Threshold Limit Values For 1967

RECOMMENDED AND INTENDED VALUES

Adopted at the 29th Annual Meeting of the American Conference of Governmental Industrial Hygienists, Chicago, Illinois, May 1–2, 1967.

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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 (Price – $4.50 – see order blank in back of this booklet).

THRESHOLD LIMIT VALUES FOR 1967

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.

Clinical tests are becoming available that permit detection of those individuals who will hyperreact upon exposure to certain industrial substances. Being predictive in character, they may be applied as screening tests in the preplacement job examination. Requests for further details of these tests should be directed to the Chairman of the Committee.

Threshold limits should be used as guides in the 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 conventional 7 or 8 hour workday.

Time-weighted average concentrations permit excursions above the limit, provided they are compensated by equivalent excursions below the limit during the work day. The degree of permissible excursion is pegged to the threshold limit value of the particular substance as given in table in Appendix C under "Test TLV Factor." Hence, it is not considered appropriate to interpret air concentration values as exceeding time-weighted average limits, if such values lie within the permissible excursions. (See section on Legislative Code.)

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.

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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 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.

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 United States of America and where substances and processes differ.

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.

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

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 $15 mg/m^3$, or 50 mppcf, whichever is less, is recommended for substances 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 minimal 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.

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.

"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.

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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RECOMMENDED VALUES
(In Alphabetical Order)

	Substance	ppm*	Mg/M³ **
	Acetaldehyde	200	360
	Acetic acid	10	25
	Acetic anhydride	5	20
	Acetone	1,000	2,400
	Acetonitrile	40	70
	Acetylene dichloride, see 1,2 Dicloro-ethylene		
	Acetylene tetrabromide	1	14
	Acrolein	0.1	0.25
+	Acrylamide-Skin	–	0.3
	Acrylonitrile-Skin	20	45
	Aldrin-Skin	–	0.25
	Allyl alcohol-Skin	2	5
	Allyl chloride	1	3
C	Allyl glycidyl ether (AGE)	10	45
	Allyl propyl disulfide	2	12
	2-Aminoethanol, see Ethanolamine		
+	2-Aminopyridine	0.5	2
	Ammonia	50	35
	Ammonium sulfamate (Ammate)	–	15
	n-Amyl acetate	100	525
+	sec-Amyl acetate	125	650
	Aniline-Skin	5	19
	Anisidine (o, p-isomers)-Skin	–	0.5
	Antimony & compounds (as Sb)	–	0.5
	ANTU (alpha naphthyl thiourea)	–	0.3
	Arsenic & Compounds (as As)	–	0.5
	Arsine	0.05	0.2
+	Azinphos-methyl-Skin	–	0.2
	Barium (soluble compounds)	–	0.5
C	Benzene (benzol)-Skin	25	80
	Benzidine-Skin	–	A1
	p-Benzoquinone, see Quinone		
	Benzoyl peroxide	–	5
	Benzyl chloride	1	5
	Beryllium	–	0.002
†	Biphenyl, see Diphenyl		
	Boron oxide	–	15
C	Boron trifluoride	1	3
	Bromine	0.1	0.7
+	Bromoform-Skin	0.5	5
	Butadiene (1,3-butadiene)	1,000	2,200

