indicate the effect on the air in the room occupied. The same air may be rebreathed for a considerable time without apparent harmful effects. However, the average carbon dioxide content of a room should at no time during occupancy be permitted to exceed 16 parts in 10,000 parts of air.

Removal of Odors. Body odors are repulsive and offensive and should be removed by the ventilating system. Odors such as come from cooking, tobacco smoking, toilet and locker rooms and laundries, even though they may eventually become tolerable and unnoticeable, should be minimized.

Removal of Harmful Substances. The removal of harmful or injurious substances from various sources of contamination is frequently of considerable importance. Exhaust systems for dust and refuse created in industrial operations are treated in Chapter 25.

Heat and Moisture. Whenever human beings are present in closed quarters the products of respiration from the lungs, together with the heat and water vapor from the skin are given off directly into the surrounding air. A comparatively large quantity of air is required for this purpose.

In a crowded place of assemblage the heat given off by the occupants, together with that given off by the lighting and power equipment, may be more than the normal heat loss through the structure even in winter under cold climatic conditions. A typical case for winter might show about 300 Btu of body heat, plus 100 Btu per person from light, etc., being given up to the building against about 200 Btu heat loss from the building, per person per hour. This would mean that 200 Btu per person must be carried away by the ventilating system.

It may be that the moisture given off by occupants or by processes will increase the relative humidity to such an extent as to cause discomfort to occupants or interfere with the processes, due to condensation; and the ventilation system must provide for such conditions.

AIR QUANTITIES

There are three standards upon which air quantities may be based, namely (1) bodily heat removal, (2) maintenance of natural ionic content, and (3) elimination of body odors and bacteria.

The most logical basis is that of bodily heat removal in which the temperature rise of the air due to the addition of heat from the bodies of occupants, disregarding other sources of heat, does not exceed a predetermined number of degrees when the full volume available is taken from the outside. Each person at rest gives off about 5 Btu of sensible heat per minute at 70 F. This is sufficient to raise 277 cu ft of air one degree per minute. If a 10-deg rise is allowable, then 27.7 or say 28 cfm per person would be required. If other heat sources are considered, the quantity of air required would be more than 28 cfm. This apparently justifies the *arbitrary assumption* of 30 cfm per person which has been used for many years and which is probably satisfactory for ordinary air change requirements where the removal of bodily heat is the primary consideration.

The air quantities given in Table 1 are stated in terms of square feet of floor area and are based on the 30-cfm-per-person assumption with

allowance for the maximum density with which the ventilated spaces would be occupied. For air conditioning problems a more exact determination should be made in accordance with the data given in Chapter 28. Body odors can be removed with as low as 7½ cfm per person, whereas between 7½ and 10 cfm per person is usually ample for chemical requirements.

Natural ventilation is usually permissible when the following requirements are met:

1. At least 50 sq ft of floor area for each occupant of the room.
2. At least 500 cu ft of air space for each occupant of the room.
3. Effective openings in windows and/or skylights equal to at least 5 per cent of the floor area.

TABLE 1. QUANTITY OF AIR REQUIRED FOR VENTILATION BASED ON SQUARE FEET OF FLOOR SPACE

TYPE OF BUILDING	ROOM	CU. FT. OF AIR PER MINUTE PER SQUARE FOOT OF FLOOR AREA
SCHOOLS	Classrooms	2.0
	Assembly Rooms	1.5
	Gymnasia	1.5
	Picture Machine Booths	1.5
	Dining Rooms	1.5
	Kitchens	2.0
	Corridors	0.5
	Wardrobes and Lockers	2.0
	Toilet, Bath, etc.	2.0
THEATERS	Seating Spaces	2.0
	Toilets, etc.	2.0
	Picture Machine Booths	2.0
HOTELS	Assembly Rooms	2.0
	Dining Rooms	1.5
	Kitchens	4.0
HOSPITALS	Wards	1.0
	Dining Rooms	1.5
	Toilets	2.0
	Kitchens	4.0

In all other cases, a positive means of ventilation should be provided which will introduce into the space or spaces of occupancy at least 0.6 cu ft of air per minute for each square foot of floor area or 30 cu ft of air per minute for each occupant (whichever is the greater). Each such positive ventilating system should be capable of taking the full quantity of air to be circulated from an outside uncontaminated source and of venting, discharging or exhausting a corresponding quantity of room air to the outside.

Special Requirements

The air supply and exhaust for toilets and chemical laboratories should be entirely separate from any other air supply or exhaust system, and should remove at least 2 cu ft of air per minute for each square foot of floor area or at least ⅛ of the volume of the space every minute (which-