanical equipment other than that which controls the performance of individual terminal units is confined to the central station.
3. Piping may slope up or down or run at a variety of elevations to suit the terrain and the architectural and structural requirements without provision for drainage at each low point, except for emptying sections of piping for shut down. This may reduce the amount of excavation required, and the number of drip points and return pump locations, as compared to steam.
4. It is common practice to use greater temperature drops than in low-temperature water systems.
5. The pressure in any part of the system must always be above the pressure corresponding to the temperature at saturation in the system, in order to prevent flashing of the water into steam.
6. Terminal units requiring different temperatures of water may be served at their required temperatures by regulating the flow of water, by modulating the water supply temperature, by placing some units in series, by the use of heat exchangers, or other methods.
7. The high heat content of the water contained in the high-temperature water circuit acts as a thermal flywheel evening out fluctuations in the load. The heat storage capacity may be further increased by build-up of temperature in the return mains, or by other methods, during periods of light load.
8. The high heat content of the heat carrier makes high-temperature water unsuitable for systems that are operated intermittently if rapid start-up and shut-down is desired, unless the system is designed for a minimum water volume and is operated with rapid response type controls.
9. Its physical properties make high-temperature water less dangerous in case of a line or equipment break, than steam under the same pressure.
10. More engineering effort is required to design a high-temperature water system that is successful, safe, and easy to operate, than a comparative steam or low-temperature water system. The design should be undertaken only by responsible engineers with previous experience. Systems should be inherently simple, but should incorporate all essential components for safety and ease of operation.

THE BASIC SYSTEM

High-temperature water systems are basically similar to the conventional forced hot water heating systems. They require a heat source for heating the water, which may be direct-fired high-temperature water generators, steam boilers, or heat exchangers of the open or closed type. The expansion of the water upon heating is usually taken up in an expansion vessel which at the same time is used for pressurizing the system. Heat transport is dependent upon circulating pumps. The distribution system is closed, comprising supply and return pipes under the same basic pressure, and heat emission at the terminal unit is indirect by heat transfer through heat transfer surfaces. The basic system is shown in Fig. 1.

The principal differences from low-temperature water systems are the higher pressure used, the consequently heavier equipment, the generally smaller pipe sizes, and the manner in which pressure is maintained on the water.

Most systems may be divided into either of two types: (1) the steam cushion system in which the high-temperature water raises its own pressure, and (2) the gas-pressurized system in which the pressure is imposed externally.

The high-temperature water generators, as well as all auxiliaries such as water makeup and feed equipment, pressure tanks and circulating pumps, are usually located in a central station.

DESIGN CONSIDERATIONS

Selection of the system pressure, supply temperature, temperature drop, type of high-temperature water generator, as well as the method of pressurization, are the most important initial design considerations. Some determining factors are:

1. Type of load (space heating, process, or both). Load fluctuation during a 24 hr period, and fluctuation during a one year period should be considered. Process loads may require water

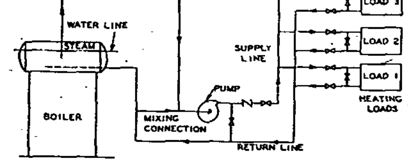

Fig. 1 .... Elements of a High-Temperature Water System