

Table 3 Approximate Limits of Flammability of Single Gases and Vapors in Air at Ordinary Temperatures and Pressures*

Gas or Vapor	Lower Limit Percent by Volume	Upper Limit Percent by Volume	Lower Limit Flash Point Fahrenheit	Upper Limit Flash Point Fahrenheit	Class	Division
Acetaldehyde	4.0	57	-17		I	
Acetone	2.5	12.8	0		I	
Acetylene	2.5	80				
Allyl alcohol	2.5		70		II	
Ammonia	15.5	28.6				
Amyl alcohol	1.2		100		III	
Amyl chloride	1.6					
Amylene	1.6	7.7				
Benzene (benzol)	1.3	6.8	12		I	
Benzyl chloride	1.1		140		II	
Butane	1.8	8.4				
Butyl acetate	1.4	15.0	84		III	
Butyl alcohol	1.7					
Butylene	2.0	9.7				
Carbon disulfide	1.2	60	-22		I	
Carbon monoxide	12.5	74.2				
Crotonaldehyde	2.1	15.5	55		II	
Cyclohexane	1.3	8.4	1		I	
Cyclopropane	2.4	10.5				
Decane	0.67	2.6	115		III	
Dichloroethylene (1, 2)	9.7	12.8	57		II	
Diethyl selenide	2.5					
Dioxane	2.0	22.2	64		II	
Ethane	3.1	12.5				
Ether (diethyl)	1.8	36.5	-49		I	
Ethyl acetate	2.2	11.5	28		II	
Ethyl alcohol	3.3	19.0	54		II	
Ethyl bromide	6.7	11.3				
Ethyl formate	2.6	15.7	104		III	
Ethyl chloride	4.0	14.8	-58		I	
Ethylene	2.7	28.6				
Ethylene dichloride	6.2	15.9	56		II	
Ethyl nitrate	2.7	16.5	-4		I	
Ethylene oxide	3.0	50	-31		I	
Furfural (125 C)	2.1		140		III	
Gasoline (variable)	1.4-1.57	4-7.6	-50		I	
Heptane	1.0	6.0	25		II	
Hexane	1.2	6.9	-15		I	
Hydrogen cyanide	5.6	40.0				
Hydrogen	4.0	74.2				
Hydrogen sulfide	4.3	45.5				
Iluminating gas (coal gas)	5.3	33.0				
Isobutyl alcohol	1.7		82		III	
Isopentane	1.8					

* Adapted from: *Fire and Explosion Hazards of Combustible Gases and Vapors*, by G. W. Jones; Chapter 13, *Industrial Hygiene and Toxicology*, edited by F. A. Patty (Interscience Publishers, 1948); *Properties of Flammable Liquids, Gases and Solids* (Associated) Factory Mutual Fire Ins. Co., January (1940); and *National Fire Codes for Flammable Liquids, Gases, Chemicals and Explosives—1945* (National Fire Protection Association).

^b Closed cup refers to the equipment used in flash point determinations.

^c From *Standards for Storage, Handling and Use of Flammable Liquids* (National Board of Fire Underwriters, No. 20, July 1954).

believed that irritant gases, principally from combustion and industrial plants, accumulating during long periods of meteorological inversion and fog contributed to the illness of many persons and to the death of some who were especially susceptible. The accumulation of contaminants may cause irritation of eyes, nose, and respiratory passages, and it appears that the exceptionally young and the exceptionally old are particularly susceptible to respiratory harm.

Much investigative work is currently being conducted to assess the potential harm of these toxic properties, not only to humans but to vegetation as well. The effects of severe pollution on paint, property, and structures are well-known. When results are established, they are certain to be many

times lower than the threshold limit values discussed earlier. As indicated, the personal limits for industrial occupation are based on limited exposures of 8 hr per day for the normal work week; air pollution limits, however, must be based on continuous exposure, not only for the healthy workmen, but for the entire exposed population, containing individuals with greater variation in age and health.

