

Threshold Limit Values For 1966

RECOMMENDED AND TENTATIVE LIMITS



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THRESHOLD LIMIT VALUES FOR 1966

The Threshold Limit Values refer to air-borne concentrations of substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed, day after day, without adverse effect. Because of wide variation in individual susceptibility, exposure of an occasional individual at or even below the threshold limit may not prevent discomfort, aggravation of a pre-existing condition, or occupational illness.

Threshold limits should be used as guides in control of health hazards and should not be regarded as fine lines between safe and dangerous concentrations. Exceptions are the substances given in Appendix A and certain of the substances given a "C" listing. The values not given a "C" listing refer to time-weighted average concentrations for a normal workday.

The amount by which these concentrations may be exceeded for short periods without injury to health depends upon a number of factors such as the nature of the contaminant, whether very high concentrations even for short periods produce acute poisoning, whether the effects are cumulative, the frequency with which high concentrations occur, and the duration of such periods. All must be taken into consideration in arriving at a decision as to whether a hazardous situation exists. Enlightened industrial hygiene practice inclines toward controlling exposures below the limit rather than maintenance at the limit.

Threshold limits are based on the best available information from industrial experience, from experimental human and animal studies, and when possible, from a combination of the three. The basis on which the values are established may differ from substance to substance; protection against impairment of health may be the guiding factor for some, whereas reasonable freedom from irritation, narcosis, nuisance or other forms of stress may dominate the basis for others. The Committee holds to the opinion that

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The 2nd edition of the Documentation of Threshold Limit Values, rewritten and greatly enlarged to include the approximately 400 substances in the list, is available and may be purchased from the Secretary-Treasurer. The Documentation should be consulted when using the Threshold Limit Values herein.

limits based on physical irritation should be considered no less binding than those based on physical impairment; growing bodies of evidence indicate that physical irritation may promote and accelerate physical impairment.

Documentation of Threshold Limit Values.

A separate companion piece to the TLVs is issued by ACGIH under this title. This publication gives the pertinent scientific information and data with reference to literature sources, that were used to base each limit. Each documentation also contains a statement defining the type of response against which the limit is safeguarding the worker. For a better understanding of the TLVs it is essential that the Documentation be consulted when the TLVs are being used.

Ceiling vs Time-Weighted Average Limits.

Although the time-weighted average concentration provides the most satisfactory, practical way of monitoring air-borne agents for compliance with the limits, there are certain substances for which it is inappropriate. In the latter group are substances which are predominantly fast acting and whose threshold limit is more appropriately based on this particular response. Substances with this type of response are best controlled by a ceiling "C" limit that should not be exceeded. It is implicit in these definitions that the manner of sampling to determine compliance with the limits for each group must differ; a single brief sample, that is applicable to a "C" limit, is not appropriate to the time-weighted limit: here, a sufficient number of samples are needed to permit a time-weighted average concentration throughout a complete cycle of operations or throughout the work shift.

Whereas the ceiling limit places a definite boundary which concentrations should not be permitted to exceed, the time-weighted average limit requires an explicit limit to the excursions that are permissible above the listed values. The magnitude of these excursions may be pegged to the magnitude of the threshold limit by an appropriate factor shown in Appendix C. It should be noted that the same factors are used

by the Committee in making a judgment whether to include or exclude a substance for a "C" listing.

"Skin" Notation. Listed substances followed by the designation "Skin" refer to the potential contribution to the over-all exposure by the cutaneous route including mucous membranes and eye, either by air-borne, or more particularly, by direct contact with the substance. Vehicles can alter skin absorption. This attention-calling designation is intended to suggest appropriate measures for the prevention of cutaneous absorption so that the threshold limit is not invalidated.

Mixtures. Special consideration should be given also to the application of these values in assessing the health hazards which may be associated with exposure to mixtures of two or more substances. A brief discussion of basic considerations involved in developing threshold limit values for mixtures, and methods for their development, amplified by specific examples are given in Appendix B.

"Inert" or Nuisance Particulates. A number of dusts or particulates that occur in the working environment ordinarily produce no specific effects upon prolonged inhalation. Some insoluble substances are classed as inert (e.g. iron and steel dusts, cement, silicon carbide, titanium dioxide, cellulose); others may be soluble (starch, soluble oils, calcium carbonate) but are of such a low order of activity that in concentrations ordinarily encountered do not cause physiologic impairment; still others may be rapidly eliminated or destroyed by the body (vegetable oils, glycerine, sucrose). In the case of the insoluble substances, there may be some accumulation in the respiratory passages. In the case of the soluble substances, this accumulation will ordinarily be temporary but may interfere to some extent with respiratory processes. Hence, it is desirable to control the concentrations of such particulates in the air breathed by any individual, in keeping with good industrial hygiene practice.

A threshold limit of 15mg/m^3 , or 50 mppcf, whichever is less, is recommended for substan-

ces in these categories and for which no specific threshold limits have been assigned. This limit, for a normal work day, does not apply to brief exposures at higher concentrations. Neither does it apply to those substances which may cause physiologic impairment at lower concentrations but for which a threshold limit has not yet been adopted. Some "inert" particulates are given in Appendix D.