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

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

A Numbers, See Appendix A

\+ 1967 Addition

† See Intended Values

	Substance	ppm*	Mg/M³ **
	Butanethiol, see Butyl mercaptan		
	2-Butanone	200	590
	2-Butoxy ethanol (Butyl Cellosolve)-Skin	50	240
+	Butyl acetate (n-butyl acetate)	150	710
+	n-Butyl acetate	150.	710.
+	sec-Butyl acetate	200	950
+	tert-Butyl acetate	200.	950.
	Butyl alcohol	100	300
	tert. Butyl alcohol	100	300
C	Butylamine-Skin	5	15
C	tert. Butyl chromate (as CrO3)-Skin	–	0.1
	n-Butyl glycidyl ether (BGE)	50	270
	Butyl mercaptan	10	35
	p-tert. Butyltoluene	10	60
+	Cadmium (Metal dust and soluble salts)	–	0.2
	Cadmium oxide fume	–	0.1
	Calcium arsenate	–	1
	Calcium oxide	–	5
†	Camphor	–	2
	Carbaryl (Sevin) (R)	–	5
+	Carbon black	–	3.5
	Carbon dioxide	5,000	9,000
	Carbon disulfide-Skin	20	60
+	Carbon monoxide	50.	55.
	Carbon tetrachloride-Skin	10	65
	Chlordane-Skin	–	0.5
	Chlorinated camphene, -Skin	–	0.5
	Chlorinated diphenyl oxide	–	0.5
+ C	Chlorine	1.	3.
	Chlorine dioxide	0.1	0.3
C	Chlorine trifluoride	0.1	0.4
C	Chloroacetaldehyde	1	3
	Chlorobenzene (monochlorobenzene)	75	350
+	o-Chlorobenzylidene malononitrile (OCBM)	0.05	0.4
	Chlorobromomethane	200	1,050
	2-Chloro-1,3 butadiene, see Chloroprene		
	Chlorodiphenyl (42% chlorine)-Skin	–	1
	Chlorodiphenyl (54% chlorine)-Skin	–	0.5
	1,Chloro, 2,3 epoxypropane, see Epichlorhydrin		
	2, Chloroethanol, see Ethylene chlorohydrin		
	Chloroethylene, see Vinyl chloride		
C	Chloroform (trichloromethane)	50	240
	1-Chloro-1-nitropropane	20	100
	Chloropicrin	0.1	0.7
	Chloroprene (2-chloro-1,3-butadiene)-Skin	25	90
	Chromic acid and chromates (as CrO3)	–	0.1
+	Coal tar pitch volatiles (benzene soluble fraction) (anthracene, BaP, phenanthrene, acridine, chrysene, pyrene)	–	0.2.
†	Cobalt	–	–

† See Intended Values

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	Substance	ppm*	Mg/M³**
	Copper fume	–	0.1
	Dusts and Mists	–	1.0
	Cotton dust (raw)	–	1
	Crag ® herbicide	–	15
	Cresol (all isomers)-Skin	5	22
–	Crotonaldehyde	2.	6.
–	Cumene-Skin	50.	245.
	Cyanide (as CN)-Skin	–	5
+	Cyclohexane	300	1,050
	Cyclohexanol	50	200
	Cyclohexanone	50	200
–	Cyclohexene	300	1,015
	Cyclopentadiene	75	200
	2,4-D	–	10
	DDT-Skin	–	1
	DDVP-Skin	–	1
	Decaborane-Skin	0.05	0.3
	Demeton (R)-Skin	–	0.1
	Diacetone alcohol (4-hydroxy-4-methyl-2-pentanone)	50	240
	1,2 Diaminoethane, see Ethylenediamine		
+	Diazomethane	0.2	0.4
	Diborane	0.1	0.1
+	1,2-Dibromoethane (ethylene dibromide)-Skin	25	190
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,-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
+	Diethylamino ethanol-Skin	10.	50.
	Diethylether, see Ethyl ether		
	Difluorodibromomethane	100	860
C	Diglycidyl ether (DGE)	0.5	2.8
	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		

+ 1967 Addition

	Substance	ppm*	Mg/M³**
	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
	Diphenylmethane diisocyanate (See Methylene bisphenyl isocyanate (MDI)		
	Dipropylene glycol methyl ether-Skin	100	600
	Di-sec, octyl phthalate (Di-2-ethylhexyl-phthalate	–	5
	Endrin-Skin	–	0.1
	Epichlorhydrin-Skin	5	19
	EPN-Skin	–	0.5
	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	10.	18.
+	Ethyl sec-amyl ketone (5-methyl-3-heptanone)	25.	130.
+	Ethyl benzene	100.	435.
	Ethyl bromide	200	890
+	Ethyl butyl ketone (3-Heptanone)	50.	230.
	Ethyl chloride	1,000	2,600
	Ethyl ether	400	1,200
	Ethyl formate	100	300
+ C	Ethyl mercaptan	10.	25.
	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		
+	Ethylene imine-Skin	0.5	1.
	Ethylene oxide	50	90
	Ethylidine chloride, see 1,1-Dichloroethane		
+	N-Ethylmorpholine-Skin	20.	94.

