of the outlet grille at a distance of 2 in. and then multiplying the average velocity by the gross area of the grille. The anemometer rating is based on the final temperature of the air leaving the grille while the unit is delivering outdoor air and recirculated air in the proper proportion, and the heating element is supplying heat as specified. This method of rating is subject to error due to differences in types and calibration of instruments and grille design, and to the care with which the rating test is conducted. Because of these variations, the *standard air rating* is used by manufacturers as the basic rating for unit ventilators.

Table 1 shows typical air capacities as determined by the two methods of rating. Heating elements are available for capacities higher and lower than those given in Table 1.

Heating Capacity Requirements for Unit Ventilators

Since a unit ventilator has the dual function of introducing outdoor air for ventilation and maintaining a specified room temperature, the heat required by the unit may be similarly divided into (1) *heat required for ventilation*, H_v, and (2) *surplus heat*, H_s. The *surplus heat* is available for maintaining room temperature. If auxiliary radiation is installed, the *surplus heat* requirement may be reduced by a corresponding amount. The sum of H_v and H_s is the total heat, H_t, to be supplied by the unit ventilator.

These quantities of heat are related by the following equations (based on the use of 100 percent outdoor air):

$$H_v = 0.24\ W\ (t - t_o) \quad (1)$$

$$H_t = 0.24\ W\ (t_f - t_o) \quad (2)$$

$$H_s = H_t - H_v = 0.24\ W\ (t_f - t) \quad (3)$$

$$W = d\ 60\ Q \quad (4)$$

$$H_t = H_s + 0.24\ d\ 60\ Q\ (t - t_o) \quad (5)$$

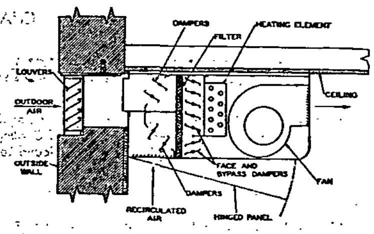

Fig. 3 . . . . Typical Ceiling-Mounted Unit Ventilator

where

d = density of air, pounds per cubic foot (0.075 lb per cu ft for Standard Air, by definition).

H_s = surplus heat, 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.

Q = volume of air handled by the ventilating equipment, cubic feet per minute.

t = temperature to be maintained in the room, Fahrenheit.

t_o = outdoor temperature, Fahrenheit.

t_f = temperature of the air leaving the unit, Fahrenheit.

W = weight of air circulated, pounds per hour.

0.24 = specific heat of air at constant pressure (approximate value).

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 outdoors at 0 F, 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: Since the surplus heat is available to replace the heat loss of the room:

$$H_s = 24{,}000 \text{ Btu per hour}$$

Substituting in Equation 5:

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

$$= 99{,}600 \text{ Btu per hour}$$

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

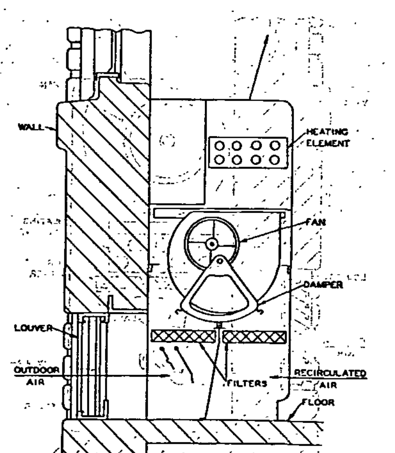

Fig. 2 . . . . Typical Floor-Mounted Unit Ventilator—Blow-Through Type

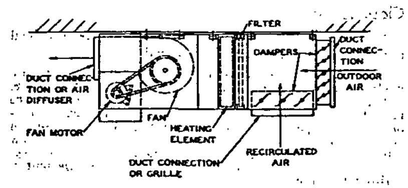

Fig. 4 . . . . Typical Auditorium Unit Ventilator in Horizontal Position

Table 1 . . . . Typical Air and Heating Capacities of Unit Ventilators

Cubic feet of air per minute		Heat for Ventilation[a]	Heating medium					
			Steam		Hot Water		Electric	
Standard air rating	Anemometer rating	H_v, MBh	Total heat H_t, MBh	Surplus heat H_s, MBh	Total heat H_t, MBh	Surplus heat H_s, MBh	Total heat H_t, MBh	Surplus heat H_s, MBh
500	750	9.45	40.6	31.2	32.0	22.5	31.6	22.2
750	1000	14.2	59.8	45.6	48.0	33.8	47.6	33.4
1000	1260	18.9	76.5	57.6	64.0	45.1	63.9	45.0
1250	1560	23.6	96.6	72.0	80.0	56.4	79.6	56.0
1500	1860	28.3	117.7	86.4	96.0	67.7	95.5	67.2

[a] Based on 25 percent outdoor air at 0 F, 70 F room temperature.

