PLAINTIFF'S EXHIBIT

GP-2204

Threshold Limit Values

of Airborne Contaminants

Adopted By ACGIH

For 1969

AND INTENDED CHANGES

Price Each

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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.

Information concerning the availability of Xerox copies of the 2nd edition of the Documentation of Threshold Limit Values should be directed to the Secretary-Treasurer.

PREFACE

THRESHOLD LIMIT VALUES FOR 1969

Threshold limit values refer to airborne 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, however, a small percentage of workers may experience discomfort from some substances at concentrations at or below the threshold limit, a smaller percentage may be affected more seriously by aggravation of a pre-existing condition or by development of an occupational illness.

Simple tests are now available (J. Occup. Med. 9, 537, 1967; Ann. N.Y. Acad. Sci. 151 Art. 2, p. 968, 1968) that may be used to detect those individuals hypersusceptible to a variety of industrial chemicals (respiratory irritants, hemolytic chemicals, organic isocyanates, carbon disulfide). These tests may be used to screen out by appropriate job placement the hyperreactive worker and thus in effect improve this "coverage" of the TLVs.

Threshold limit values refer to time-weighted concentrations for a 7 or 8-hour workday and 40-hour workweek. They should be used as guides in the control of health hazards and should not be used as fine lines between safe and dangerous concentrations. (Exceptions are the substances listed in Appendices A and E and those substances designated with a "C" or Ceiling value, Appendix C.)

Time-weighted averages permit excursions above the limit provided they are compensated by equivalent excursions below the limit during the workday. In some instances it may be permissible to calculate the average concentration for a workweek rather than for a workday. The degree of permissible excursion is related to the magnitude of the threshold limit value of a particular substance as given in Appendix C. The relationship between threshold limit and permissible excursion is a rule of thumb and in certain cases may not apply. The amount by which threshold limits 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 factors must be taken into consideration in arriving at decision as to whether a hazardous condition exists.

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 a guiding factor for some, whereas reasonable freedom from irritation, narcosis, nuisance or other forms of stress may form 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. There is increasing evidence that physical irritation may initiate, promote or accelerate physical impairment through interaction with other chemical or biologic agents.

In spite of the fact that serious injury is not believed likely as a result of exposure to the threshold limit concentrations, the best practice is to maintain concentrations of all atmospheric contaminants as low as is practical.

These limits are intended for use in the practice of industrial hygiene and should be interpreted and applied only by a person trained in this discipline. They are not intended for use, or for modification for use, (1) as a relative index of hazard or toxicity (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 conditions, or (5) for adoption by countries whose working conditions differ from those in the United States of America and where substances and processes differ.

Ceiling vs Time-Weighted Average Limits. Although the time-weighted average concentration provides the most satisfactory, practical way of monitoring airborne 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 the TLVs 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, of total dust <1% SiO_2, 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 workday, 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 oxgyen 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 ordorless. Several simple asphyxiants present an explosion hazard. Account should be taken of this factor in limiting the concentration of the asphyxiant. Specific examples are listed in Appendix E.

Physical Factors. It is recognized that such physical factors as heat, ultraviolet and ionizing radiation, humidity, abnormal pressure (altitude) 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 to 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 workweek more than 25%, 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. Although the Conference does not consider the TLVs appropriate matter for adoption into legislative codes and regulations, it recognizes that the values may be so used. If so used, the intent of the concepts contained in the Preface should be maintained and provisions should be made to keep the list current. These values are reviewed annually by the Committee on Threshold Limits for revision or additions, as further information becomes available.

ADOPTED VALUES
(In Alphabetical Order)

Substance	ppm[a]	mg/M³ [b]
*Abate	-	15
Acetaldehyde	200	360
Acetic acid	10	25
Acetic anhydride	5	20
Acetone	1,000	2,400
Acetonitrile	40	70
Acetylene dichloride, see 1, 2 Dicloroethylene		
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-Amino ethanol, 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
Anisid e (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	-	A[1]
p-Benzoquinone, see Quinone		
Benzoyl peroxide	-	5
Benzyl chloride	1	5
Beryllium	-	0.002
Biphenyl, see Diphenyl		
Boron oxide	-	15
* Boron tribromide	1	-

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

b) Approximate milligrams of particulate per cubic meter of air.

