

TABLE 5. TOXICITY OF GASES AND FUMES IN PARTS PER 10,000 PARTS OF AIR^a

VAPOUR OR GAS	RAPIDLY FATAL	MAXIMUM CONCENTRATION FOR FROM 1/4 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	1 1/2	1/2	1/5
Ammonia.....	50-100	25	3	1
Hydrochloric acid gas.....	10-20	1/2	-----	1/10
Chlorine.....	10	1/2	-----	1/100
Hydrofluoric acid gas.....	2	1/10	-----	1/33
Sulphur dioxide.....	4-5	1/2-1	-----	1/10
Hydrogen sulphide.....	10-30	5-7	2-3	1
Carbon bisulphide.....	-----	11	5	1/2
Phosphene.....	20	4-6	1-2	-----
Arsine.....	2 1/2	1/2	1/2	-----
Phosgene.....	Over 1/4	1/4	-----	1/100
Nitrous fumes.....	2 1/2-7 1/2	1-1 1/2	-----	1/3
Benzene.....	190	-----	31-47	1 1/2-3
Toluene and xylene.....	190	-----	31-47	-----
Aniline.....	-----	-----	1-1 1/2	1/10
Nitrobenzene.....	-----	-----	1/100	1/500
Petrol.....	243	100-220	-----	-----
Carbon tetrachloride.....	480	240	40	16
Chloroform.....	250	140	50	2
Tetrachlorethane.....	73	-----	-----	1 1/2
Trichlorethylene.....	370	-----	-----	-----
Methyl chloride.....	1500-3000	200-400	70	5-10
Methyl bromide.....	200-400	20-40	10	2
Lead vapor.....	-----	-----	-----	5-6

^aOriginal data compiled by Y. Henderson and H. Haggard. (See *Noxious Gases*, 1927). Data revised by T. M. Legge. (See *Lessons Learned from Industrial Gases and Fumes*, Institute of Chemistry of Great Britain and Ireland, London, 1930).

manifold and the effects too diverse to be considered here. It would suffice to discuss the commonest and most serious with which the ventilating engineer may be confronted, namely, carbon monoxide, lead, and silica. For a more thorough treatise on the subject, refer to books by Hamilton²⁶, Rosenau²⁷, and Henderson and Haggard²⁸.

Carbon monoxide is one of the commonest forms of gas poisoning. It is met with in mines, foundries, coke-oven sheds, garages, and in houses. The poisonous action is due to the fact that the combining power of carbon monoxide with the hæmoglobin of the red blood corpuscles is about 300 times greater than that of oxygen. This stable combination destroys the power of the hæmoglobin to unite with oxygen in the lungs, and to supply it to the tissues. The effects are, therefore, due to lack of oxygen and the symptoms are those of anoxemia, namely, dizziness, headaches, sleepiness, fatigue, and in extreme cases, paralysis and death. The dangerous saturation level of the blood with carbon monoxide is about 50 per cent. Even as little as 0.07 per cent in air will render, in half an hour, one quarter of the red corpuscles incapable of uniting with oxygen.

²⁶*Industrial Poisons in the United States*, by Alice Hamilton.

²⁷*Preventive Medicine and Hygiene*, by Milton J. Rosenau.

²⁸*Noxious Gases*, by Y. Henderson and H. Haggard.

One to two parts per 10,000 parts of air is set as a safe limit of pollution which may be breathed for a long time without producing perceptible symptoms.

Silicosis is a chronic disease of the lungs which results from local physio-chemical action of hydrated silica upon the pulmonary tissue causing progressive lumphatic fibrosis and rendering the tissue susceptible to tuberculosis. The disease is slow in evolution, requiring usually a number of years of exposure. It occurs principally among granite workers, sand blasters, metal miners, metal polishers, potters, millstone workers and others.

Studies have shown that dust containing a high percentage of free silica in particles less than 10 microns (1 micron = 0.0004 in.) in size are chiefly responsible for silicosis because only these particles reach the depths of the lungs. Workers exposed to air containing about 15,000,000 or less, dust particles per cubic foot (35 per cent free silica in the form of quartz) under 10 microns in size, showed practically no sickness from tuberculosis. In order to attain this safe concentration, a velocity of 1500 fpm was necessary in the suction hoods²⁹ intended for dust removal.

Lead poisoning is the most insidious and most frequent of all of the occupational intoxicants. It occurs principally among lead workers and smelters, lead miners, potters, painters, typesetters, stereotypers, plumbers, glass, gold and silver workers. Lead, in practically all forms is a cumulative poison which is absorbed by way of the blood stream, chiefly from the respiratory tract, but also from the digestive tract and from the skin. The effect may be acute or chronic poisoning. The principal symptoms are colic, constipation, anæmia, headache, anorexia, a bluish line along the edges of the gums, rheumatic pains, and in extreme conditions, paralysis, blindness, insanity and death.

It has been found³⁰ that 2 mg per day is the lowest dose, by inhalation, which in the course of years may result in lead poisoning. Regular inhalation during the usual working hours of air containing less than 0.2 mg of lead per cubic meter does not seem to produce serious lead intoxication in individuals of representative industrial groups³¹.

The prevention of industrial hazards from dusts and poisonous gases is largely a ventilation problem, and it consists in keeping the impurities in air down to a safe concentration. At present, there are no accurate standards on which to base the design of the ventilation equipment. Approximate data on the toxicity of various gases and fumes met with in industrial establishments are given in Table 5. The maximum allowable concentrations for prolonged exposure, (Column 5) will, perhaps, in the course of weeks, months or years, produce pernicious effects because the experiments cited here were limited in most cases to exposures of not more than a week.

Very little is known concerning the physiologic effects induced by various concentrations of dusts and by various durations of exposure.

²⁹*A Study of the Efficiency of Dust Removal Systems in Granite-Cutting Plants*, by J. J. Bloomfield (*Public Health Reports* No. 44, 1929, Vol. 42, p. 2505).

³⁰*Lead Poisoning*, by Thomas Morrison Legge (*Journal Royal Society Arts*, 1929, Vol. 77, p. 1023).

³¹*What is a Dangerous Quantity of Lead Dust in Air*, by C. M. Salls (*Industrial Hygiene Bulletin*, New York State Department of Labor, 1925).