† See Intended Values

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	Substance	ppm*	Mg/M³
	Ferbam	–	15
	Ferrovanadium dust	–	1
	Fluoride (as F)	–	2.5
	Fluorine	0.1	0.2
	Fluorotrichloromethane	1,000	5,600
C	Formaldehyde	5	6
+	Formic acid	5.	9.
	Furfural-Skin	5	20
	Furfuryl alcohol	50	200
	Gasoline	–	A6
	Glycidol (2,3-Epoxy-1-propanol)	50	150
	Glycol monoethyl ether, see 2-Ethoxyethanol		
	Guthion, 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
	2-Hexanone	100	410
	Hexone	100	410
+	sec-Hexyl acetate	50.	300.
	Hydrazine-Skin	1	1.3
	Hydrogen bromide	3	10
C	Hydrogen chloride	5	7
	Hydrogen cyanide-Skin	10	11
	Hydrogen fluoride	3	2
	Hydrogen peroxide, 90%	1	1.4
	Hydrogen selenide	0.05	0.2
	Hydrogen sulfide	10	15
	Hydroquinone	–	2
C	Iodine	0.1	1
+	Iron oxide fume	–	10.
	Isoamyl alcohol	100	360
+	Isoamyl acetate	100.	525.
+	Isobutyl acetate	150.	700.
	Isophorone	25	140
+	Isopropyl acetate	250.	950.
	Isopropyl alcohol	400	980
	Isopropylamine	5	12
	Isopropylether	500	2,100
	Isopropyl glycidyl ether (IGE)	50	240
	Ketene	0.5	0.9
	Lead	–	0.2
	Lead arsenate	–	0.15
	Lindane-Skin	–	0.5
	Lithium hydride	–	0.02
	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

+ 1967 Addition

	Substance	ppm*	Mg/M³**
	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
+	Methylamine	10.	12.
	Methyl amyl alcohol, see Methyl isobutyl carbinol		
+	Methyl (n-amyl) ketone (2-Heptanone)	100.	465.
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 iodide - Skin	5.	28.
	Methyl isobutyl carbinol-Skin	25	100
	Methyl isobutyl ketone, see Hexone		
+	Methyl isocyanate - Skin	0.02	0.05
C	Methyl mercaptan	10	20
	Methyl methacrylate	100	410
	Methyl propyl ketone, see 2-Pentanone		
C	αMethyl 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
C	Monomethyl hydrazine-Skin	0.2	0.35
	Morpholine-Skin	20	70
†	Naphtha (coal tar)	200	800
	Napthalene	10	50
	β-Naphthylamine	–	A2
	Nickel carbonyl	0.001	0.007
	Nickel, metal and soluble compounds	–	1
	Nicotine-Skin	–	0.5
	Nitric acid	2	5
	p-Nitroaniline-Skin	1	6
	Nitrobenzene-Skin	1	5
	p-Nitrochloro-benezene-Skin	–	1
	Nitroethane	100	310
C	Nitrogen dioxide	5	9
	Nitrogen trifluoride	10	29

† See Intended Values

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	Substance	ppm*	Mg/M³**
C	Nitroglycerin-Skin	0.2	2
	Nitromethane	100	250
	1-Nitropropane	25	90
	2-Nitropropane	25	90
	N-Nitrosodimethyl-amine (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
+	Oxalic acid	–	1.
	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
	Petroleum Distillates (naphtha)	500	2,000
	Phenol-Skin	5	19
	p-Phenylene diamine-Skin	–	0.1
+	Phenyl ether (vapor)	1.	7.
+	Phenyl ether-Biphenyl mixture (vapor)	1.	7.
	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
	Phosphorus (yellow)	–	0.1
	Phosphorus pentachloride	–	1
	Phosphorus pentasulfide	–	1
	Phosphorus trichloride	0.5	3
	Phthalic anhydride	2	12
	Picric acid-Skin	–	0.1
+	Pival (2-Pivalyl-1,3-indandione)	–	0.1
	Platinum (Soluble Salts)	–	0.002
	Polytetrafluoroethylene decomposition products	–	A[4]
	Propane	1,000	1,800
	βPropiolactone	–	A[5]
	n-Propyl acetate	200	840
	n-Propyl nitrate	25	110
	Propylene dichloride	75	350
+	Propylene imine - Skin	2.	5.
	Propylene oxide	100	240
	Propyne, see Methylacetylene		
	Pyrethrum	–	5