A Numbers, See Appendix A

* 1968 Addition
** See Notice of Intended Changes

Substance	ppm[a]	mg/m³ [b]
C Boron trifluoride	1	3
Bromine	0.1	0.7
* Bromine pentafluoride	0.1	-
Bromoform-Skin	0.5	5
Butadiene (1, 3-butadiene)	1,000	2,200
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
sec-Butyl alcohol	150	450
tert. Butyl alcohol	100	300
C Butylamine-Skin	5	15
C tert. Butyl chromate (as CrO3) - Skin	-	0.1
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 ●)	-	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
*Chlorine	1	-
Chlorine dioxide	0.1	0.3
C Chlorine trifluoride	0.1	0.4
C Chloroacetaldehyde	1	3
α-Chloroacetophenone (phenacyl-chloride)	0.05	0.3
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

** See Notice of Intended Changes

Substance	ppm[a]	mg/m³ [b]
Chlorodiphenyl (54% Chlorine) - Skin	-	0.5
1, Chloro, 2, 3 epoxypropane, see Epichlorhydrin		
2, Chloroethanol, see Ethylene chlorohydrin		
Chloroethylene, see Vinyl choride.		
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
Chromium, sol. chromic, chromous salts as Cr	-	0.5
Metal & insol. salts	-	1
Coal tar pitch volatiles (benzene soluble fraction) anthracene, BaP, phenanthrene, acridine, chrysene, pyrene)	-	0.2
Cobalt, metal fume & dust	-	0.1
Copper fume	-	0.1
Dusts and Mists	-	1
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
* Cyanogen	10	-
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 ● -Skin	-	0.1
Diacetone alcohol (4-methyl-2-pentanone)	50	240
1, 2 Diaminoethane, see Ethylenediamine Diazomethane	0.2	0.4
Diborane	0.1	0.1
C 1, 2-Dibromoethane (ethylene dibromide)-Skin	25	190
Dibutyl phosphate	1	5
Dibutylphthalate	-	5
C o-Dichlorobenzene	50	300
p-Dichlorobenzene	75	450

** See Notice of Intended Changes

Substance	ppm[a]	mg/m³ [b]
Dichlorodifluoromethane	1,000	4,950
1, 3-Dichloro-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 Methylene-chloride		
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
*C Diethylene triamine-Skin	10	-
Diethylether, see Ethyl ether		
Difluorodibromomethane	100	860
C Diglycidyl ether (DGE)	0.5	2.8
Dihydroxybenzene, see Hydroquinone		
Diisobutyl ketone	50	290
Diisopropylamine-Skin	5	20
* Diphenyl amine	-	10
Dimethoxymethane, see Methylal		
Dimethyl acetamide-Skin	10	35
Dimethyl amine	10	18
Dimethylaminobenzene, see Xylidene		
Dimethyl aniline (N-dimethylaniline)-Skin	5	25
Dimethylbenzene, see Xylene		
Dimethyl 1, 2-dibromo-2, 2-dichloroethyl phosphate, (Dibrom)	-	3
Dimethylformamide-Skin	10	30
2, 6 Dimethylheptanone, see Diisobutyl ketone		
1, 1-Dimethylhydrazine-Skin	0.5	1
Dimethylphthalate	-	5
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
Diphenyl	0.2	1
*Diphenyl Amine	-	10
Diphenylmethane diisocyanate (see Methylene bisphenyl isocyanate (MDI)		

