REQUIRED AIR QUANTITY THROUGH CONDITIONING EQUIPMENT

The procedure for determining the required air quantity is based upon the thermodynamic principles of Chapter 3 and the use of the Goff diagram supplied with THE GUIDE, or a psychrometric chart. Readers are advised to review these principles, paying particular attention to the illustrative examples of cooling load calculations, and to refer to the section on Apparatus Dew-Point in Chapter 29.

Calculation of the cooling load for a conditioned space is equivalent to making, for the space, a heat balance in which all heat, moisture, and infiltration are treated as directly entering the space. As explained in the section, *Load from Outside Air—Ventilation and Infiltration*, the outside air load normally does not become a part of the space load, because heat and moisture are removed in the air conditioner before this air gets into the conditioned space. The desired conditions are maintained by considering a certain quantity of air to be withdrawn from the space, passed through the conditioning equipment, and returned to the space with such a temperature and humidity ratio that its net effect will be to counterbalance or *remove* the given entering amounts of heat and water vapor. This quantity of *indoor air*, which is considered to be circulated in this manner, is called the *required air quantity* and its determination is normally part of every cooling-load estimate. The procedure is as follows:

1. Determine the total sensible and latent heat loads in Btu per hour for the space.

2. Compute the quantity called the heat-moisture ratio of the room load, q_w. Use the following equation:

$$q_w = \left(\frac{\text{Space sensible load} + \text{space latent load}}{\text{Space latent load}}\right) \times 1076 \text{ Btu/lb of moisture difference.} \qquad (19)$$

Note that the ratio (Space latent load) ÷ 1076 is the equivalent of the required rate of water-vapor removal, in pounds per hour. If the rate of water-vapor removal is known, it may be used directly in Equation 19.

3. Locate the state point of the room air (design wet-bulb and dry-bulb temperatures) on the Goff diagram. From this state point draw a line intersecting the saturation line, using the slope established by the protractor on the Goff diagram for the particular value of q_w prevailing. This line is the *condition line* for the process.

4. Read the temperature where the condition line from step 3 intersects the saturation line. This is called the *apparatus dew-point.*

5. Compute the *required air quantity* from the relation

$$Q_{ra} = \frac{(\text{Space sensible load})}{1.08\left[\left(\begin{matrix}\text{Space}\\ \text{dry-bulb}\end{matrix}\right) - \left(\begin{matrix}\text{Apparatus}\\ \text{dew-point}\end{matrix}\right)\right] \times \left(\begin{matrix}\text{Coil}\\ \text{efficiency}\end{matrix}\right)} \qquad (20)$$

The magnitude of Q_{ra} is substantially the quantity, cfm, of cooled and dehumidified air for which the distribution system must be designed.

The numerical factor 1.08 is derived from the product 1 cfm × 60 min. × 0.244 × $0.075\left(1 - \frac{0.00923}{0.62}\right) = 1.08$, assuming an average supply air dew-point of 55 F. Since standard air density (0.075) includes the weight of the water vapor, it is desirable to reduce it to the basis of dry air by the last factor where 0.00923 = humidity ratio of air at 55 F dew-point, and 0.62 = ratio of density of water vapor to dry air at same temperature and pressure. Refer to Chapter 35 for coil selection.

Note that the product [(Space dry-bulb) − (Apparatus dew-point)] × (Coil efficiency) is equal to the dry-bulb range through which the conditioned air is cooled. Hence, in rare instances when the *condition line* of the process may not intersect the saturation line, any other convenient reference temperature on the *condition line* may be used instead, provided that the coil efficiency is specified accordingly on the proper basis.

MINIMUM ENTERING AIR TEMPERATURE

Due consideration must be given to the temperature of the air entering the conditioned space in order to prevent objectionable drafts. With ceiling type diffusers or wall grilles with a high aspect ratio (see Chapter 30), many engineers consider 20 deg as the maximum difference for good design under average conditions. This difference can only be exceeded with extremely high ceiling outlets or wall grilles. Thus, if 80 F dry-bulb is to be maintained in a space with average ceiling height, the minimum delivered air temperature would be limited to about 60 F dry-bulb temperature. If the latent heat load is relatively high, it is often necessary to circulate more air with a higher delivered dry-bulb temperature in order to produce a thermodynamic balance. If the temperature difference is known, the required air quantity can be calculated from the formula,

$$Q_{ra} = \frac{q_s}{1.08\,(t_i - t_d)} \qquad (21)$$

or the temperature difference t_d can be determined as follows,

$$t_d = t_i - \frac{q_s}{1.08 \times Q_{ra}} \qquad (22)$$

EXAMPLE—COOLING LOAD CALCULATION

An effective means of summarizing the calculation procedure will be the use of an illustrative example. While condensed calculation forms are commonly employed for work of this nature, an outline will be used here in order to facilitate explanatory comments.

Example 11: A one-story office building Fig. 7 is located in an eastern state near 40 deg latitude. The adjoining buildings on the north and west are not conditioned, and the air temperature within them is known to be substantially equal to the outdoor air temperature at any time of the day.

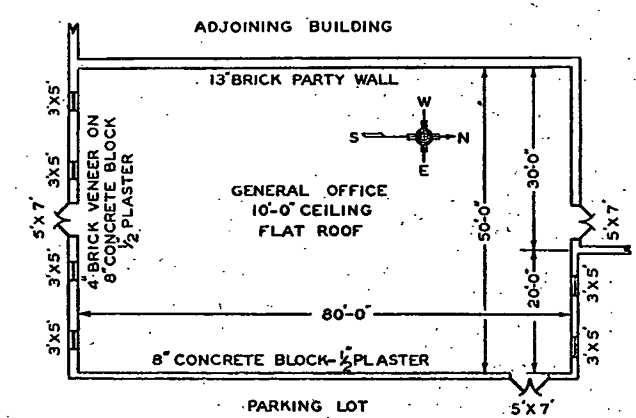

FIG. 7. PLAN OF ONE-STORY OFFICE BUILDING