Another typical application is the control of a low- or medium-pressure steam generator, usually less than 50 psig, using high-temperature water as the source of heat. In this application a proportional pressure controller in the steam generator supply positions a high-temperature water valve located in the return line to maintain the desired steam pressure.

High-temperature water is sometimes used to supply coils in air handling units where heating surfaces are so placed that possibility of personal contact is avoided. Careful sizing of coil and valve is required to obtain stable control. In some cases face and bypass damper control is used, because then the control of water flow through the coil is not as critical.

In some cases face and bypass damper control is used in conjunction with valve control. The coil valve, operating in sequence with the damper, must be closed when the face damper is closed. The coil arrangement should be such as to minimize air temperature pick-up when the bypass damper is at or near the open position.

WATER TREATMENT

Water treatment is seldom required where there is continual re-use of the water. Where none of the water is lost, except such minor amounts as may accompany venting or be due to occasional leakage at stuffing boxes, it is usually sufficient to make the water slightly alkaline when the system is first filled. Where the make-up water is appreciable, treatment appropriate to the mineral content and quantity is indicated.

It is desirable that systems with steam driven auxiliaries be arranged to conserve the heat in the exhaust. Steam driven auxiliaries can rarely be justified unless the exhaust steam can be used. Usually this is accomplished with a minor addition in capital expenditure.

STORAGE

High-temperature water systems may be operated to even out the peak loads and low loads within 24-hr cycles by storage. Storage is usually accomplished by the bypassing of water from the flow to the return mains and thereby storing heat in the return main for future use, or storing heat in accumulators. Systems which experience normal peaks may obtain as much as 15 percent added capacity through such heat storage.

SAFETY CONSIDERATIONS

Two characteristic features accompany the sudden expansion of high-temperature water upon the release of pressure.

1. A very high rate of increase in volume.
2. A very low rate of energy release during expansion.

In consequence, in the case of equipment or pipe failure, only small quantities of high-temperature water will escape per unit of time. Flashing into steam and expansion will absorb the potential energy stored in the liquid. The expanding high-temperature water will transform into a very wet fog, and it has been the general observation that its temperature is reduced to approximately 125 F and that it can be withstood by the human body a relatively short distance away.[10] High-temperature water will not expand with explosive force. It can be considered a much safer heat transfer agent than high pressure steam. Basic research is now being conducted to determine the exact rates of energy release and the possible results from a sudden release of HTW in a closed room.

REFERENCES

[1] E. G. Hansen: High-temperature hot water district heating at the U.S. Air Force Academy (*National District Heating Association Proceedings*, 1959, p. 129).

[2] J. G. Frost: High-temperature hot water boiler plant at Dartmouth (*Engineering Journal of Canada*, 1953).

[3] *High Temperature Water for Heating and Light Process Loads* (*Federal Construction Council Technical Report* No. 37, National Academy of Sciences—National Research Council Publication No. 753, 1959).

[4] J. S. Blossom and P. H. Ziel: Pressurizing high-temperature water systems (ASHRAE JOURNAL, November 1959, p. 47).

[5] George Applegate, Jr.: British and European design and construction methods (ASHAE JOURNAL SECTION, *Heating, Piping and Air Conditioning*, March 1958, p. 169).

[6] O. S. Lieberg: High temperature water (*Air Conditioning, Heating and Ventilating*, September 1955, p. 83; November 1955, p. 85; January 1956, p. 69). Also published as a separate bulletin.

[7] E. G. Hansen and William Liddy: A flexible high pressure hot water and steam boiler plant (*Power*, May 1958, p.109).

[8] E. G. Hansen and N. E. Pearsall: Turbo-generators supply steam for high-temperature water heating (*Air Conditioning, Heating and Ventilating*, June 1960, p. 90).

[9] C. A. Carter and B. L. Sturtevant: Design of high temperature water systems for military installations (ASHAE JOURNAL SECTION, *Heating, Piping and Air Conditioning*, February 1958, p. 109).

[10] E. G. Hansen: Safety of high temperature hot water (*Actual Specifying Engineer*, July 1959).

BIBLIOGRAPHY

E. A. Pierce: High pressure hot water systems (*The Heating and Ventilating Engineer & Journal of Air Conditioning*, London, 1942).

J. R. Kell: High pressure hot water (*Heating, Piping and Air Conditioning*, April 1948, p. 93; June 1948, p. 97; August 1948, p. 91; October 1948, p. 85).

Centrifugal Pump Section, *Standards of the Hydraulic Institute*, p. B(Vi)-9 (Hydraulic Institute, New York, 1955).

Oscar Faber and J. R. Kell: *Heating and Air Conditioning of Buildings* (Architectural Press, London).

E. A. Pierce: Hot water engineering (*The Heating and Ventilating Engineer and Journal of Air Conditioning*, London, 1957 and 1958).

E. G. Hansen: HTHW components at user end of the system (*Actual Specifying Engineer*, April 1959, p. 96, May 1959, p. 73)

J. R. Carroll: High temperature hot water (HTHW) for university expansion (*The Illinois Engineer*, March 1957, p. 7).

J. H. Keenan and F. G. Keyes: *Thermodynamic Properties of Steam* (John Wiley & Sons, Inc., New York, 1936, 1st ed.).

S. R. Lewis: Hot-water system of advantage in meeting plant heating requirements (*Heating, Piping and Air Conditioning*, May 1938, p. 319).

K. Aschof: Die Calliqua-Heisswasserheizung (*Die Wärme:* Zeitschrift für Dampfkessel & Machinenbetrieb, October 1931).

F. R. L. White: Some notes on high-pressure hot-water heating (*Journal of the Institution of Heating and Ventilating Engineers*, 1945).