* 1969 Addition

Substance	ppm[a]	mg/m³ [b]
Dipropylene glycol methyl ether-Skin	100	600
Di-sec, octyl phthalate (Di-2-ethylhexylphthalate	-	5
Endrin-Skin	-	0.1
Epichlorhydrin-Skin	5	19
EPN-Skin	-	0.5
1, 2-Epoxypropane, see Propylene-oxide		
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
** 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 and/or Nitroglycerin-Skin	0.2[d]	1
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
Ferbam	-	15
Ferrovanadium dust	-	1
Fluoride (as F)	-	2.5
Fluorine	0.1	0.2
Fluorotrichloromethane	1,000	5,600
C Formaldehyde	5	6

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

Substance	ppm[a]	mg/M³ [b]
Formic acid	5	9
Furfural-Skin	5	20
Furfuryl alcohol	50	200
Gasoline	-	A[3]
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
Hexachloronaphthalene-Skin	-	0.2
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
* Indium and compounds, as In	-	0.1
C Iodine	0.1	1
Iron oxide fume	-	10
* Iron salts, soluble, as Fe	-	1
Isoamyl acetate	100	525
Isoamyl alcohol	100	360
Isobutyl acetate	150	700
Isobutyl alcohol	100	300
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	-	0.025
L. P. G. (Liquified petroleum gas)	1,000	1,800
Magnesium oxide fume	-	15
Malathion-Skin	-	15
Maleic anhydride	0.25	1
C Manganese	-	5
** Mercury-Skin	-	0.1

* 1968 Addition
** See Notice of Intended Changes

Substance	ppm[a]	mg/M³ [b]
** 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
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 Methyl silicate	5	--
C α 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
C Monomethyl hydrazine-Skin	0.2	0.35
Morpholine-Skin	20	70
Naphtha (coal tar)	100	400

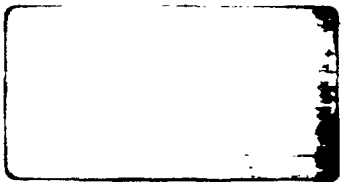
* 1968 Addition

Substance	ppm[a]	mg/m³ [b]
Naphthalene	10	50
β-Naphthylamine	-	A[1]
Nickel carbonyl	0.001	0.007
Nickel, metal and soluble cmpds.	-	1
Nicotine-Skin	-	0.5
Nitric acid	2	5
Nitric oxide	25	30
p-Nitroaniline-Skin	1	6
Nitrobenzene-Skin	1	5
p-Nitrochloro-benzene-Skin	-	1
Nitroethane	100	310
C Nitrogen dioxide	5	9
Nitrogen Trifluoride	10	29
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[1]
Nitrotoluene-Skin	5	30
Nitrotrichloromethane, see Chloropicrin		
Octachloronaphthalene-Skin	-	0.1
** 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
Paraquat-Skin	-	0.5
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)	10	60
Phenylhydrazine-Skin	5	22
Phosdrin (Mevinphos)® -Skin	-	0.1
Phosgene (carbonyl chloride)	0.1	0.4
Phosphine	0.3	0.4

** See Notice of Intended Changes

Substance	ppm[a]	mg/m³ [b]
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[2]
Propane	1,000	1,800
β Propiolactone	-	A[1]
* Propargyl alcohol-Skin	1	-
n-Propyl acetate	200	840
Propyl alcohol	200	500
n-Propyl nitrate	25	110
Propylene dichloride	75	350
Propylene imine-Skin	2	5
Propylene oxide	100	240
Propyne, see Methylacetylene		
Pyrethrum	-	5
Pyridine	5	15
Quinone	0.1	0.4
* RDX-Skin	-	1.5
Rhodium, Metal fume and dusts	-	0.1
Soluble salts	-	0.001
Ronnel	-	15
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	0.025
Sulfuryl fluoride	5	20
Systox, see Demeton®		
2,4,5 T	-	10
Tantalum	-	5
TEDP-Skin	-	0.2
Teflon® decomposition products	-	A[4]
Tellurium	-	0.1