Simple Asphyxiants--"Inert" Gases or Vapors.

A number of gases and vapors, when present in high concentrations in air, act primarily as simple asphyxiants without other significant physiologic effects. A TLV may not be recommended for each simple asphyxiant because the limiting factor is the available oxygen. The minimum oxygen content should be 18 percent by volume under normal atmospheric pressure (equivalent to a partial pressure, pO_2 , of 135 mm Hg). Atmospheres deficient in O_2 do not provide adequate warning and most simple asphyxiants are odorless. Several simple asphyxiants are listed in Appendix E. Some asphyxiants present an explosion hazard. Account should be taken of this factor in limiting the concentration of the asphyxiant.

These limits are intended for use in the field of industrial hygiene and should be interpreted and applied only by persons trained in this field. They are not intended for use, or for modification for use, (1) as a relative index of toxicity, by making a ratio of two limits, (2) in the evaluation or control of community air pollution or air pollution nuisances, (3) in estimating the toxic potential of continuous uninterrupted exposures, (4) as proof or disproof of an existing disease or physical condition, or (5) for adoption by countries whose working conditions differ from those in the U.S.

Physical Factors. It is recognized that such physical factors as heat, ultraviolet and ionizing radiation, humidity, abnormal pressure and the like may place added stress on the body so that the effects from exposure at a threshold limit may be altered. Most of these stresses act

adversely to increase the toxic response of a substance. Although most threshold limits have built-in safety factors to guard against adverse effects of moderate deviations from normal environments, the safety factors of most substances are not of such a magnitude as to take care of gross deviations. For example, continuous work at temperatures above 90°F or over-time, extending the work-week more than 50%, might be considered gross deviations. In such instances judgment must be exercised in the proper adjustments of the threshold limit values.

These values are reviewed annually by the Committee on Threshold Limits for revision or additions, as further information becomes available.

"Notice of Intent" At the beginning of each year, proposed actions of the Committee for the forthcoming year are issued in the form of a "Notice of Intent." This Notice provides not only an opportunity for comment, but solicits suggestions of substances to be added to the list. The suggestions should be accompanied by substantiating evidence for a tentative limit.

As Legislative Code. The Conference does not consider the Threshold Limit Values appropriate matter for adoption in legislative codes and regulations and recommends against such use. If, however, the list is so used, the intent of the concepts contained in the Preface should be maintained and provisions should be made to keep the list current.

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Substance	ppm*	Mg/M ³ **
C o-Dichlorobenzene	50	300
p-Dichlorobenzene	75	450
Dichlorodifluoromethane	1,000	4,950
+ 1,3-Dichloro-5,5-dimethyl hydantoin	—	0.2
1,1,1-Dichloroethane	100	400
1,2-Dichloroethane	50	200
1,2-Dichloroethylene	200	790
C Dichloroethyl ether-Skin	15	90
Dichloromethane, see Methylenechloride		
Dichloromonofluoromethane	1,000	4,200
C 1,1-Dichloro-1-nitroethane	10	60
1,2-Dichloropropane, see Propylenedichloride		
Dichlorotetrafluoroethane	1,000	7,000
Dieldrin-Skin	—	0.25
Diethylamine	25	75
Diethylether, see Ethyl ether		
Difluorodibromomethane	100	865
C Diglycidyl ether (DGE)	0.5	
Dihydroxybenzene, see Hydroquinone		
Diisobutyl ketone	50	290
Dimethoxymethane, see Methylal		
Dimethyl acetamide-Skin	10	35
+ Dimethylamine	10	18
Dimethylaminobenzene, see Xylidene		
Dimethylaniline (N-dimethylaniline)-Skin	5	25
Dimethylbenzene, see Xylene		
+ Dimethyl 1,2-dibromo-2,2-dichloroethyl phosphate, (Dibrom) (R)	—	3
+ Dimethylformamide-Skin	10	30
2,6 Dimethylheptanone, see Diisobutyl ketone		
1,1-Dimethylhydrazine-Skin	0.5	1
Dimethylsulfate-Skin	1	5
Dinitrobenzene (all isomers)-Skin	—	1
Dinitro-o-cresol-Skin	—	0.2
Dinitrotoluene-Skin	—	1.5
Dioxane (Diethylene dioxide)-Skin	100	360
Dipropylene glycol methyl ether-Skin	100	600
+ Di-sec, octyl phthalate (Di-2-ethylhexylphthalate)	—	5
Endrin-Skin	—	0.1
Epichlorohydrin-Skin	5	12
EPN-Skin	—	
1,2-Epoxypropane, see Propyleneoxide		
2,3-Epoxy-1-propanol see Glycidol		
Ethanethiol, see Ethylmercaptan		
Ethanolamine	3	6
2 Ethoxyethanol-Skin	200	740
2 Ethoxyethylacetate (Cellosolve acetate)-Skin	100	540
Ethyl acetate	400	1,400
Ethyl acrylate-Skin	25	100
Ethyl alcohol (ethanol)	1,000	1,900
† Ethylamine	—	—

