occasionally the engineer is confronted with the problem of removing such material before the air in question is suitable for use in building ventilation.

The physical properties of the particulate impurities of air are summarized conveniently in the chart of Fig. 1.

In the case of gases, the objectionable features are the injurious physiological effects and the danger from inflammability. (See Table 1.)

Dust Concentrations

It is customary to report dust concentrations as grains per 1000 cu ft or milligrams per cubic meter (except for dusts that may cause pneumoconiosis, which are reported as so many particles per cubic foot of air). Gas concentrations are commonly recorded as milligrams per cubic meter or as parts per million or as per cent by volume. Typical ranges in dust concentrations as now found in practical applications are given in Table 2.

TABLE 2. DUST CONCENTRATION RANGES IN PRACTICAL APPLICATIONS[a]

APPLICATION	GRAINS PER 1000 CU FT	MGS PER CU M
Rural and suburban districts	0.2 to 0.4	0.4 to 0.8
Metropolitan districts	0.4 to 0.8	0.9 to 1.8
Industrial districts	0.8 to 1.5	1.8 to 3.5
Dusty factories or mines	4.0 to 80.0	10 to 200
Explosive concentrations (as of flour or soft coal)	4000 to 8000	10,000 to 20,000

[a]1 grains per 1000 cu ft = 2.3 mgs per cubic meter; 1 oz per cubic foot = 1 g per liter.

The engineer frequently desires information regarding the effects of various concentrations of gases or dusts upon man, as the success of a particular installation may depend upon the maintenance of air which is adequately clean. At the present time there are several organizations working on this problem all of them publishing literature of various kinds.[1] References to books covering the hygienic significance, determination and control of dust are listed at the end of this chapter.

AIR POLLUTION AND HEALTH

The prevention of various diseases which result from exposure to atmospheric impurities is an engineering problem. It is important for the engineer to insure, by proper ventilation, suitable environments for working or for general living. If the equipment used is to be successful, it must operate automatically as in the modern air conditioned theater or railroad train.

In Table 3 are given data on permissible concentrations of various substances, gases and dusts, which occur in industry. The prudent engineer will design equipment using these bench marks as the upper limits of pollution. In general it is good practice to avoid recirculation of air which originally contains toxic substances. Obviously there may be

[1]National Institute for Health, U. S. Public Health Service; Division of Labor Standards, U. S. Department of Labor; University of Toronto Medical School, Canada; Saranac Laboratories, Saranac Lake, N. Y.; Industrial Hygiene Foundation, Inc., Pittsburgh, Pa.; Harvard School of Public Health, Boston, Mass.; Haskell Laboratory, Wilmington, Del.; and the Departments of Health and of Labor in the United States and in various provinces of Canada.

exceptions to this rule, but it is one which is generally being followed in current practice.

Affections of the respiratory tract are associated with exposure to thick dust, and may follow inhalation of practically any kind of insoluble and non-colloidal dust. Atmospheric dust in itself cannot be blamed for causing tuberculosis, but it may aggravate the disease once it has started.[2]

TABLE 3. TOXICITY OF GASES, VAPORS, DUSTS AND FUMES[a]

SUBSTANCE	SINGLE EXPOSURES: Rapidly Fatal (ppm)	SINGLE EXPOSURES: Dangerous for from ½ to 1 Hour (ppm)	SINGLE EXPOSURES: Max. Safe Concentration for ½ to 1 Hour (ppm)	MAX. ALLOWABLE AVERAGE CONCENTRATION FOR REPEATED EXPOSURES (ppm)
Ammonia	5,000–10,000	2500	300	100
Aniline	....	....	105–160	5
Arsine	250	15	6	1
Benzene	190	....	31–47	100
Carbon bisulfide	4800	3200–3850	960–1600	20
Carbon dioxide	80,000–100,000	....	....	.....
Carbon monoxide	4000	1500–2000	400	100
Carbon tetrachloride	10,000	....	1000	100
Chlorine	900	14–21	3.5	1
Hydrogen cyanide	270	110–135	45–54	20
Hydrogen chloride	1250–1750	1000–1350	40–90	10
Hydrogen fluoride	660	50–250	10	3
Hydrogen sulfide	1000–2000	360–500	200–300	20
Methyl bromide	20,000–40,000	2000–4000	1000	.....
Methyl chloride	150,000–300,000	20,000–40,000	7000	.....
Nitrobenzene	....	....	200	5
Oxides of nitrogen	320–530	117–154	....	10
Phosgene	90	12.5	....	1
Phosphine	2000	400–600	100–200	2
Sulfur dioxide	400–500	150–190	50–100	10
Tetrachlorethane	7300	....	....	10
Toluene and xylene	....	....	....	200
Trichlorethylene	7800	....	3700	200
DUSTS:				
Containing high percentages of free silica				5 million[b]
Containing 25 to 35 percentages of free silica				10–20 million[b]
Containing small percentages of free silica				30 million[b]
Cadmium				0.1[c]
Lead				0.15[c]
Mercury				0.1[c]
Manganese				30[c]
Zinc				15[c]

[a]Adapted from Sayers and DallaValle, *Mechanical Engineering*, April, 1935; *American Standards Association*; *Journal of Industrial Hygiene and Toxicology*, June, 1940; and other authoritative sources.
[b]Particles (less than 10 microns) per cubic foot of air.
[c]Milligrams per cubic meter of air.

The sulphurous fumes and tarry matter in smoke are more dangerous than the carbon. In foggy weather the accumulation of these substances in the lower strata may be such as to cause irritation of the eyes, nose, and respiratory passages. The Meuse Valley fog disaster will probably become

[2]Physiological Response of the Peritoneal Tissue to Dusts Introduced as Foreign Bodies, by Miller and Sayers (*U. S. Public Health Reports*, 49:80, 1934).