* 1969 Addition



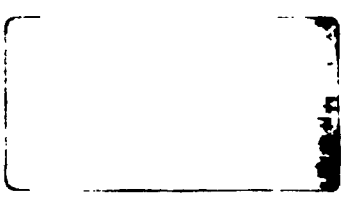
Substance	ppm[a]	mg/M³ [b]
Tellurium hexafluoride	0.02	0.2
TEPP - Skin	-	0.05
C Terphenyls	1	9
1, 1, 1, 2-Tetrachloro-2, 2-difluoroethane	500	4,170
1, 1, 2, 2-Tetrachloro-1, 2-difluoroethane	500	4,170
1, 1, 2, 2-Tetrachloroethane-Skin	5	35
Tetrachloroethylene, see Perchloroethylene		
Tetrachloromethane, see Carbon tetrachloride		
Tetrachloronaphthalene - Skin	-	2
** Tetraethyl lead (as Pb) - Skin	-	0.075
Tetrahydrofuran	200	590
** Tetramethyl lead (TML) (as Pb) - 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 SnH_4 and SnO_2)	-	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		
Tributyl phosphate	-	5
1, 1, 1-Trichloroethane, see Methyl chloroform		
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

** See Notice of Intended Changes

Substance	ppm[a]	mg/M³ [b]
Triphenyl phosphate	-	3
* Tungsten & Compounds, as W		
Soluble	-	1
Insoluble	-	5
Turpentine	100	560
* Uranium (natural) sol. & insol. compounds as U	-	0.2
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 chloride fume	-	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.

* 1968 Addition



MINERAL DUSTS

Substance	m.p.p.c.f.[e]
SILICA	
Crystalline	
** Quartz, Threshold Limit calculated from the formula	$\frac{250}{\%SiO_2 + 5}$ [f]
** Cristobalite " " "	
Amorphous, including natural diatomaceous earth	20
SILICATES (less than 1% crystalline silica)	
** Asbestos	5
Mica	20
Soapstone	20
Talc	20
Tremolite	5
Portland Cement	50
GRAPHITE (natural)	15
"Inert" or Nuisance Particulates see Appendix D	50 (or 15 mg/M^3 whichever is the smaller) of total dust < 1% SiO_2

Conversion factors

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

e) Millions of particles per cubic foot of air, based on impinger samples counted by light-field technics.

f) 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.

** See Notice of Intended Changes

NOTICE OF INTENDED CHANGES

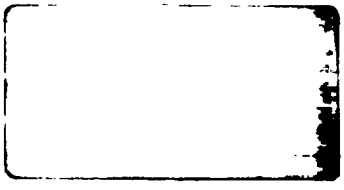
These substances, with their corresponding values, comprise those for which either a limit has been proposed for the first time, or for which a change in the "Adopted" listing has been proposed. In both cases, the proposed limits should be considered trial limits that will remain in the listing for a period of at least two years. During this time, the previously Adopted 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 "Adopted" list. Documentation is available for each of these substances.

	Substance	ppm[a]	$mg/^3$ [b]
+ C	Ammonia	50	35
+ +	2-Acetylaminofluorene	-	A[1]
+ +	4-Aminodiphenyl	-	A[1]
+ +	Ammonium chloride fume	-	1
+ +	Asphalt (Petroleum) fumes	-	2
	Butyl mercaptan	0.5	-
C	Cadmium oxide fume (as Cd)	-	0.1
C	Dichloroacetylene	0.1	-
+ +	Dichlorobenzidine	-	A[1]
+ +	4-Dimethylaminoazobenzene	-	A[1]
	Endosulfan (Thiodan ®) - Skin	-	0.1
	Ethyl mercaptan	0.5	-
+	Fibrous glass	g) -	Appendix D
	Heptane	500	2,000
+	Hydrogen peroxide	1	1
	Indene	10	-
+	Mercury vapor, inorganic and organic cmpds, excluding alkyl Mercury - Skin	-	0.05
+	Methyl 2-cyanoacrylate	2	
+	Methyl demeton - Skin	-	0.5
	Methyl isoamyl ketone	100	475
	Methyl mercaptan	0.5	-
+ +	Methyl parathion - Skin	-	0.2
+ +	4-Dimethylaminoazobenzene	-	A[1]
	Octane	400	1,900
+	Oil mist (particulate)	-	5[h]
	Oil vapors	1) A[5]	-
	~~Pentaerythritol (tetramethylolmethane)~~	-	15
+	Pentane	500	1,500

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

b) Approximate milligrams of particulate per cubic meter of air.