+ 1966 Addition

Substance	ppm*	Mg/M ³ **
†C Ethylbenzene	—	—
Ethyl bromide	200	890
Ethyl chloride	1,000	2,600
Ethyl ether	400	1,200
Ethyl formate	100	300
Ethyl mercaptan	—	—
Ethyl silicate	100	850
Ethylene chlorohydrin-Skin	5	16
Ethylenediamine	10	25
Ethylene dibromide, see 1,2-Dibromoethane		
Ethylene dichloride, see 1,2-Dichloroethane		
C Ethylene glycol dinitrate-Skin	0.2	1.2
Ethylene glycol monomethyl ether acetate, see Methyl cellosolve acetate		
† Ethyleneimine-Skin	—	—
Ethylene oxide	50	90
Ethylene chloride, see 1,1-Dichloroethane		
Ferbam	—	15
Ferrovanadium dust	—	1
Fluoride (as F)	—	2.5
Fluorine	0.1	0.2
Fluorotrichloromethane	1,000	5,600
C Formaldehyde	5	6
Freon 11, see Fluorotrichloromethane		
Freon 12, see Dichlorodifluoromethane		
Freon 13B1, see Trifluoromonobromomethane		
Freon 21, See Dichloromonofluoromethane		
Freon 112, see 1,1,2,2-Tetrachloro-1,2 difluoroethane		
Freon 113, see 1,1,2-Trichloro, 1,2,2-trifluoroethane		
Freon 114, see Dichlorotetrafluoroethane		
Furfural-Skin	5	20
Furfuryl alcohol	50	200
Gasoline	—	A6
Glycidol (2,3-Epoxy-1-propanol)	50	150
Glycol monoethyl ether, see 2-Ethoxyethanol		
† Gudion, see Azinphosmethyl		
Hafnium	—	0.5
Heptachlor-Skin	—	0.5
Heptane (n-heptane)	500	2,000
+ Hexachloroethane-Skin	1	10
Hexane (n-hexane)	500	1,800
Hexanone	100	410
Hexone	100	410
sec-Hexyl acetate	50	295
Hydrazine-Skin	1	1.3
Hydrogen bromide	3	10

† See Tentative Limits

Substance	ppm*	Mg/M**
C Hydrogen chloride	5	7
Hydrogen cyanide-Skin	10	11
Hydrogen fluoride	3	2
Hydrogen peroxide, 90%	1	1.4
Hydrogen selenide	0.05	0
+ Hydrogen sulfide	10	15
Hydroquinone	-	2
C Iodine	0.1	1
† Iron oxide fume	-	-
Isoamyl alcohol	100	360
Isophorone	25	140
Isopropyl alcohol	400	980
Isopropylamine	5	12
Isopropylether	500	2,100
Isopropyl glycidyl ether (IGE)	50	240
Ketene	0.5	0
Lead	-	-
Lead arsenate	-	-
Lindane-Skin	-	-
Lithium hydride	-	0.025
+ L. P. G. (Liquified petroleum gas)	1,000	1,800
Magnesium oxide fume	-	15
Malathion-Skin	-	15
C Manganese	-	5
Mercury-Skin	-	0.1
Mercury (organic compounds)-Skin	-	0.01
Mesityl oxide	25	100
Methanethiol, see Methyl mercaptan	-	-
Methoxychlor	-	15
2-Methoxyethanol, see Methyl cellosolve	-	-
Methyl acetate	200	610
Methyl acetylene (propyne)	1,000	1,650
+ Methyl acetylene-propadiene mixture (MAPP)	1,000	1,800
Methyl acrylate-Skin	10	35
Methylal (dimethoxymethane)	1,000	3,100
Methyl alcohol (methanol)	200	260
Methyl amyl alcohol, see Methyl isobutyl carbinol	-	-
C Methyl bromide-Skin	20	80
Methyl butyl ketone, see 2-Hexanone	-	-
Methyl cellosolve-Skin	25	80
Methyl cellosolve acetate-Skin	25	120
C Methyl chloride	100	210
Methyl chloroform	350	1,900
Methylcyclohexane	500	2,000
Methylcyclohexanol	100	470
o-Methylcyclohexanone-Skin	100	460
Methyl ethyl ketone (MEK), see 2-Butanone	-	-
Methyl formate	100	250
Methyl isobutyl carbinol-Skin	25	100
Methyl isobutyl ketone, see Hexone	-	-
+C Methyl mercaptan	10	20

