

For office buildings using steam during daylight hours only to maintain 70 F from 9 A.M. to 6 P.M. for approximately 240 days (heating season). No night use. Factor: 400 lb per square foot of heating surface per season.

For office buildings using steam during day hours and at night when required to 7, 8 and 9 P.M. (customary where there are stock brokers or banking offices), 240 days. Factor: 500 lb per square foot of heating surface per season.

For residences of the block type (not detached) where high-class heating service is required somewhat similar to apartment buildings. Factor: 550 lb per square foot of heating surface per season.

For apartment houses where high-class heating service is required. (Steam off at midnight). Factor: 650 lb per square foot of heating surface per season.

For hotels (commercial type) where very high-class service is required; 24-hour service. Factor: 800 lb per square foot of heating surface per season.

By assuming one square foot of equivalent heating surface for each 100 cu ft of space heated, which seems a fair ratio in New York City, it is possible roughly to estimate the steam required per cubic foot of space, information which is often more easily obtained than the square feet of heating surface. Considerable additional data on the heating requirements of various types of buildings in a number of cities may be found in the Handbook of the *National District Heating Association*.

#### REFERENCES

- Pipe Line Design for Central Station Heating*, by B. T. Gifford (A.S.H.V.E. TRANSACTIONS, Vol. 17, 1911).  
*Engineering and Cost Data Relative to the Installation of Steam Distributing Systems in a Large City*, by F. H. Valentine (A.S.H.V.E. TRANSACTIONS, Vol. 22, 1916).  
*Transmission of Steam in a Central Heating System*, by J. H. Walker (A.S.H.V.E. TRANSACTIONS, Vol. 23, 1917).  
*Efficiency of Underground Conduit*, by G. B. Nichols (A.S.H.V.E. TRANSACTIONS, Vol. 23, 1917).  
*Economical Utilization of Heat from Central Plants*, by N. W. Calvert and J. E. Seiter (A.S.H.V.E. TRANSACTIONS, Vol. 30, 1924).  
*Standard Connections for Condensation Meters*, (N.D.H.A. Proceedings, Vol. XII, pp. 63-76).  
*Installation and Maintenance of Steam Meters*, (N.D.H.A. Proceedings, Vol. XIII, pp. 177-183).  
*Inaccuracy in Flow Meter Calculations*, (N.D.H.A. Proceedings, Vol. XIII, pp. 183-193).  
*Testing of Steam Meters*, (N.D.H.A. Proceedings, Vol. XIV, pp. 272-276).  
*Meter Accuracy Guarantees*, (N.D.H.A. Proceedings, Vol. XIV, pp. 276-277).  
*Effect of Pulsations on the Flow of Gases*, (N.D.H.A. Proceedings, Vol. XIV, pp. 277-281).  
*Meter Connections*, (N.D.H.A. Proceedings, Vol. XX, pp. 126-143).  
*Layout for Testing Meters*, (N.D.H.A. Proceedings, Vol. XX, pp. 391-392).  
*Characteristic Meter Calibration Curves*, (N.D.H.A. Proceedings, Vol. XX, pp. 444-453).

## Chapter 23

### AUTOMATIC TEMPERATURE CONTROL

*Thermostats; Temperature Control Systems; Heating Plant Control; Zone Control; Control of Humidity; Industrial Process Control.*

WHENEVER the maximum installed capacity of heating, ventilating and air conditioning equipment is not required, some method of limiting or controlling the output is desirable. This chapter contains information relative to the principles of operation of automatic temperature control systems, as well as data pertaining to the various devices available for the design of such systems. Additional information on this subject will be found in other chapters. Various types of control devices and systems are described in the Catalog Data Section of THE GUIDE.

Controls are applied for the following reasons:

1. To maintain conditions required for human comfort and efficiency.
2. To maintain conditions required for industrial processes.
3. To obtain economy in operation.
4. To provide necessary safety measures.

The proper operation of all control systems depends on the selection of the correct type of control instrument, as well as on its correct application within the complete system.

#### THERMOSTATS

Automatic control of temperature requires the use of an instrument known as a *thermostat* which responds to a change in temperature. Although there are many types of thermostats, the basic principles of operation of practically all types are included in the following classifications:

1. The *diaphragm* type (Fig. 1) which, by means of an expanding liquid or gas within a diaphragm or bellows, furnishes motion; and this motion may be mechanically transmitted in proportion to the rise and fall of temperatures surrounding the diaphragm.
2. The *direct-expansion* type (Fig. 2) which operates by direct expansion and contraction of a substance which has a high coefficient of expansion such as hard rubber. The slight movement of the thermostatic element usually must be multiplied through a system of levers.
3. The *bi-metallic* type (Fig. 3-a, b and c) which is actuated by means of two intimately attached metals having dissimilar coefficients of expansion. This type is inherently more sensitive to temperature changes than the diaphragm or direct expansion types, but lacks the necessary force to cause motion of the controlled equipment and must be used with compressed air, electric current or other source of power. The sensitive element may take any one of a number of forms, the most common being the