+ 1968 Revision
+ + 1968 Addition



Substance	ppm[e]	mg/M³[g] [h]
Petroleum distillates	[i] A[3]	-
++ Phenothiazine - Skin	-	5
Stoddard Solvent	200	-
+ Styrene	100	-
Tetraethyl lead (as Pb) - Skin	-	0.100[j]
Tetramethyl lead (as Pb) - Skin	-	0.150[j]
Trimethyl benzene	25	-
++ Vinyl acetate	10	-
++ Wood Dust (total dust)	-	10

e) <5-7 μ Diameter. No TLV for coarse fibrous glass has yet been set.

h) As sampled by method that does not collect vapors.

i) According to analytically determined composition.

j) For control of general room air; biologic monitoring is essential for personnel control.

+ 1969 Revision

++ 1969 Addition

NOTICE OF INTENDED CHANGES (Continued)

MINERAL DUST

Substance	
Asbestos	12 fibers/ml - 5μ in length[k], or 2 mppcf[m]
++ Coal Dust (bituminous)	3.5 mg/M³ (respirable dust) n)
Cristobalite	Use one-half the value calculated from the count or mass formulae for quartz.
Quartz	(1) TLV for respirable dust in mg/M³: [p] $\frac{10 \text{ mg/M}^3}{\% \text{ Respirable Quartz} + 2}$ (2) "Total dust" respirable and nonrespirable: $\frac{30 \text{ mg/M}^3}{\% \text{ Quartz} + 2}$
++ Fused Silica	Use quartz formulae.
Tridymite	Use one-half the value calculated from formulae for quartz.

k) As determined by the membrane filter method at 430 x phase contrast magnification.

m) As counted by the standard impinger, light-field count technique.

n) "Respirable" dust as defined by the British Medical Research Council Criteria (1) and as sampled by a device producing equivalent results (2).

(1) Hatch, T.K. and Gross, P., Pulmonary Deposition and Retention of Inhaled Aerosols, p. 149. Academic Press, New York, New York, 1964.

(2) Interim Guide for Respirable Mass Sampling, AIHA Aerosol Technology Committee. In draft form, to be published in late 1969.

p) Both concentration and per cent quartz for the application of this limit are to be determined from the fraction passing a size-selector with the following characteristics:

Aerodynamic Diameter (μ) (unit density sphere)	% passing selector
≤2	90
2.5	75
3.5	50
5.0	25
10	0

+ 1969 Revision

++ 1969 Addition

APPENDIX A

A[1] Because of the high incidence of cancer, either in man or in animals, no exposure or contact by any route, respiratory, oral or skin should be permitted for the compounds:

2-Acetylaminofluorene	beta-Naphthylamine
4-Aminodiphenyl	4-Nitrodiphenyl
Benzidine & its salts	N-Nitrodimethylamine
Dichlorobenzidine	beta-Propiolactone
4-Dimethylaminoazobenzene	

Because of the extremely high incidence of bladder tumors in workers handling beta-naphthylamine and the potential carcinogenic activity of the other compounds, the State of Pennsylvania prohibits the manufacture, use and other activities that involve human exposure without express approval by the Department of Health.

A[2] 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[3] Gasoline and/or Petroleum Distillates. The composition of these materials varies greatly and thus a single TLV for all types of these materials 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,

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

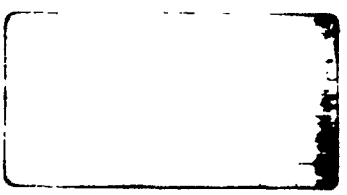
exceeds unity, then the threshold limit of the mixture should be considered as being exceeded. C_1 indicates the observed atmospheric concentration, and T_1 the corresponding threshold limit, (See Example 1A.a.).