+ 1966 Addition

Substance	ppm*	Mg/M**
+ Methyl methacrylate	100	410
Methyl propyl ketone, see 2-Pentanone	-	-
C Methyl styrene	100	480
C Methylene bisphenyl isocyanate (MDI)	0.02	0.2
Methylene chloride (dichloromethane)	500	1,740
Molybdenum (soluble compounds)	-	5
(insoluble compounds)	-	15
Monomethyl aniline-Skin	2	9
+ Morpholine-Skin	20	70
Naphtha (coal tar)	200	800
Naphtha (petroleum)	500	2,000
+ Naphthalene	10	50
β-Naphthylamine	-	A ²
Nickel carbonyl	0.001	0.007
+ Nickel, metal and soluble compounds	-	1
Nicotine-Skin	-	0.5
ric acid	2	5
Nitroaniline-Skin	1	6
Nitrobenzene-Skin	1	5
+ Nitrochlorobenzene-Skin	-	1
Nitroethane	100	310
C Nitrogen dioxide	5	9
+ Nitrogen trifluoride	10	29
C Nitroglycerin- + EGDN-Skin	0.2	2
Nitromethane	100	250
1-Nitropropane	25	90
2-Nitropropane	25	90
N-Nitrosodimethylamine (DI-methyl-nitrosoamine)-Skin	-	A ³
Nitrotoluene-Skin	5	30
Nitrotrichloromethane, see Chloropicrin	-	-
Octane	500	2,350
Oil mist (mineral)	-	5
Osmium tetroxide	-	0.002
+ Oxygen difluoride	0.05	0.1
Ozone	0.1	0.2
Parathion-Skin	-	0.1
Pentaborane	0.005	0.01
Pentachloronaphthalene-Skin	-	0.5
Pentachlorophenol-Skin	-	0.5
Pentane	1,000	2,950
2-Pentanone	200	700
Perchloroethylene	100	670
Perchloromethyl mercaptan	0.1	0.8
Perchloryl fluoride	3	13.5
Phenol-Skin	5	19
+ p-Phenylene diamine-Skin	-	0.1
Phenylethylene, see Styrene	-	-
Phenyl glycidyl ether (PGE)	50	310
Phenylhydrazine-Skin	5	22
Phosdrin (Mevinphos) (R)-Skin	-	0.1
Phosgene (carbonyl chloride)	0.1	0.4
Phosphine	0.3	0.4
Phosphoric acid	-	1

† See Tentative Limits

Substance	ppm*	Mg/M ³ **
Phosphorus (yellow)	—	0.1
Phosphorus pentachloride	—	1
Phosphorus pentasulfide	—	1
Phosphorus trichloride	0.5	3
+ Phthalic anhydride	2	12
Picric acid-Skin	—	0.
Platinum (Soluble Salts)	—	0.002
Polytetrafluoroethylene decomposition products	—	A ⁴
+ Propane	1,000	1,800
Propyne, see Methylacetylene	—	A ⁵
β-Propiolactone	—	—
n-Propyl acetate	200	840
n-Propyl nitrate	25	110
Propylene dichloride	75	350
† Propylene imine-Skin	—	—
Propylene oxide	100	24
Pyrethrum	—	—
Pyridine	5	1
Quinone	0.1	0.4
Rotenone (commercial)	—	5
+ Selenium compounds (as Se)	—	0.2
+ Silver, metal and soluble compounds	—	0.01
Sodium fluoroacetate (1080) - Skin	—	0.05
Sodium hydroxide	—	2
Stibine	0.1	0.5
Stoddard solvent	500	2,900
Strychnine	—	0.15
C Styrene monomer (phenylethylene)	100	420
Sulfur dioxide	5	13
Sulfur hexafluoride	1,000	6,000
Sulfuric acid	—	1
Sulfur monochloride	1	6
Sulfur pentafluoride	0.025	0.2
Sulfuryl fluoride	5	20
Systox, see Demeton	—	—
2, 4, 5 T	—	10
Tantalum	—	5
TEDP - Skin	—	0.2
Teflon (R) decomposition products	—	A ⁴
Tellurium	—	0.1
TEPP - Skin	—	0.05
+ 1, 1, 1, 2-Tetrachloro-2, 2-difluoroethane	500	4,170
1, 1, 2, 2-Tetrachloro-1, 2-difluoroethane	500	4,170
1, 1, 2, 2-Tetrachloroethane-Skin	5	33
Tetrachloroethylene, see Perchloroethylene	—	—
Tetrachloromethane, see Carbon tetrachloride	—	—
Tetraethyl lead (as Pb) - Skin	—	0.075
Tetrahydrofuran	200	590
Tetranitromethane	1	8
Tetryl (2, 4, 6-trinitrophenylmethyl nitramine) - Skin	—	1.5

+ 1966 Addition

Substance	ppm*	Mg/M ³ **
Thallium (soluble compounds) - Skin	—	0.1
Thiram	—	5
Tin (inorganic cmpds, except oxide)	—	2
Tin (organic cmpds)	—	0.1
Titanium dioxide	—	15
Toluene (toluol)	200	750
Toluene-2, 4-diisocyanate	0.02	0.14
o-Toluidine - Skin	5	22
Toxaphene, see Chlorinated camphene	—	—
1, 1, 1-Trichloroethane, see Methyl chloroform	—	—
Trichloroethylene	100	535
Trichloromethane, see Chloroform	—	—
Trichloronaphthalene - Skin	—	5
1, 2, 3-Trichloropropane	50	300
1, 1, 2-Trichloro 1, 2, 2-trifluoroethane	1,000	7,600
Triethylamine	25	100
Trifluoromonomobromomethane	1,000	6,100
2, 4, 6-Trinitrophenol see Picric acid	—	—
2, 4, 6-Trinitrophenylmethyl nitramine, see Tetryl	—	—
Trinitrotoluene - Skin	—	1.5
Triorthocresyl phosphate	—	0.1
Triphenyl phosphate	—	3
Turpentine	100	560
Uranium (soluble compounds)	—	0.05
(insoluble compounds)	—	0.25
C Vanadium (V ₂ O ₅ dust)	—	0.5
(V ₂ O ₅ fume)	—	0.1
Vinyl benzene, see Styrene	—	—
C Vinyl chloride	500	1,300
Vinylcyanide, see Acrylonitrile	—	—
Vinyl toluene	100	480
Xarfarin	—	0.1
† Xylene (xylol)	—	—
Xylidine - Skin	5	25
+ Yttrium	—	1
Zinc oxide fume	—	5
Zirconium compounds (as Zr)	—	5

