Standard test conditions specify either a steam pressure of 1 lb gage 15.6 lb per sq in. absolute (215 F) or an average hot water temperature of 170 F and a room temperature of 70 F (5 ft above floor) for radiators, or an inlet air temperature of 65 F for convectors. The heating capacity of a *steam radiator* or *steam convector* is determined as follows:

$$H_t = W_s h_{fg} \tag{1}$$

where

H_t = Btu per hour under test conditions.
W_s = condensation in pounds per hour.
h_{fg} = latent heat in Btu per pound.

H_t may be converted to standard conditions of code ratings by using the proper correction factor from the following formulae:

For radiators:

$$C_s = \left(\frac{215 - 70}{T_s - T_r}\right)^{1.3} = \left(\frac{145}{T_s - T_r}\right)^{1.3} \tag{2}$$

For convectors:

$$C_s = \left(\frac{215 - 65}{T_s - T_i}\right)^{1.5} = \left(\frac{150}{T_s - T_i}\right)^{1.5} \tag{3}$$

The output under standard conditions will be:

$$H_s = C_s H_t \tag{4}$$

where

C_s = correction factor.
T_s = steam temperature during test, degrees Fahrenheit.
T_r = room temperature during test, degrees Fahrenheit.
T_i = inlet air temperature during test, degrees Fahrenheit.
H_s = heat emission rating under standard conditions, Btu per hour.

Similarly, for *hot water convectors*, the output under test conditions may be determined as follows:

$$H = W(\theta_1 - \theta_2)\frac{3600}{t} \tag{5}$$

where

H = Btu per hour under test conditions.
W = pounds of water handled during test.
θ_1 = average temperature of inlet water, degrees Fahrenheit.
θ_2 = average temperature of outlet water, degrees Fahrenheit.
t = duration of test, seconds.

To convert test results to standard conditions, the following correction factor is used:

$$C = \left(\frac{170 - 65}{\frac{\theta_1 + \theta_2}{2} - T_i}\right)^{1.5} = \left(\frac{105}{\frac{\theta_1 + \theta_2}{2} - T_i}\right)^{1.5} \tag{6}$$

It has been shown that when the exponent 1.5 is used the range of error is less than 3 per cent[13] for convectors.

[13]Loc. Cit. Note 10.

Chapter 15

STEAM HEATING SYSTEMS

Gravity and Mechanical Return, Gravity One-Pipe Air-Vent, Gravity Two-Pipe Air-Vent, Air Line Heating, One-Pipe Vapor, Two-Pipe Vapor, Atmospheric, Condensation Return, Vacuum, Sub-Atmospheric, Orifice, Zone Control, Condensation Return Pumps, Vacuum Heating Pumps, Traps

STEAM heating systems may be classified according to the pipe arrangement, the accessories used, the method of returning the condensate to the boiler, the method of expelling air from the system, or the type of control employed. Information concerning the design and layout of steam heating systems will be found in Chapter 16.

GRAVITY AND MECHANICAL RETURN

Systems are classified as gravity or mechanical according to the method of returning the condensate from the system to the boiler. In *gravity systems* the condensate is returned by gravity due to the static head of water in the return pipes or mains. The elevation of the boiler water line must be sufficiently below the lowest heating unit, steam pipe or dry return pipe to permit the return by gravity. The *water line difference* forming the *static head* must be sufficient to overcome the maximum pressure drop in the system, including the pressure drop due to the condensing effect of the radiation. When radiator and drip traps are used, as in two-pipe vapor systems, the static pressure must also exceed the operating pressure of the boiler. The pressure drop caused by condensing rate of the radiation is especially important during those portions of the operating periods where changing pressure conditions prevail, as for example, when the system is being initially filled with steam. In systems where the condensate is wasted to the sewer no water line difference is required as is the case with closed systems. However, the waste of condensate may introduce conditions which warrant the use of an appropriate mechanical system. Whenever the conditions of a heating system are such that the returns from the radiation cannot gravitate to the boiler they must be returned by some mechanical means.

In *mechanical systems* the condensate flows to a receiver by gravity and is then forced into the boiler against its pressure. In all instances the preferable practice is to provide for gravity flow even where a vacuum pump is used. The lowest parts of the supply side of the system must be kept sufficiently above the water line of the receiver to insure adequate drainage of water from the system.