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. inhaled 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

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

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/M^3 of lead (TLV, 0.2) and 0.7 mg/M^3 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).

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

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

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

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

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

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

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

(1) $\frac{C_1}{T_1} + \frac{C_2}{T_2} + \cdots + \frac{C_n}{T_n} = 1;$

(2) $C_1 + C_2 + \cdots + C_n = T;$

(2.1) $\frac{C_1}{T} + \frac{C_2}{T} + \cdots + \frac{C_n}{T} = 1.$

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) $\frac{F_1 p_1^{\circ}}{T} + \frac{F_2 p_2^{\circ}}{T} + \cdots + \frac{F_n p_n^{\circ}}{T} = \frac{F_1 p_1^{\circ}}{T_1} + \frac{F_2 p_2^{\circ}}{T_2} + \cdots + \frac{F_n p_n^{\circ}}{T_n}$

and solving for T,

(6.1) $T = \dfrac{F_1 p_1^{\circ} + F_2 p_2^{\circ} + \cdots + F_n p_n^{\circ}}{\frac{F_1 p_1^{\circ}}{T_1} + \frac{F_2 p_2^{\circ}}{T_2} + \cdots + \frac{F_n p_n^{\circ}}{T_n}}$

or $\dfrac{\sum_{i=1}^{n} F_i p_i^{\circ}}{F_1 p_1^{\circ}}$

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

T = Threshold Limit Value in ppm.
C = Vapor concentration in ppm.
p = Vapor pressure of component in solution.
p^o = 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^o at 25°C	Mol fraction in half-and-half solution by volume
Trichloroethylene	(1) 131.4	1.46g/ml	100	73mm Hg	0.527
Methyl chloroform	(2) 133.42	1.33g/ml	350	125mm Hg	0.473

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

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

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

T = 177 ppm (Note difference in TLV 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).

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

$$C_m = 3C_1$$

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

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

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

1C. TLV 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:

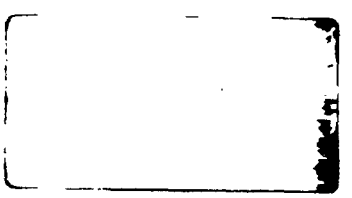
$$TLV = \frac{1}{\frac{0.8}{20} + \frac{0.2}{2.5}} = 8.4 \text{ mppcf}$$

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.



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 asssigning 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.

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.
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. 350 ppm, 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.

PERMISSIBLE EXCURSIONS FOR TIME-WEIGHTED AVERAGE (TWA) LIMITS

The test TLV Factor in the Table serves also as a guide to the magnitude of the permissible excursion above the limit for those substances not given a "C" designation i.e. the TWA limits. Thus for HF, with a TWA limit of 3 ppm, a concentration of 6 ppm is permissible for periods not exceeding 15 minutes, provided an equivalent exposure below the limit is experienced.

APPENDIX D

Some "Inert" or Nuisance Particulates q)

Alundum (Al_2O_3)
Calcium carbonate
Cellulose
Portland Cement
Corundum (Al_2O_3)
Emery
Glycerine Mist
Graphite (synthetic)
Gypsum
Vegetable oil mists (except castor, cashew nut, or similar irritant oils)
Limestone
Magnesite
Marble
Pentaerythritol
Plaster of Paris
Rouge
Silicon Carbide
Starch
Sucrose
Tin Oxide
Titanium Dioxide

q) When toxic impurities are not present, e.g. quartz < 1%.

APPENDIX E

Some Simple Asphyxiants - "Inert" Gases and Vapors

Acetylene
Argon
Ethane
Ethylene
Helium
Hydrogen
Methane
Neon
Nitrogen
Nitrous Oxide
Propane