Radioactivity: For permissible concentrations of radioisotopes in air, see U. S. Department of Commerce, National Bureau of Standards, Handbook 69, "Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure," June 5, 1959. Also, see U. S. Department of Commerce National Bureau of Standards, Handbook 59, "Permissible Dose from External Sources of Ionizing Radiation," September 24, 1954, and addendum of April 15, 1958.

Parts of vapor or gas per million parts of air plus vapor by volume at 25°C and 760 mm. Hg pressure.

** Approximate milligrams of particulate per cubic meter of air.

A Numbers, See Appendix A

† See Tentative Limits

RESPIRABLE DUSTS EVALUATED BY COUNT

Substance	m. p. p. c. f. *
SILICA	
Crystalline	
Quartz, Threshold Limit calculated from the formula	250 **
Cristobalite	%SiO ₂ + 5
Amorphous, including natural diatomaceous earth	20

SILICATES (less than 1% crystalline silica)

Asbestos	5
Mica	20
Soapstone	20
Talc	20
Portland Cement	50
GRAPHITE (natural)	15
"Inert" or Nuisance Particulates	50 (or 15 mg/m ³ whichever is the smaller)
see Appendix D	

Conversion factors

mppcf x 35.3 = million particles per cubic meter
= particles per c. c.

* Millions of particles per cubic foot of air, based on impinger samples counted by light-field technique.

** The percentage of crystalline silica in the formula is the amount determined from air-borne samples, except in those instances in which other methods have been shown to be applicable.

TENTATIVE VALUES

These substances, with their corresponding tentative limits, comprise those for which a limit has been assigned for the first time or for which a change in the 'Recommended' listing has been made. In both cases, the assigned limits could be considered trial values that will remain in the tentative listing for a period of at least two years, during which time definitive evidence and experience is sought. If acceptable at the end of two years, these substances and values will be moved to the RECOMMENDED list. Documentation for tentative values are available for each of these substances.

Substance	ppm*	Mg/M ³ **
Acrylamide - Skin	-	0.3
Aminopyridine	0.5	2
n-Amyl acetate	125	650
Asinphos-methyl-Skin	-	0.2
Bromoform-Skin	0.5	5
n-Butyl acetate	150.	710.
sec-Butyl acetate	200	950
tert-Butyl acetate	200.	950.
++ sec-Butyl alcohol	150.	450.
Cadmium (Metal dust and soluble salts)	-	0.2
Carbon black	-	3.5
Carbon monoxide	50.	55.
++ o-Chloroacetophenone (phenacylchloride)	0.05	0.3
o-Chlorobenzylidene malononitrile (OCBM)	.05	0.4
Chlorine	1.	3.
++ Chromium, sol. chromic, chromous salts, as Cr	-	0.5
Metallic & insol. salts	-	1.
Coal tar pitch volatiles (benzene soluble fraction) (anthracene, BaP, phenanthrene, acridine, chrysene, pyrene)	-	0.2
++ Cobalt, Metal fume & dust	-	0.1
Crotonaldehyde	2.	6.
Cumene - Skin	50.	245.
Cyclohexane	300.	1,050.
Cyclohexene	300.	1,015.
Diazomethane	0.2	0.4
(2-Dibromo-ethane-Skin	25.	190.
Diethyl phosphate	1.	5.
+ Dibutylphthalate	-	5.
Diethylamino ethanol-Skin	10.	50.
++ Diisopropylamine-Skin	5.	20.

* Parts of vapor or gas per million parts of air plus vapor by volume at 25°C and 760 mm. Hg pressure. Approximate milligrams of particulate per cubic meter of air.