The engineer must accept his responsibilities not only in coping with existing pollution by selecting equipment that will provide clean air but also in abating pollution by providing the necessary controls to accompany the design. This must include proper selection of equipment to give satisfactory combustion, as well as controls to enable the super-

Table 4 Explosion Characteristics of Various Dusts*

Type of Dust	Ignition Temperature of Dust Cloud, Deg. C	Minimum Spark Energy Required for Ignition of Dust Cloud, Millijoules	Minimum Explosive Concentration, Oz Per Cu Ft	Maximum Explosion Pressure, Psi	Rates of Pressure Rise, Psi per Second		Limiting Oxygen % to Prevent Ignition of Dust Cloud by Electric Sparks
					Average	Maximum	
Metal Powders							
Aluminum, atomized	700	50	0.040	58	1,050	2,250	3
Aluminum, stamped	645	20	0.035	89	2,150	5,700	
Iron, hydrogen reduced	315	160	0.120	29	650	1,200	13
Magnesium, atomized	600	240	0.030	57	750	1,450	<3
Magnesium, milled	520	80	0.020	65	1,500	3,150	
Magnesium, stamped	520	20	0.020	72	4,400	4,750	
Manganese	450	120	0.210	25	200	300	15
Silicon	775	900	0.160	62	450	1,200	15
Tin	630	160	0.190	28	250	400	16
Titanium	480	120	0.045	44	750	1,100	
Vanadium	500	60	0.220	34	200	300	13
Zinc	680	900	0.500	13	150	300	10
Zirconium	15	0.045	49	42	1,450	4,000	
Downmetal	430	80	0.020	56	1,600	2,550	
Ferrosilicon (88% Si)	370	80	0.140	34	600	1,400	13
Ferrosilicon	360	400	0.425	36	200	300	19
Magnesium-aluminum (50-50)	535	80	0.050	61	2,250	3,000	
Allyl alcohol resin	600	20	0.035	68	1,750	3,550	
Ceclin	520	20	0.045	49	500	500	17
Cellulose acetate	320	10	0.025	82	1,200	2,400	14.5
Cellulose propionate	460	60	0.025	66	1,350	2,350	
Coumarone-indene resin	520	10	0.015	63	1,350	3,000	14.5
Hexamethylenetetramine	410	10	0.015	64	950	2,550	14.5
Plastics							
Lignin resin	450	20	0.040	69	750	2,700	17
Methyl methacrylate	440	15	0.020	57	550	1,200	14.5
Pentacrythritol	450	10	0.030	65	1,000	2,150	14.5
Phenolic resin	490	10	0.025	61	1,350	3,150	14.5
Phthalic anhydride	650	15	0.015	49	1,250	1,700	14.5
Polyethylene resin	450	80	0.025	63	400	1,250	15
Polystyrene	490	120	0.020	44	350	650	17
Shellac, rosin, gum	390	10	0.015	58	1,250	3,000	14.5
Synthetic rubber, hard	320	30	0.030	59	1,850	1,850	15
Urea molding compound	450	80	0.075	63	700	1,800	17
Vinyl butyl resin	390	10	0.020	60	450	1,000	14.5
Agricultural Products							
Alfalfa	530	320	0.100	66	500	1,100	
Cellulose	440	60	0.050	70	800	2,250	
Citrus peel, dehydrated	490	45	0.065	51	600	1,000	
Clover seed	470	80	0.060	49			17
Cornstarch, modified	470	40	0.045	72	1,050	2,150	
Corn cob, ground, dried	400	60	0.030	64	1,300	2,150	
Onion, dehydrated	410	60	0.130	60	400	1,300	
Pea, dehydrated	560	370	0.050	68	800	1,950	
Peanut cracklings	570	40	0.085	41	200	350	
Rice	490	80	0.045	61	850	1,350	
Soybean	560	100	0.040	65	800	2,450	17
Wing kernels	540	240	0.070	74	650	1,950	
Wheat, cracked	470	160	0.060	58			
Miscellaneous							
Aluminum stearate	400	15	0.015	62	750	2,100	
Bark dust, Douglas fir	540	40	0.030	60	800	1,800	
Coal, bituminous	610	40	0.035	46	350	800	16
Coal-tar pitch	430	80	0.080	49	650	1,500	15
Crude rubber, hard	350	50	0.025	57	850	3,350	15
Dinitro-ortho-cresol	440	50	0.025	55	1,300	2,250	15
Gilsonite	530	25	0.020	56	900	1,850	
Phenothiazine	540	60	0.015	60	1,450	1,450	16
Soap	430	60	0.045	60	660	1,300	
Sulphur	190	15	0.035	41	700	1,950	11
Thyroid, desiccated	610	60	0.060	64	550	1,200	
Wood flour	430	20	0.040	62	850	1,200	17

* When aluminum powder was dispersed into air at room temperature, it ignited under some conditions, apparently due to static electric discharge between the particles in the dust cloud.

^b The oxygen reduction tests were made in air-CO₂ mixtures. Dust clouds of aluminum, magnesium, titanium, and certain magnesium-aluminum alloys ignited in pure CO₂.

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