method of rating is subject to error from differences in types and calibration of instruments, grille design, and the care with which the rating test is conducted. Because of this, the *standard air rating* is used by manufacturers to rate unit ventilators.

Table 1 shows the air delivery capacities by the two methods of rating and the approximate room heating equivalent in square feet of direct radiation (EDR) of an intermediate size of heating element. Heating elements are available for higher and lower capacities.

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:

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

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

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

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

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

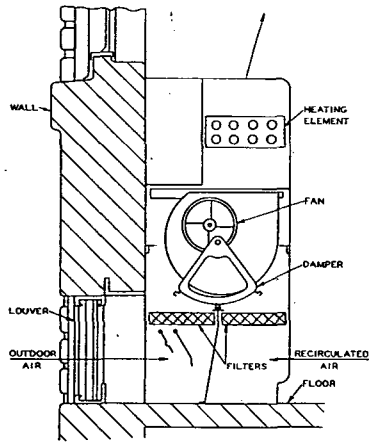

Fig. 2 .... Typical Floor-Mounted Unit Ventilator—Blow-Through Type

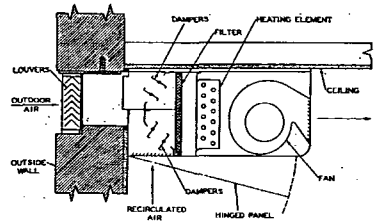

Fig. 3 .... Typical Ceiling-Mounted Unit Ventilator

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:

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

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

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

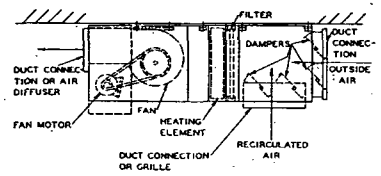

Fig. 4 .... Typical Auditorium Unit Ventilator in Horizontal Position

Table 1 .... Typical Capacities of Unit Ventilators for an Entering Air Temperature of 0 F

Cubic feet of air per minute		Total capacity in square feet, equivalent direct radiation	Capacity available for heating the room, square feet equivalent direct radiation	Final air temperature F
Anemometer rating	Standard air rating			
750	500	214	56	95
1000	750	320	84	95
1260	1000	427	112	95
1560	1250	534	141	95

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 is:

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

$$= 42{,}900$$

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

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

Heating Capacity Ratings

Heating capacity ratings for *steam* unit ventilators are obtained in accordance with the ASHAE *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 ASHAE *Standard Code for Testing and Rating Steam Unit Ventilators*.[1]

Applications 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 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. A safe rule for determining unit air capacity is to allow a total air quantity of 30 cfm per person, or six to nine room air changes, per hour, whichever is greater. With this quantity of air handled, it is possible to obtain satisfactory cooling in mild weather. Table 2 gives recommended room volume circulation rates for different types of spaces served. For rooms facing East, South or West, higher values should be used.

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.

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 determining the basic size of unit by selecting the unit *air capacity*.

Automatic Control of Unit Ventilators

Many different *cycles of control* are available. The principle difference in the various cycles pertains to the amount of outdoor air delivered to the room during normal periods of occupancy. Usually a room thermostat controls both a valve 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 temperature rises above the normal level, cool air is discharged into the room. The room thermostat accomplishes this by throttling the heat supply, finally shutting it off, and opening the outdoor air damper to prevent overheating of the room. The air stream thermostat frequently takes control during this stage to prevent the discharge temperature from falling below a set level.

The three basic *cycles of control* commonly used are as follows:

Cycle X. 100 percent of outdoor air is admitted at all times except during the *warm-up stage.*

Table 2 .... Recommended Outdoor Air Capacities for Mild Weather Cooling

For North Exposure

Type of space	Recommended outdoor air delivery—room volumes per hour
Classrooms	6–9
Laboratories, Forge Shops	6–8
Metal Working Shops	6–8
Offices	6–8
Card Rooms, Lodges	6–9
Private Offices	6–9
Cafeterias & Kitchens	4½–7