+ 1966 Revision
++ 1966 Additions

Substance	ppm*	Mg/M ³ **
++ Dimethylphthalate	—	5.
++ Diphenyl	0.2	1.
Ethylamine	10.	18.
Ethyl sec-amy! ketone (5-methyl-3-heptanone)	25.	130.
Ethyl benzene	100.	435.
Ethyl butyl ketone (3-Heptanone)	50.	230.
+ C Ethylene glycol dinitrate &/or nitroglycerin-Skin	0.02†	0.1†
Ethylene imine-Skin	0.5	1.
C Ethyl mercaptan	10.	25.
N-Ethylmorpholine-Skin	20.	94.
Fibrous glass	—	5.
Formic acid	5.	9.
++ Gasoline	A ⁶	—
sec-Hexyl acetate	50.	300.
++ Hexachloronaphthalene - Skin	—	0.
Iron oxide fume	—	10.
Isoamyl acetate	100.	525.
Isobutyl acetate	150.	700.
++ Isobutyl alcohol	100.	300.
Isopropyl acetate	250.	950.
+ Maleic anhydride	0.25	1.
Methylamine	10.	12.
Methyl (n-amy!) ketone (2-Heptanone)	100.	465.
Methyl iodide - Skin	5.	28.
Methyl isocyanate - Skin	0.02	0.05
C Monomethyl hydrazine - Skin	0.2	0.35
+ Naphtha (coal tar)	100.	400.
++ Nitric oxide	25.	30.
++ Octachloronaphthalene - Skin	—	0.1
Oxalic acid	—	1.
++ Parquat - Skin	—	0.5
Phenyl ether (vapor)	1.	7.
Phenyl ether-Biphenyl mixture (vapor)	1.	7.
+ Phenyl glycidyl ether (PGE)	10.	62.
Pival (2-Pivalyl-1,3-indandione)	—	0.1
++ Propyl alcohol	200.	450.
Propylene imine - Skin	2.	5.
Rhodium, Metal fume and dusts	—	0.1
Soluble salts	—	0.001
++ Ronnel	—	15.
Selenium hexafluoride	0.05	0.4
Tellurium hexafluoride	0.02	0.2
++C Terphenyls	1.	9.2
++ Tetrachloronaphthalene - Skin	—	2.
Tetramethyl lead (TML) (as lead) - Skin ..	—	0.075
Tetramethyl succinonitrile - Skin	0.5	3.
Tremolite	5 mppcf	—
++ Tributyl phosphate	—	5.
1,1,2-Trichloroethane - Skin	10.	45.
Xylene	100.	435.
++ Zinc chloride	—	1.

+ 1966 Revision

++ 1966 Additions

† For intermittent exposure only

Appendix A

A¹ Benzidine Because of high incidence of bladder tumors in man, any exposure, including skin, is extremely hazardous.

A² β-Naphthylamine. Because of the extremely high incidence of bladder tumors in workers handling this compound and the inability to control exposures, β-naphthylamine has been prohibited from manufacture, use and other activities that involve human contact by the State of Pennsylvania.

A³ N-Nitrosodimethylamine Because of extremely high toxicity and presumed carcinogenic potential of this compound, contact by any route should not be permitted.

Polytetrafluoroethylene* decomposition products.

Thermal decomposition of the fluorocarbon chain in air leads to the formation of oxidized products containing carbon, fluorine and oxygen. Because these products decompose by hydrolysis in alkaline solution, they can be quantitatively determined in air as fluoride to provide an index of exposure. No TLV is recommended pending determination of the toxicity of the products, but air concentrations should be minimal.

A⁵ β Propiolactone Because of high acute toxicity and demonstrated skin tumor production in animals, contact by any route should be avoided.

A⁶ Gasoline. The composition of gasoline varies greatly and thus a single TLV for all types of gasoline is no longer applicable. In general, the aromatic hydrocarbon content will determine what TLV applies. Consequently the content of benzene, other aromatics and additives should be determined to arrive at the appropriate TLV (Elkins, et al. A.I.H.A.J. 24, 99, 1963).

Trade Names: Algonflon, Fluon, Halon, Teflon, Tetran

Appendix B

B.1 THRESHOLD LIMIT VALUES FOR MIXTURES

When two or more hazardous substances are present, their combined effect, rather than that of either individually, should be given primary consideration. In the absence of information to the contrary, the effects of the different hazards should

be considered as additive. That is, if the sum of the following fractions;

$$\frac{C_1}{T_1} + \frac{C_2}{T_2} + \dots + \frac{C_n}{T_n}$$

exceeds unity, then the threshold limit of the mixture should be considered as being exceeded. C_1 indicates the observed atmospheric concentration, and T_1 the corresponding threshold limit, (See Example 1A.a.).

Exceptions to the above rule may be made when there is good reason to believe that the chief effects of the different harmful substances are not in fact additive, but independent as when purely local effects on different organs of the body are produced by the various components of the mixture. In such cases the threshold limit ordinarily is exceeded when at least one member of the series ($\frac{C_1}{T_1}$ or $\frac{C_2}{T_2}$ etc.)

has a value exceeding unity, (See Example 1A.b.)

Antagonistic action or potentiation may occur with some combinations of atmospheric contaminants. Such cases at present must be determined individually. Potentiating or antagonistic agents are not necessarily harmful by themselves. Potentiating effects of exposure to such agents by routes other than that of inhalation is also possible, e.g. imbibed alcohol and inhaled narcotic (trichloroethylene). Potentiation is characteristically exhibited at high concentrations, is probably at low.

When a given operation or process characteristically emits a number of harmful dusts, fumes, vapors or gases, it will frequently be only feasible to attempt to evaluate the hazard by measurement of a single substance. In such cases, the threshold limit used for this substance should be reduced by a suitable factor, the magnitude of which will depend on the number, toxicity and relative quantity of the other contaminants ordinarily present.

