of the fact that sufficient outdoor air will find its way into the structure by natural forces. Certainly the advisability of operating an air-conditioning system without the use of outdoor air will depend upon future discoveries in the realm of air "freshness" and whether it proves possible to convince most persons that a synthetic environment is just as fresh and healthful as outdoor air.

Ventilation rates for the control of tobacco smoke and body odors in various applications are suggested in Table 2.

TABLE 2

Recommended Quantities of Outdoor Air per Person[a]

Outdoor air (c.f.m./person)	Type of space or occupancy
5–10	High-ceiling space such as: bank, auditorium, church, department store, theater; room with no smoking
10–15	Apartment, barber shop, beauty parlor, hotel room; room with light smoking
15–20	Cafeteria, drug store with lunch counter, general office, hospital room, public dining room, restaurant; room with moderate smoking
20–30	Broker's board room, private office, tavern; room with heavy smoking
30–60	Conference room, night club; crowded room with heavy smoking

[a] Air-cleaning or odor-removing devices not used. (Space not less than 150 cu. ft. per person or floor area not less than 15 sq. ft. per person.)

State and city codes should be consulted to make certain that minimum outdoor-air requirements are followed.

C. EFFECT OF ROOM SIZE ON VENTILATION REQUIREMENTS

A series of experiments[3,5] on ventilation requirements for human occupancy demonstrated that

> air space per occupant in a room not only affects the disappearance rate of body odors and hence ventilation requirements, but also the efficiency of ventilation systems. Large rooms have an advantage over small ones, as they act like reservoirs, allowing body odors to disappear with a minimum supply of outdoor air and maximum ventilation efficiency. A small room would require a greater air supply per occupant for the control of body odor. An increased air supply entails a loss of ventilation efficiency, as the air passes quickly to the exhaust without removing a full share of odors, heat, and moisture.[5]

Table 3 summarizes the results of these experiments.

With respect to tobacco odors, however, their tendency to become more offensive during the first few hours after smoking indicated that retaining them longer in the occupied space by increasing the volume of the space actually was a handicap. The conclusion was that for control of tobacco smoke by dilution ventilation, small volumes of air space and high ventilation rates per capita would be a preferable combination.

[5] C. P. Yaglou and W. N. Witheridge, *Trans. ASHVE*, **43**, 423 (1937).

TABLE 3

Requirements of Outdoor or Odor-Free Air for Dilution of Body Odors[a]

Air space (cu. ft./person)	Clean air supply (c.f.m./person[a])	Type of occupants and kind of ventilating equipment[b]
100	29	School children; av. personal hygiene
100	25	Sedentary adults
100	22	School children; best personal hygiene
200	38	School children; poor personal hygiene
200	23	Laborers
200	21	School children; av. personal hygiene
200	18	School children; above av. personal hygiene
200	16	Sedentary adults
200	12	Sedentary adults; air washed by centrifugal atomizing humidifier
200	<4	Sedentary adults; summer season; air cooled and dehumidified by spray washer; water changed daily
300	17	School children
300	12	Sedentary adults
500	11	School children
500	7	Sedentary adults

[a] Based on impressions of persons entering experimental room from relatively clean air at "threshold" odor intensity. Allowable odor intensity of 2 on a scale ranging from 0 for no perceptible odor to 5 for nauseating or overpowering odor.

[b] Heating season, air not washed or conditioned, except as noted.

D. MINES, TUNNELS, AND UNDERGROUND SPACES

Man has burrowed underground for many years, and the deeper he goes, the more acutely conscious he becomes of excessively high temperatures and humidities and the presence of dangerous gases. The removal of industrial and residential quarters to underground air-raid shelters makes the ventilating and air-conditioning engineer a highly essential member of the design organization. Industrial hygienists are now generally aware that the conditioning of underground atmospheres is indispensable in the safe operation of deep mines.

The specialized problems of underground ventilation will not be discussed here. The reader is referred to comprehensive publications on this subject.[6]

II. General Ventilation

General ventilation may be classified in several ways to accommodate such functions as (*1*) natural or mechanical, (*2*) supply or exhaust, (*3*) directional

[6] G. E. McElroy, *U. S. Bur. Mines Bull.* No. **385**, 1935; D. Harrington and S. J. Davenport, Part 1, *U. S. Bur. Mines Circ.* No. **7001**, 1938, Part 2, *ibid.*, No. **7182**, 1941; D. Harrington, *Heating, Piping, Air Conditioning*, **17**, 275 (May, 1945); G. E. McElroy, A mine air-conditioning chart, *U. S. Bur. Mines Rept. Invest.* No. **4165**, 1947; I. M. Rice, Heating, ventilating and air conditioning of underground installations, *Quart. Colo. School Mines*, **46**, 258 (January, 1951).