+ 1967 Addition

	Substance	ppm*	Mg/M³**
	Pyridine	5	15
	Quinone	0.1	0.4
+	Rhodium, Metal fume and dusts	–	0.1
	Soluble salts	–	0.001
	Rotenone (commercial)	–	5
	Selenium compounds (as Se)	–	0.2
+	Selenium hexafluoride	0.05	0.4
	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	0.25
	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
+	Tellurium hexafluoride	0.02	0.2
	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	35
	Tetrachloroethylene, see Perchloroethylene		
	Tetrachloromethane, see Carbon tetrachloride		
	Tetraethyl lead (as Pb) - Skin	–	0.075
	Tetrahydrofuran	200	590
+	Tetramethyl lead (TML) (as lead) - Skin	–	0.075
+	Tetramethyl succinonitrile - Skin	0.5	3.
	Tetranitromethane	1	8
	Tetryl (2,4,6-trinitrophenylmethylnitramine) - Skin	–	1.5
	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
C	Toluene-2,4-diisocyanate	0.02	0.14
	o-Toluidine - Skin	5	22
	Toxaphene, see Chlorinated camphene		
	1,1,1-Trichloroethane, see Methyl chloroform		

† See Intended Values

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Substance	ppm*	Mg. M³**
+ 1, 1, 2-Trichloroethane - Skin	10.	45.
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
Trifluoromonobromomethane	1,000	6,100
2, 4, 6-Trinitrophenol see Picric acid		
2, 4, 6-Trinitrophenylmethylnitramine, 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_2O_5 dust)	–	0.5
(V_2O_5 fume)	–	0.1
Vinyl benzene, see Styrene		
C Vinyl chloride	500	1,300
Vinylcyanide, see Acrylonitrile		
Vinyl toluene	100	480
Warfarin	–	0.1
+ Xylene (xylol)	100.	435.
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.

+ 1967 Addition

RESPIRABLE DUSTS EVALUATED BY COUNT

Substance	m. p. p. c. f. *
SILICA	
Crystalline	
Quartz, Threshold Limit calculated from the formula	$\frac{250\ **}{\%SiO_2 + 5}$
Cristobalite " " "	
Amorphous, including natural diatomaceous earth	20
+ Tremolite	5
SILICATES (less than 1% crystalline silica)	
Asbestos	5
Mica	20
Soapstone	20
Talc	20
Portland Cement	50
GRAPHITE (natural)	15
"Inert" or Nuisance Particulates see Appendix D	50 (or 15 mg/m³ whichever is the smaller)

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 technics.

** 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.

NOTICE OF INTENDED CHANGES

These substances, with their corresponding values, comprise those for which either a limit has been proposed for the first time, or for which a change in the "Recommended" listing has been proposed. In both cases, the proposed limits should be considered trial limits that will remain in this listing for a period of at least two years. During this time, the previously Recommended Limit will remain in effect. If, after two years no evidence comes to light that questions the appropriateness of the values herein, the values will be placed in the "Recommended" list. Documentation is available for each of these substances.

	Substance	ppm*	Mg/M³
++	Abate	—	15
++	Boron tribromide	1.0	—
++	Bromine pentafluoride	0.1	—
	sec-Butyl alcohol	150	450
+	Camphor	2	—
+	Chlorine	1	—
	α-Chloroacetophenone (phenacylchloride)	0.05	0.3
	Chromium, sol. chromic, chromous salts, as Cr	—	0.5
	Metallic & insol. salts	—	1.
	Cobalt, Metal fume & dust	—	0.1
++	Cyanogen	10	—
	Dibutyl phosphate	1.	5.
	Dibutylphthalate	—	5.
++C	Diethylene triamine-Skin	10	—
	Diisopropylamine-Skin	5.	20.
	Dimethylphthalate	—	5.
	Diphenyl	0.2	1.
++	Diphenylamine	—	10
+	Ethyleneglycol dinitrate and/or Nitroglycerin	0.2*	—
	Fibrous glass	—	5.
	Gasoline	A6	
+	Heptane	200	800
	Hexachloronaphthalene-Skin	—	0.2

* 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.

* An atmospheric concentration of not more than 0.02 ppm or personal protection may be necessary to avoid headache.