Examples of processes which are typically associated with two or more harmful atmospheric contaminants are welding, automobile repair, blasting, painting, lacquering, certain foundry operations, diesel exhausts, etc. (Example 2.)

THRESHOLD LIMIT VALUES FOR MIXTURES EXAMPLES

1A. General case, where air is analyzed for each component.

a. ADDITIVE EFFECTS

$$\frac{C_1}{T_1} + \frac{C_2}{T_2} + \frac{C_3}{T_3} + \dots + \frac{C_n}{T_n} = 1$$

Air contains 5 ppm of carbon tetrachloride (TLV, 10), 20 ppm of ethylene dichloride (TLV, 50) and 10 ppm of ethylene dibromide, (TLV, 25).

$$\frac{5}{10} + \frac{20}{50} + \frac{10}{25} = \frac{65}{50} = 1.3$$

Threshold limit is exceeded.

b. INDEPENDENT EFFECTS

Air contains 0.15 mg/m³ of lead (TLV, 0.2) and 0.7 mg/m³ of sulfuric acid (TLV, 1).

$$\frac{0.15}{0.20} = 0.75; \quad \frac{0.7}{1} = 0.7$$

Threshold limit is not exceeded.

1B. Special case when source of contaminant is a mixture and atmospheric composition is assumed similar to that of original material, i.e. vapor pressure of each component is the same at the observed temperature.

a. ADDITIVE EFFECTS, approximate solution.

1. A mixture of equal parts (1) trichloroethylene (TLV, 100), and (2) methyl chloroform (TLV, 350).

$$\frac{C_1}{100} + \frac{C_2}{350} = \frac{C_m}{T_m}$$

Solution applicable to "spot" solvent mixture usage, where all or nearly all, solvent evaporates.

$$C_1 = C_2 = \frac{1}{2} C_m$$

$$\frac{C_1}{100} + \frac{C_1}{350} = \frac{2C_1}{T_m}$$

$$\frac{7C_1}{700} + \frac{2C_1}{700} = \frac{2C_1}{T_m}$$

$$T_m = 700 \times \frac{2}{9} = 155 \text{ ppm}$$

1B.b. General Exact Solution for Mixtures of N Components With Additive Effects and Different Vapor Pressures.

$$(1) \frac{C_1}{T_1} + \frac{C_2}{T_2} + \dots + \frac{C_N}{T_N} = 1;$$

$$(2) C_1 + C_2 + \dots + C_N = T;$$

$$(2.1) \frac{C_1}{T} + \frac{C_2}{T} + \dots + \frac{C_N}{T} = 1.$$

By the Law of Partial Pressures,

$$(3) C_1 = a p_1.$$

And by Raoult's Law,

$$(4) p_1 = F_1 p_1^0.$$

Combine (3) and (4) to obtain

$$(5) C_1 = a F_1 p_1^0.$$

Combining (1), (2, 1) and (5), we obtain

$$(6) \frac{F_1 p_1^0}{T} + \frac{F_2 p_2^0}{T} + \dots + \frac{F_N p_N^0}{T} =$$

$$\frac{F_1 p_1^0}{T_1} + \frac{F_2 p_2^0}{T_2} + \dots + \frac{F_N p_N^0}{T_N}$$

and solving for T,

$$(6.1) T = \frac{F_1 p_1^0 + F_2 p_2^0 + \dots + F_N p_N^0}{\frac{F_1 p_1^0}{T_1} + \frac{F_2 p_2^0}{T_2} + \dots + \frac{F_N p_N^0}{T_N}}$$

$$\text{or } \sum_{i=1}^n F_i p_i^0$$

$$(6.2) T = \frac{1}{\sum_{i=1}^n \frac{F_i p_i^0}{T_i}}$$

T = Threshold Limit Value in ppm.

C = Vapor concentration in ppm.

p = Vapor pressure of component in solution.

p^0 = Vapor pressure of pure component.

F = Mol fraction of component in solution.

a = A constant of proportionality.

Subscripts 1, 2, . . . n relate the above quantities to components 1, 2, . . . n, respectively.

Subscript i refers to an arbitrary component from 1 to n.

Absence of subscript relates the quantity to the mixture.

Solution to be applied when there is a reservoir of the solvent mixture whose composition does not change appreciably by evaporation.

Exact Arithmetic Solution of Specific Mixture

	Mol. wt.	Density	T	p^0 at 25°C	Mol fraction in half-and-half solution by volume
Trichloro-ylene (1)	131.4	1.46 g/ml	100	73mm Hg	0.527
Methylchloroform (2)	133.42	1.33 g/ml	350	125mm Hg	0.473

$$F_1 p_1^0 = (0.527) (73) = 38.2$$

$$F_2 p_2^0 = (0.473) (125) = 59.2$$

$$T = \frac{38.2 + 59.2}{\frac{38.2}{100} + \frac{59.2}{350}} = \frac{(97.4) (350)}{133.8 + 59.2} = \frac{(97.4) (350)}{193.0} = 177$$

T = 177 ppm (Note difference in T.L.V. when account is taken of vapor pressure and mol fraction in comparison with above example where such account is not taken).