If, in *Example 1*, a 1000 cfm (Standard Air) unit were required, but only 25 percent of the air introduced were outdoor air, the solution would be:

$$H_t = 24{,}000 + 0.24 \times 0.075 \times 60 \times 0.25 \times 1000\ (70 - 0)$$

$$= 42{,}900$$

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

The only difference from *Example 1* is that the ventilation load has been reduced.

Heating Capacity Ratings

Heating and air capacity ratings for all unit ventilators are obtained in accordance with the ASHRAE *Standard Code for Testing and Rating Steam Unit Ventilators*.[1] Under this code, the capacities are established for varying air entering temperatures in addition to the standard rating. Capacity ratings include the *entering air temperature*, the *total heating capacity*, the *surplus* or *heating capacity*, and the *final air temperature*.

Hot water unit ventilators have heating capacity ratings based on various entering water temperatures, flow rates or temperature drops, and entering air temperatures.

Gas-fired unit ventilators have heating capacity ratings obtained in accordance with regulations established by the American Gas Association. Heating capacities include the *total heat input* and the *total heat output*, in Btu per hour, for various entering air temperatures.

Electric unit ventilators have heating capacity ratings based on the heat input to the electric heating element, in kilowatts or Btu per hour.

The air capacities of hot water, gas-fired, and electric unit ventilators are obtained in accordance with the ASHRAE *Standard Code for Testing and Rating Steam Unit Ventilators*.[1]

Application of Unit Ventilators

Items to be considered in the application of unit ventilators are: (1) unit air capacity, (2) percent minimum outdoor air, (3) heating and cooling capacity, (4) cycle of control, and (5) location of unit.

The primary considerations in the selection of the unit air capacity are the mild weather cooling capacity and the number of occupants in the space. Other factors to be considered are state and local code requirements, volume of the room, density of occupancy, and the usage of the room. The number of air changes required for a specific application also depends on window area, orientation, and the maximum outdoor temperature at which the unit will be expected to prevent overheating. Values approaching 6 air changes are associated with northerly oriented rooms having smaller window areas. Values approaching 9 air changes are required in southerly oriented classrooms having larger window areas. With very large window areas and southern exposures, as many as 12 air changes may be required. The air capacities listed are based on preventing overheating at outdoor temperatures up to about 55 F. For satisfactory cooling, using outdoor air temperatures up to 60 F, the air capacity provided should be increased accordingly.

The air capacities recommended above principally apply to classroom applications. In factories and kitchens, 30 to 60 air changes or more may be required. Office areas may need from 10 to 15 air changes per hour.

The minimum amount of outdoor air for ventilation is determined after the total air capacity has been established. It may be governed by state or local codes, or may be calculated by the engineer to meet the ventilating air needs of the particular application.

In the absence of other criteria, 10 cfm standard air per occupant is frequently used as a minimum ventilation rate for classroom applications. Spaces such as laboratories, cafeterias, and meeting rooms will usually require larger outdoor air quantities.

The *heating capacity* of a unit to meet the heating requirement can be determined from manufacturers tables. Selection of *heating capacity* should always be made after selecting the unit *air capacity* for mild weather cooling.

Automatic Control of Unit Ventilators

Many different cycles of control are available. The principal difference in the various cycles pertains to the amount of outdoor air delivered to the room. Usually, a room thermostat simultaneously controls a valve, damper, or step controller to regulate the heat supply, and a damper to regulate the supply of outdoor air. An air-stream thermostat in the unit prevents *the discharge of air below the desired minimum* temperature. Unit ventilator control cycles provide the proper sequence for the following stages:

Warm-up Stage. All control cycles function to provide rapid warm-up by having the units provide full heat with the outdoor damper closed. Thus 100 percent room air is recirculated and heated until the room temperature approaches the desired temperature level.

Heating and Ventilating Stage. As the room temperature rises into the operating range of the thermostat, ventilation is accomplished by the partial or complete opening of the outdoor-air damper, according to the cycle used. Auxiliary heating equipment is shut off. As the room temperature continues to rise, the unit ventilator heat supply is throttled.

Cooling and Ventilating Stage. When the room temper-