(This appendix is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

INFORMATIVE APPENDIX D RATIONALE FOR MINIMUM PHYSIOLOGICAL REQUIREMENTS FOR RESPIRATION AIR BASED ON CO_2 CONCENTRATION

Oxygen is necessary for metabolism of food to sustain life. Carbon and hydrogen in foods are oxidized to carbon dioxide (CO_2) and water (H_2O), which are eliminated by the body as waste products. Foods can be classified as carbohydrates, fats, and proteins, and the ratio of carbon to hydrogen in each is somewhat different. The respiratory quotient (RQ) is the volumetric ratio of CO_2 produced to oxygen consumed. It varies from 0.71 for a diet of 100% fat to 0.8 for a diet of 100% protein and 1.00 for a diet of 100% carbohydrates [D-1]. A value of RQ = 0.83 applies to a normal diet mix of fat, carbohydrate, and protein.

The rate at which oxygen is consumed and CO_2 is generated depends on physical activity. These relationships are shown in Figure D-2 (see Reference D-2). The breathing rate is shown also. A simple mass balance equation gives the outdoor airflow rate needed to maintain the steady-state CO_2 concentration below a given limit.

$$V_o = N/(C_s - C_o) \qquad \text{(D-1)}$$

where

V_o = outdoor airflow rate per person

V_e = breathing rate

N = CO_2 generation rate per person

C_e = CO_2 concentration in exhaled breath

C_s = CO_2 concentration in the space

C_o = CO_2 concentration in outdoor air

For example, at an activity level of 1.2 met units (1.0 met = 18.4 Btu/h· ft^2), corresponding to sedentary persons, the CO_2 generation rate is 0.31 L/min. Laboratory and field studies have shown that with sedentary persons about15 cfm (7.5 L/s) per person of outdoor air will dilute odors from human bioeffluents to levels that will satisfy a substantial majority (about 80%) of unadapted persons (visitors) to a space [D-3,D-4,D-5,D-6,D-7]. If the ventilation rate is to be held to 15 cfm (7.5 L/s) per person, the resulting steady-state CO_2 concentration relative to that in the outdoor air is

$$\begin{aligned} C_s - C_o &= N/V_o \\ &= 0.31/(7.5 \times 60 \text{ s/min}) \\ &= 0.000689 \text{ L of } CO_2 \text{ per L of air} \\ &\approx 700 \text{ ppm} \end{aligned}$$

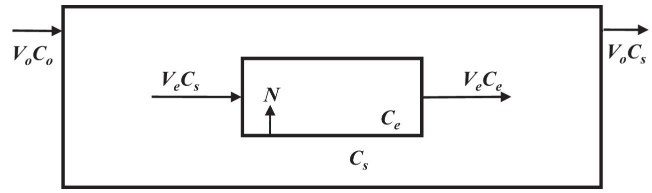

FIGURE D-1 Two-chamber model.

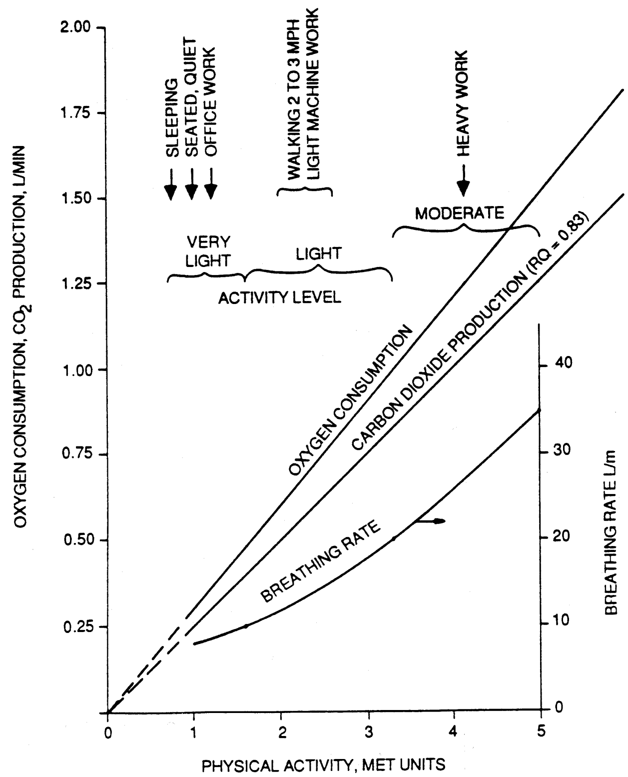

FIGURE D-2 Metabolic data.

Thus, maintaining a steady-state CO_2 concentration in a space no greater than about 700 ppm above outdoor air levels will indicate that a substantial majority of visitors entering a space will be satisfied with respect to human bioeffluents (body odor). A more detailed discussion of this relationship between CO_2 concentrations and the perception of bioeffluents, as well as the use of indoor CO_2 to estimate building ventilation rates, is contained in ASTM Standard D6245 [D-8].

CO_2 concentrations in acceptable outdoor air typically range from 300 to 500 ppm. High CO_2 concentrations in the outdoor air can be an indicator of combustion and/or other contaminant sources.

Figure D-3 shows the outdoor airflow rate required as a function of physical activity and steady-state room concentration. If the activity level is greater than 1.2 met, the required ventilation must be increased to maintain the same CO_2 level.

Also the decrease in oxygen content of the room air can be found from Equation D-l when oxygen concentration is substituted for carbon dioxide concentration.

$$C_o - C_s = N/V_o \qquad \text{(D-2)}$$

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