as far east as Boston was affected noticeably and particles as large as 40 to 50 microns were actually carried half way across the continent before they settled out. In similar manner volcanic ash has been carried even further. It is not surprising, therefore, that fly-ash from furnace gases, cement dust and the like, can be carried for considerable distances and 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. 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 gr 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 theatre or railroad train.

In Table 3 are given data on permissible concentrations of various substances, gases and dusts, which occur in industry. The prudent

[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.; Air 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.

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 contains originally toxic substances. Obviously there may be exceptions to this rule, but it is one which is generally being followed in current practice.

Bronchitis is the chief condition associated with exposure to thick dust, and follows upon 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 and Fumes in Parts per 10,000 Parts of Air[a]

Vapor or Gas	Rapidly Fatal	Maximum Concentration for from ½ to 1 Hour	Maximum Concentration for 1 Hour	Maximum Allowable for Prolonged Exposure
Carbon monoxide	40	15–20	10	1
Carbon dioxide	800–1000	....	....	....
Hydrocyanic acid	30	1½	½	⅕
Ammonia	50–100	25	3	1
Hydrochloric acid gas	10–20	½	....	1/10
Chlorine	10	½	....	1/100
Hydrofluoric acid gas	2	1/10	....	1/33
Sulphur dioxide	4–5	½–1	....	1/10
Hydrogen sulphide	10–30	5–7	2–3	1
Carbon bisulphide	....	11	5	½
Phosphene	20	4–6	1–2	....
Arsine	2½	½	½	....
Phosgene	Over ¼	¼	....	1/100
Nitrous fumes	2½–7½	1–1½	....	⅓
Benzene	190	....	31–47	1½–3
Toluene and xylene	190	....	31–47	....
Aniline	....	....	1–1½	1/10
Nitrobenzene	....	....	1/100	1/500
Carbon tetrachloride	480	240	40	1
Chloroform	250	140	50	2
Tetrachlorethane	73	....	....	1/10
Trichlorethylene	370	....	....	....
Methyl chloride	1500–3000	200–400	70	5–10
Methyl bromide	200–400	20–40	10	2
Lead dust	....	....	....	0.15 mg/cu m
Quartz dust	....	....	....	1 mg/cu m

[a]Adapted from Y. Henderson and H. Haggard. (See *Noxious Gases, 1927*, and *Lessons Learned from Industrial Gases and Fumes, Institute of Chemistry of Great Britain and Ireland*, London, 1930.)

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 a classic example in the history of gaseous air pollution. Released in a rare combination of atmospheric calm and dense fog, it is believed that sulphur dioxide and other toxic gases from the industrial region of the valley caused 63 sudden deaths, and injuries to several hundred persons.

Carbon monoxide from automobiles and from chimney gases constitutes another important source of aerial pollution in busy cities. During

[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).