consideration be given to *operation above 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.

Ability of a flammable liquid to form explosive mixtures is determined largely by its vapor pressure, volatility, or rate of evaporation. *Flash point* is a convenient method of expressing this property in terms of the temperature scale. It may be defined as the temperature to which a combustible liquid must be heated to produce a flash when a small flame is passed across the surface of the liquid. The higher the flash point, the more safely can the liquid be handled. Liquids with flash points under 70 F should be regarded as highly flammable.

TABLE 4. LIMITS FOR TOXIC DUSTS, FUMES AND MISTS

SUBSTANCE	A.S.A. STANDARDS, M.A.C. mg/cu m	THRESHOLD LIMIT VALUES, *A.C.G.I.H.* 1951 mg/cu m
Antimony		0.5
Arsenic		0.5
Barium		0.5
Cadmium	0.1 (W)	0.1
Chlorodiphenyl		1
Chromic acid & chromates (As CrO_3	0.1	0.1
Cyanide as CN		5
Dinitrotoluene		1.5
Fluorides		2.5
Iron Oxide fume		15
Lead	0.15	0.15
Magnesium oxide fume		15
Manganese	6	6
Mercury	0.1	0.1
Pentachloroanphthalene		0.5
Pentachlorophenol		0.5
Phosphorus (yellow)		0.1
Phosphorus pentachloride		1
Phosphorus pentasulfide		1
Selenium compounds as selenium		0.1
Sulfuric acid		1
Tellurium		0.1
Tetryl		1.5
Trichloronaphthalene		5
Trinitrotoluene		1.5
Zinc oxide fumes		15

Upper and lower limits of flammability of gases and vapors, and the flash points of the corresponding liquids are given in Table 6.

Methods for estimating the flammable limits of mixtures of gases or vapors must be applied with caution; the reader is referred to other publications for this information.[12, 13]

Design of equipment for the control of combustible anesthetics is outlined in Chapter 7. Construction of equipment for handling air containing flammable substances, or operating in atmospheres so contaminated, is discussed in Chapter 45.

It is customary to report the concentrations of flammable gases or vapors in percent by volume, or *volume percent* Comparison with concentrations on the *part per million* scale used in chemical, medical or industrial hygiene literature is readily made by the conversion: 1 percent = 10,000

ppm (parts of contaminant per million parts of air, by volume, or in other words, cubic feet of contaminant per million cubic feet of air). It will be noted in Table 6 that nearly all of the substances listed have lower explosive limits above 1.0 percent, while the *maximum allowable concentrations* for gases and vapors in Table 3 are below 1000 ppm or 0.1 percent in most cases. Therefore, control of toxic or injurious vapors to levels below their maximum allowable concentrations for health usually requires much more effective ventilation than for the prevention of a fire hazard.

COMBUSTIBLE DUSTS

A dust explosion is essentially a sudden pressure rise caused by the very rapid burning of airborne dust. The primary explosion often originates from a small amount of dust in suspension exposed to a source of ignition, and the pressure and vibration it creates may be sufficient to dislodge large accumulations of dust on horizontal ledges or surfaces of the building and equipment, thereby creating a secondary explosion of great force.

TABLE 5. LIMITS FOR MINERAL DUSTS

SUBSTANCE	THRESHOLD LIMIT VALUES *A.C.G.I.H.* 1951 mppcf[a]
Alundum	50
Asbestos	5
Carborundum	50
Dust (nuisance, no free silica)	50
Mica	20
Portland cement	50
Silica—high (above 50% free SiO_2)	5
Silica—medium (5 to 50% free SiO_2)	20
Silica—low (below 5% free SiO_2)	50
Slate (below 5% free SiO_2)	50
Soapstone (below 5% free SiO_2)	20
Talc	20
Total dust (below 5% free SiO_2)	50

[a] mppcf—million particles per cubic foot of air, standard light field count.

Thus the air conditioning engineer is involved for two reasons: (1) to obtain a movement of dust-laden air into exhaust hoods or openings, and through ventilating or pneumatic conveying ducts, in a manner that will prevent accumulation of highly flammable dust at points where it could ignite inside the equipment; and (2) to so design *process ventilation* as to prevent the escape of dust which might settle on horizontal surfaces and become a potential source of disaster at some distance from the dusty operation. (See Chapter 45).

Intensity of a dust explosion depends upon: chemical and thermal properties of the dust; particle size and shape; concentration in air; proportion of inert dust in the air; moisture content and composition of the air; size and temperature of the ignition source; and degree of dispersion of the dust cloud. Investigations on the explosibility of dusts require determination of the maximum pressure developed during explosion of a known air concentration, as well as determination of the rate of pressure rise. Investigators frequently experience difficulty in obtaining dust suspensions of uniform dispersion, and this should be kept in mind when comparing results from several sources.[14]

Minimum explosive concentrations of airborne dusts already tested range from 0.01 to 0.5 oz per cubic foot, or 10 to 500 grams per cubic meter