2. A mixture of one part of (1) parathion (TLV, 0.1) and two parts of (2) EPN (TLV, 0.5).

$$\frac{C_1}{0.1} + \frac{C_2}{0.5} = \frac{C_m}{T_m} \quad C_2 = 2C_1$$

$$C_m = 3C_1$$

$$\frac{C_1}{0.1} + \frac{2C_1}{0.5} = \frac{3C_1}{T_m}$$

$$\frac{7C_1}{0.5} = \frac{3C_1}{T_m}$$

$$T_m = \frac{1.5}{7} = 0.21 \text{ mg/m}^3$$

1C. T. L. V. for Mixtures of Mineral Dusts.

For mixtures of biologically active mineral dusts the general formula for mixtures may be used. With the exception of asbestos, pure minerals are assigned TLV of 2.5, 20 or 50.

For a mixture containing 80% talc and 20% quartz, the TLV for 100% of the mixture "C" is given by:

$$TLV = \frac{1}{\frac{0.8}{2.5} + \frac{0.2}{20}} = 8.4 \text{ mppcf}$$

Essentially the same result will be obtained if the limit of the more (most) toxic component is used provided the effects are additive. In the above example the limit for 20% quartz is 10 mppcf.

For another mixture of 25% quartz 25% amorphous silica and 50% talc:

$$TLV = \frac{1}{\frac{0.25}{2.5} + \frac{0.25}{20} + \frac{0.5}{50}} = 7.3 \text{ mppcf}$$

The limit for 25% quartz approximates 8 mppcf.

Appendix C

BASES FOR ASSIGNING LIMITING "C" VALUES

By definition in the Preface, a listed value bearing a "C" designation refers to 'ceiling' value that should not be exceeded; all values should fluctuate below the listed value. In general the bases for assigning or not assigning a "C" value rest on whether excursions of concentration above a proposed limit for periods up to 15 minutes may result in a) intolerable irritation, b) chronic, or irreversible tissue change, or c) narcosis of sufficient degree to increase accident proneness, impair self rescue or materially reduce work efficiency.

In order for the Committee to decide whether a substance is a candidate for a "C" listing, some guidelines must be formulated on the permissive fluctuation above the limit in terms of the seriousness of the response in the categories a, b, c, given above. For this the factors given in the table below have been used by the Committee. For both technical and practical reasons, the factors have been pegged to the concentration in an inverse manner. It will be noted that as the magnitude of the T. L. V. increases a correspondingly decreased range of fluctuation is permitted; not to decrease the factor for T. L. V. s of increasing magnitude would permit exposures to large absolute quantities, an undesirable condition, a condition that is minimized at low T. L. V. s. Moreover, larger factors at the lower T. L. V. s are consistent with the difficulties in analyzing and controlling trace quantities.

T.L.V. RANGE ppm* or mg/m ³	Test T.L.V. Factor	Examples
0 to 1	3	Toluene diisocyanate-T. L. V., 0.02 ppm, if permitted to rise above 0.06 ppm may result in sensitization in a single subsequent exposure. "C" listing recommended on category b.
1 + to 10	2	Manganese -T.L.V., 5mg/m ³ , contains little or no safety factor. All values should fluctuate below 5mg/m ³ . "C" listing recommended on category b.

T.L.V. RANGE ppm* or mg/m ³	Test T.L.V. Factor	Examples
10 + to 100	1.5	Methyl styrene-T. L. V. 100 if encountered at levels of 150 ppm will prove intensely irritating. "C" listing recommended on category a.
100 + to 1000	1.25	Methyl chloroform-T. L. V. 350ppm, at 438 ppm for periods not exceeding 15 minutes is not expected to result in untoward effects relating to category c. No "C" listing recommended.

* Whichever unit is applicable

PERMISSIBLE EXCURSIONS FOR TIME-WEIGHTED AVERAGE (TWA) LIMITS

As stated in the preface, the same factors may be used as guides for reasonable excursions above the limit for substances to which the time-weighted average applies. The time-weighted average implies that each excursion above the limit is compensated by a comparable excursion below the limit. Thus, a value of 6 -ppm HF is permissible for periods not exceeding 15 minutes, provided an equivalent decrease below the limit of 3 -ppm obtains.

Appendix D

Some "Inert" or Nuisance Particulates*

Alundum (Al ₂ O ₃)	Limestone
Calcium carbonate	Magnesite
Cellulose	Marble
Portland Cement	Plaster of Paris
Corundum (Al ₂ O ₃)	Rouge
Emery	Silicon Carbide
Glycerine Mist	Starch
Graphite (synthetic)	Sucrose
Gypsum	Tin Oxide
Vegetable oil mists (except castor, cashew nut, or similar irritant oils)	Titanium Dioxide

*When toxic impurities are not present.

Appendix E

Some Simple Asphyxiants - "Inert" Gases and Vapors.

Acetylene	Hydrogen
Argon	Methane
Ethane	Neon
Ethylene	Nitrogen
Helium	Nitrous Oxide

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