select the unit best adapted to the heating and ventilating load. Typical capacities are given in Table 2[9].

If no direct heating surface (radiation) is installed, the combined heating and ventilating requirements must be taken care of by the unit ventilators, and the total heat to be supplied is obtained by means of the following formulæ:

When all of the air handled by the unit is taken from the outside,

$$H_t = 0.24\ W\ (t_y - t_o) \tag{1}$$

$$W = d\ 60\ Q \tag{2}$$

$$t_y = \frac{H}{0.24W} + t \tag{3}$$

where

- d = density of air, pounds per cubic foot.
- H = heat loss of room, Btu per hour.
- H_v = heat required to warm air for ventilation, Btu per hour.
- H_t = total heat requirements for both heating and ventilation, Btu per hour $= H + H_v$.
- Q = volume of air handled by the ventilating equipment, cubic feet per minute.
- t = temperature to be maintained in the room.
- t_o = outside temperature.
- t_y = temperature of the air leaving the unit.
- W = weight of air circulated, pounds per hour.
- 0.24 = specific heat of air at constant pressure.

From Equations 1, 2 and 3:

$$H_t = H + 0.24\ d\ 60\ Q\ (t - t_o) \tag{4}$$

Example 1. The heat loss of a certain room is 24,000 Btu per hour, and the ventilating requirements are 1000 cfm. If the room temperature is to be 70 F and all air is taken from the outside at zero, what will be the total heat demand on the unit if it is required to provide for both the heating and ventilating requirements (combined system)?

Solution. $H = 24{,}000$; $d = 0.075$ $Q = 1000$ cfm; $t = 70$ F; $t_o = 0$ F.

Substituting in Equation 4:

$$H_t = 24{,}000 + 0.24 \times 0.075 \times 60 \times 1000\ (70-0) = 99{,}600 \text{ Btu}$$

$$t_y = \frac{24{,}000}{0.24 \times 0.075 \times 60 \times 1000} + 70 = 92.2 \text{ F}$$

When part of the air handled by the unit is taken from the room and the remainder from the outside,

$$H_t = 0.24 W_o\ (t_y - t_o) + 0.24\ W_i\ (t_y - t) \tag{5}$$

where

- W_o = weight of air, pounds per hour taken from out-of-doors.
- W_i = weight of air, pounds per hour taken from the room.

$$W_o = d_o\ 60\ Q_o \tag{6}$$

$$W_i = d_i\ 60\ Q_i \tag{7}$$

[9]A.S.H.V.E. Standard Code for Testing and Rating Steam Unit Ventilators (A.S.H.V.E. TRANSACTIONS, Vol. 38, 1932, p. 25).

where

- d_o = density of air, pounds per cubic foot at temperature t_o.
- d_i = density of air, pounds per cubic foot at temperature t.
- Q_o = volume of air taken in from the outside, cubic feet per minute.
- Q_i = volume of air taken in from the room, cubic feet per minute.

$$t_y = \frac{H}{0.24\ (W_o + W_i)} + t \tag{8}$$

$$H_t = H + 0.24\ d_o\ 60\ Q_o\ (t - t_o) \tag{9}$$

Equations 5, 6, 7, 8, and 9 may be used in the same manner as is illustrated above for Equations 1, 2, 3, and 4. It may be noted in Equation 9, representing the total heat requirements, that as the quantity Q_o is diminished the heat requirements for the unit diminish very materially.

In Example 1, if the quantity of air taken in from the outside is reduced to zero, or all of the air handled by the unit is recirculated, the total heat requirements H_t reduce from 99,600 Btu to 24,000 Btu, or to about one fourth. Such a unit handling one third of its air volume from the outside and two thirds from the room would show a total heat requirement of $24{,}000 + \frac{99{,}600 - 24{,}000}{3} = 59{,}200$ Btu. Units designed and operated on this principle show an average heat requirement and, therefore, a boiler capacity requirement of less than 50 per cent of that required for units taking all their air from the outside.

If all of the air is recirculated, the total heat required is the same as the heat loss of the room, or

$$H_t = H = 0.24\ W\ (t_y - t) \tag{10}$$

If the heat loss of the room is to be taken care of by the direct heating surface, the unit ventilators will be required to warm the air introduced for the ventilating requirements. Therefore:

$$H_v = 0.24\ W\ (t_y - t_o) \tag{11}$$

In this case t_y should be equal to or slightly higher than t. If the unit ventilator were of such capacity as to exactly provide for the ventilating requirements, the direct radiation would be selected on the usual basis. However, it is necessary to employ a unit which may not exactly meet the ventilating requirements, since standard units are usually rated in terms of the volume of air that will be delivered at a certain temperature t_y for an initial temperature of t_o. Therefore a certain amount of heat (H_h) may be available from the unit ventilator for heating purposes, as previously stated, and the amount of equivalent direct heating surface may, if desired, be deducted from the amount required for heating the room.

COOLING UNITS

Cooling units as applied to industrial product conditioning and processing are similar in construction to unit heaters except that the heat transfer surface is supplied with refrigeration instead of with steam or hot water. They are normally installed within the space to be served, or at