they are made for either gravity or vacuum installations. Typical meter installations are shown in Fig. 3. In diagram A a continuous-flow type trap is shown installed ahead of the meter, while in diagram B an intermittent type trap is used. In the latter case, a receiving tank must be placed between the trap and meter to prevent intermittent overloading of the meter. When measuring the discharge from a vacuum pump, a vented receiver should always be installed ahead of the meter.

Installations of meters in a vacuum return line are shown in diagrams C and D. In diagram C a master, continuous-flow trap is installed immediately ahead of the meter to prevent steam from entering it in case of leaking radiator or fixture traps. Where individual traps are reliable, connections may be made as shown in diagram D.

Flow meters are generally used for measuring sendout from plants, high-pressure requirements in buildings, and in installations where all of the condensate cannot be returned to a central point. Further information on flow meters is available from publications of the Fluid Meter committee of the American Society of Mechanical Engineers and from the *District Heating Handbook*,[22] and are described in Chapter 4.

HOT WATER DISTRIBUTION

District heating in the United States is confined almost entirely to the use of steam as the heating medium. Hot water has been used and is being used today, where economic conditions are favorable and good engineering practice dictates.

The use of low-pressure hot water distribution below 200 F has been practically discontinued for district heating in the United States because of practical and economic difficulties. The use of high-pressure, high-temperature water distribution at 275 to 400 F has found favor in Europe, where fuel is scarce and is finding some application in the United States.[23]

High-pressure water distribution has some practical and economic advantages over steam (see Chapter 29 High Temperature Water Systems). Higher thermal efficiencies, better daily and annual system load factors, lower water treatment costs, smaller pipe sizes, fewer piping accessories, and feasibility of installing pipe to follow contour of ground are given as a few. On the other hand hot water requires a two-pipe distribution system which increases the capital investment in some cases. System maintenance is complicated by the necessity to drain at least a portion of the system when connections are made or leaks repaired.

The advantages of hot water have exceeded the disadvantages in some industrial applications and in Air Force bases in this country. As the cost of fuel increases, additional applications will probably become practicable, especially in new installations serving buildings designed for hot water heating.[1]

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CHAPTER 28

HOT WATER HEATING SYSTEMS

Features and Design of Low Temperature Hot Water Systems; Two-Pipe, One-Pipe, and Series-Loop Systems; Piping Principles; Circulating Pumps; Expansion Tanks; Boiler Room Piping; Use of Steam; Temperature Control; System Adjustment; Cleaning Systems

A HOT WATER heating system is one in which water is used to convey heat by flowing through pipes connecting a boiler or water heater with radiators, convectors, or other suitable heat distributing means. The systems discussed in this chapter have supply water temperatures less than 250 F and are classified as *Low Temperature Systems*. Systems having supply water temperatures above 250 F are classified as *High Temperature Systems* and are discussed in Chapter 29. Classified according to the means of generating flow, hot water heating systems are of two types: the *Gravity System* in which circulation of the water is due to the difference in weight between the supply and return water columns of any circuit or system, and the *Forced System* in which a pump, usually driven by an electric motor, maintains the necessary flow.

Since the available head or force producing circulation in a gravity system is limited, the piping must be of such size that the friction loss at the desired flow is not in excess of the available head.

Gravity circulation heads which can be obtained with various supply and return temperatures are shown in Fig. 1. The basic principles which determine design in gravity and forced systems are the same but since the former has less total head available to produce flow, greater precautions are necessary in design to secure even distribution of heat with gravity systems. Gravity systems are no longer of commercial importance. Complete details on the design of gravity type systems are contained in editions of THE GUIDE issued before 1957. Fig. 1 is also useful in determining effects due to temperature difference in forced systems when large elevation or temperature differentials occur.

This chapter is devoted to the design of forced hot water systems using supply water temperatures below 250 F.

The selection of type of distribution system for heating a particular building should be based upon an objective analysis of the characteristics of the building, the comfort and temperature conditions required, the system operating and maintenance characteristics, the space available for piping and equipment, and the economics involved.

FEATURES OF HOT WATER SYSTEMS

Advantageous features of forced low temperature hot water systems are:

1. The piping need not be run at a definite level or pitch but may change up and down as required by architectural and structural elements of the building. High points should be vented and low points be provided with drain connections.
2. Heat distribution when warming up is uniform.
3. Hot water systems are readily adaptable to simple approximate control of capacity and indoor temperature by instruments sensitive to outdoor temperature changes.
4. The system may generally be designed with a minimum of mechanical specialties thereby favoring economical maintenance.
5. Due to practical elimination of air, corrosion within the system is minimized.
6. Where extended glass exposures occur, the heating elements, which are relatively large because they operate at low temperature, may be well distributed under such exposures to counteract downdrafts.
7. Quiet operation may be expected in a properly designed and installed system.

In the design and operation of forced circulation systems, it is necessary to take precautions against any condition that would permit the water temperature to fall below freezing, particularly where coils are used to heat incoming outdoor air or where the heating plant may be shut down for more than 24 hours in cold weather.

If the static pressure in the system is high, it may be necessary to use boilers built for operating pressures above 30 psig unless a steam boiler with heat exchanger is used to heat the water. See discussion in this chapter in section Expansion Tanks and System Pressure Control.

DESIGN OF LOW TEMPERATURE HEATING SYSTEMS

The significant factors affecting the design of low temperature hot water heating systems are discussed in the sections that follow.

Heat Loss Calculations

The adequacy as well as the proper distribution of the heat in a building served by a hot water system depends primarily on the proper calculation of the heat loss for the individual spaces and the accurate sizing of the heating units to offset those heat losses. Heat loss should be determined in accordance with the principles discussed in Chapter 12, Heating Load.

Selection and Location of Heating Units

Information on the types of room heating units available for hot water systems will be found in: Chapter 14, Radiators and Convectors; Chapter 30, Panel Heating; and Chapter 15, Unit Ventilators and Unit Heaters. While the style or type of unit selected for a given space may depend on personal preferences of the purchaser, the designer should make certain that the heat output at the water temperature available is equivalent to the calculated heat loss from the space.

The heating units within each separately controlled circuit should be of similar types, for example: either all cast-iron or all fin-tube convector-type units. Fan units should not be included in a controlled direct radiation zone. The