P. L. Geiringer: High pressure hot water (*Heating, Piping and Air Conditioning*, May 1948, p. 103).

T. W. Reynolds: The high temperature water system (*Heating and Ventilating*, September 1951).

High Temperature High Pressure Hot Water Heating Manual No. 2685 (Dunham-Bush, Inc., New York, 1955).

Charles Broder: Heating and air-conditioning a civilian airport (ASHAE JOURNAL SECTION, *Heating, Piping and Air Conditioning*, March 1958, p. 147).

S. W. Brown: Marine applications of high-temperature water (ASHAE JOURNAL SECTION, *Heating, Piping and Air Conditioning*, March 1958, p. 161).

E. M. Thompson: Economic evaluation of high-temperature water (ASHAE JOURNAL SECTION, *Heating, Piping and Air Conditioning*, April 1958, p. 140).

CHAPTER 10

PANEL HEATING

Application Methods: Embedded Piping for Ceilings, Walls, or Floors; Warm Air and Electrically Heated Ceilings, Walls, or Floors; Output from Panel Surfaces: Radiation, Convection and Combined Heat Transfer, Panel Heat Losses; Design of Panel Heating Systems: Warm Water Panels for Plaster, Metal, and Concrete Ceilings; Wall Panels and Concrete Floor Panels, Installation Details and Accessories, Controls; Warm Air and Electric Panels

IN this chapter the term, Panel Heating, is used to describe a method of space heating in which heat is supplied by large heated areas of interior room surfaces operating at relatively low surface temperatures (80 to 125 F). The heating elements usually consist of warm water piping, warm air ducts, or electrical resistance elements embedded in, or located behind, ceiling, wall, or floor surfaces.

Panel heating may be considered as another method of convenient and effective space heating. The heat loss requirements may be calculated in the conventional manner except that the heat loss through the area occupied by the heated panel need not be included. An assumed or computed reverse heat loss from the panel, however, should be included in determining heating main size and the boiler load. The heat release from the panel is expressed in terms of hourly heat output per square foot of surface. The room air temperatures to be maintained are approximately the same as those maintained by heating systems employing cast-iron radiators, convectors, or warm air ducts.

This chapter does not include a separate discussion of such topics as the influence of radiation on human comfort, the mechanisms by which human beings release heat, and other similar topics that apply to all methods of heating interior spaces for human comfort. The reader is referred to Chapter 8 of the 1961 GUIDE AND DATA BOOK for a detailed discussion of these subjects.

APPLICATION METHODS

The great majority of panel installations of the past 50 years (which is the period of the modern utilization of this method of heating) have used warm water as the heating medium which is circulated in embedded piping. More recently, the use of warm air ducts, and embedded electrical heating elements, has come into favor, especially where specific local factors have influenced such use. Steam has been used only occasionally because of the problems which result from its higher temperature.

When the heating medium is warm water, both ferrous (steel or wrought iron) or non-ferrous (generally copper or aluminum) pipe or tube are used widely in ceiling, wall, or floor panel construction. Tube sizes used are 3/8, 1/2, 5/8, and 7/8 in. OD, while piping is generally 1/2, 3/4, or 1 in. IPS. Where coils are embedded in concrete or plaster, no threaded joints should be used for either pipe coils or mains. The construction should be of all-welded type. Changes in direction should be made by bending the pipe itself, rather than by use of fittings. Solder-joint fittings are used for non-ferrous heating coils and piping. It is recommended that a medium temperature solder of 95 percent tin—5 percent antimony, or capillary brazing alloys, be used. All piping should be subjected to a hydrostatic test of at least three times the working pressure, but not less than 150 psig.

The most common forms of panels applied in panel heating are: (1) embedded piping for ceilings; (2) embedded piping for walls; (3) embedded piping for floors; (4) air heated ceilings, walls, or floors; (5) electrically heated ceilings, walls, or floors.

Embedded Piping for Ceilings

When piping is embedded in ceilings, the construction used is generally one of the following:

a. Pipe or tube is embedded in the lower portion of a concrete slab, generally very close to its lower surface. If plaster is to be applied to the concrete, the piping may be placed directly on the wood forms. If the slab is to be used without plaster finish, then the piping should be installed not less than 1/4 in. above the undersurface of the slab. Fig. 1 shows this method of construction. The minimum coverage must be in compliance with the local building code requirements.

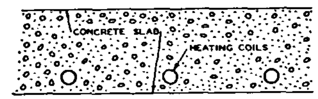

Fig. 1 .... Coils in Structural Concrete Slab

b. Pipe or tube is embedded in a metal lath and plaster ceiling. If the lath is suspended to form a hung ceiling, both the lath and the heating coils are securely wired to the supporting members in such a way that the lath is below, but in good contact with the coils, as shown in Fig. 2. Plaster is then applied to the metal lath, care being taken to embed the coil, as shown in Fig. 2.

c. Copper tube of the smaller diameters is attached to the underside of wire lath or gypsum lath. Plaster is then applied to the lath to embed the tube, as shown in Fig. 3.

d. Other forms of ceiling construction are prefabricated panels of metal, composition board, wood paneling, etc., having warm water piping, tube, or channels built into the panel sections.

Coils are usually of the sinuous type, although some header or grid type coils have been used in ceilings. Coils may be of either ferrous or non-ferrous pipe or tube, with coil pipes spaced from 4 1/2 to 9 in. on centers, depending on the required output, pipe or tube size, and other factors.

Where plastering is applied to pipe coils, a standard three-coat gypsum plastering specification[1] is followed, with a minimum of 3/8 in. of cover below the tubes when the tubes