or unfamiliar odors tend to receive much more attention from the neighborhood than the customary odors generated by well known processes and raw materials. Methods of odor control currently in use include charcoal adsorption, scrubbing towers and air washers, chlorination, condensation, masking, passage of the odorous air through combustion chambers, and best of all, substitution of less offensive materials whenever possible [8, 9, 10, 11].

The control of air quality within buildings ventilated for human occupancy is discussed in Chapter 12. Tobacco smoke odors, cooking odors and body odors are air contaminants of the nuisance type which now command a decisive position in the standards of air quality for indoor comfort. However, the engineer will find, at times, that odors originating outside buildings in industrial or business districts may have an even greater bearing than indoor contamination on the kind and capacity of equipment he must provide for a high quality air supply installation.

INDUSTRIAL AIR CONTAMINANTS

Many industrial processes are sources of contaminants. Their undesirable effects are known to the public and their control is an important function of the ventilating or air conditioning engineer, because the atmosphere within buildings is the medium whereby such finely divided matter is dispersed and transported from the source to remote locations where it may cause property damage, nuisance, fire, explosion, disease and even death.

Tables 3, 4 and 5 give the maximum allowable concentrations for industrial air contaminants as currently accepted in most sections of the country. They apply to *exposures of 8 hours per day*, and refer to the quantities of contaminant permissible in the *workers' breathing zone*. Some of these figures may be altered as the result of continuous research, and some may differ from those in force in a few cities or states. The prudent engineer will design equipment using these values as the *upper* limits of air contamination, and will incorporate a reasonable margin of safety in his estimates of ventilation capacity.

Information on the properties and effects, with respect to health, of specific industrial air contaminants has developed rapidly within the past decade into an extensive literature. Some of the more readily available publications are listed at the end of this chapter.

FLAMMABLE GASES AND VAPORS

Adequate ventilation is a primary requirement for eliminating or minimizing the hazard of fire or explosion due to gases and vapors. The need for good ventilation is not removed by the use of other precautions, such as the elimination of known ignition sources, segregation of hazardous operations, adoption of safe building construction, and installation of automatic alarms. Some safety engineers regard overventilation of an operation employing flammable liquids as a legitimate operating charge for the privilege or necessity of using a dangerous process. However, it is not possible to apply a reasonable safety factor to the ventilation estimate without consideration of the concentrations of gases or vapors that approach the danger point. Safety engineers prefer to limit the concentration to ¼ or ⅕ of the lower explosive limit, and this fact should be given full weight in determining the capacity and design of ventilating equipment. Rarely should consideration be given to *operation above*

TABLE 3. PHYSIOLOGICAL RESPONSE TO GASES AND VAPORS[a]
Concentrations in Parts of Substance per Million Parts of Air (ppm)

Substance	Rapidly Fatal	Dangerous to Life in ½ to 1 Hr	Maximum Allowable Concentration for Daily Exposures
Acrolein	2,000	100	1
Ammonia	5,000	2,500	100
Amyl acetate	....	....	400
Aniline	....	200	5
Arsine	250	10	1
Benzene (benzol)	20,000	5,000	100[b]
Bromine	500	40	1
Butyl acetate	....	10,000	400
Carbon dioxide	100,000	50,000	5,000
Carbon disulfide	2,000	1,000	20[b]
Carbon monoxide	4,000	1,000	100[b]
Carbon tetrachloride	50,000	....	100[c]
Chlorine	1,000	10	1
Dichlorobenzene	....	....	75
Dichloroethyl ether	....	500	15
Ether (diethyl)	....	35,000	400
Ethyl acetate	40,000	10,000	400
Ethylene dichloride	....	4,000	100
Formaldehyde	....	....	10[b]
Gasoline	....	....	1,000
Hydrogen chloride	1,000	....	10
Hydrogen cyanide	200	100	20
Hydrogen fluoride	....	50	3
Hydrogen sulfide	600	200	20[b]
Methyl alcohol	....	....	200[b]
Methyl bromide	20,000	2,000	50
Methyl chloride	150,000	20,000	100
Methylene chloride	....	....	500
Monochlorobenzene	....	....	75
Nitrobenzene	....	....	5
Nitrogen oxides	300	100	25[b]
Phosgene	50	5	1
Phosphine	1,000	400	1
Styrene	....	....	400[b]
Sulfur dioxide	400	150	10
Tetrachloroethane	7,000	....	10
Tetrachloroethylene	....	....	200
Toluene (toluol)	20,000	5,000	200
Trichloroethylene	....	....	200
Turpentine	....	....	200
Xylene (xylol)	20,000	5,000	200[b]

[a]Adapted from: Manual of Industrial Hygiene, by W. M. Gafafer et al, U. S. Public Health Service (W. B. Saunders Co., 1943); Analytical Chemistry of Industrial Poisons, Hazards and Solvents, by M. B. Jacobs (Interscience Publishers, 1941); Noxious Gases, by Henderson and Haggard (Reinhold Publishing Co., N. Y., 1943); and other authoritative sources.

[b]Adopted by the *American Standards Association* (American Standard Z-37).

[c]50 ppm recommended by the Detroit Bureau of Industrial Hygiene.

the upper explosive limit in the open areas of buildings or rooms—even though unoccupied—because the danger of temporary drop of gas concentration to a point within the explosive range is too great.

The ability of a flammable liquid to form explosive mixtures is determined largely by its vapor pressure, volatility, or rate of evaporation.