\+ 1967 Revision
++ 1967 Additions

	Substance	ppm*	Mg/M³**
++	Indium and compounds, as In	—	0.1
++	Iron salts, soluble, as Fe	—	1
	Isobutyl alcohol	100.	300.
	Maleic anhydride	0.25	1.
++C	Methyl silicate	5	—
	Naphtha (coal tar)	100.	400.
	Nitric oxide	25.	30.
	Octachloronaphthalene-Skin	—	0.1
+	Octane	200	930
	Parquat-Skin	—	0.5
	Phenyl glycidyl ether (PGE)	10.	62.
++	Propargyl alcohol-Skin	1	—
	Propyl alcohol	200.	510.
++	RDX-Skin	—	1.5
	Ronnel	—	15.
+	Stoddard solvent	200	—
+	Styrene	50	—
C	Terphenyls	1.	9.4
	Tetrachloronaphthalene-Skin	—	2.
	Tributyl phosphate	—	5.
++	Tungsten & compounds, as W		
	Soluble	—	1
	Insoluble	—	5
+	Uranium, sol. & insol. compounds as U	—	0.2
	Zinc chloride (fume)	—	1.

\+ 1967 Revision
++ 1967 Additions

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Appendix A

A[1] **Benzidine** Because of high incidence of bladder tumors in man, any exposure, including skin, is extremely hazardous.

A[2] **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 by the State of Pennsylvania from manufacture, use and other activities that involve human contact.

A[3] **N-Nitrosodimethylamine** Because of extremely high toxicity and presumed carcinogenic potential of this compound, contact by any route should not be permitted.

A[4] **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 in part 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.

A[5] **β Propiolactone** Because of high acute toxicity and demonstrated skin tumor production in animals, contact by any route should be avoided.

A[6] **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: Algoflon, 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.

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

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 only when at least one member of the series ($\frac{C_1}{T_1}$ or $\frac{C_2}{T_2}$ etc.) itself 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, less 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

$$\frac{C_1}{T_1} + \frac{C_2}{T_2} + \frac{C_3}{T_3} + \ldots \frac{C_N}{T_N} = 1$$

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).

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

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).

$$\frac{C_1}{100} + \frac{C_2}{350} = \frac{Cm}{Tm}$$

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

$$C_1 = C_2 = \frac{1}{2}\,Cm$$

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

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

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

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

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

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

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

By the Law of Partial Pressures,

(3) $C_1 = ap_1.$

And by Raoult's Law,

(4) $p_1 = F_1 p_1^\circ.$

Combine (3) and (4) to obtain

(5) $C_1 = aF_1 p_1^\circ.$

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

(6) $$\frac{F_1p_1^\circ}{T} + \frac{F_2p_2^\circ}{T} + \ldots + \frac{F_Np_N^\circ}{T} = \frac{F_1p_1^\circ}{T_1} + \frac{F_2p_2^\circ}{T_2} + \ldots + \frac{F_Np_N^\circ}{T_N}$$

and solving for T,

(6.1) $$T = \frac{F_1p_1^\circ + F_2p_2^\circ + \ldots + F_Np_N^\circ}{\frac{F_1p_1^\circ}{T_1} + \frac{F_2p_2^\circ}{T_2} + \ldots + \frac{F_Np_N^\circ}{T_N}}$$

or $\sum\limits^{i = n} F_i p_i^\circ$

(6.2) $$T = \frac{i = 1}{\sum\limits_{i=1}^{i=n} \frac{F_ip_i^\circ}{T_i}}$$

T = Threshold Limit Value in ppm.
C = Vapor concentration in ppm.
p = Vapor pressure of component in solution.

p° = 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° at 25°C	Mol fraction in half-and half solution by volume
Trichloroethylene (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

$$F_1 p_1^\circ = (0.527)(73) = 38.2$$
$$F_2 p_2^\circ = (0.473)(125) = 59.2$$

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

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:

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

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:

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

The limit for 25% quartz approximates 8 mppcf.

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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/m³	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/m³, contains little or no safety factor. All values should fluctuate below 5mg/m³. "C" listing recommended on category b.
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_2O_3)	Limestone
Calcium carbonate	Magnesite
Cellulose	Marble
Portland Cement	Plaster of Paris
Corundum (Al_2O_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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