Threshold Limit Values For 1964

Adopted at the 26th Annual Meeting of the American Conference of Governmental Industrial Hygienists, Philadelphia, Pennsylvania, April 25 - 28, 1964

THRESHOLD LIMIT VALUES FOR 1964

Adopted at the 25th Annual Meeting of the American Conference of Governmental Industrial Hygienists Philadelphia, Pa., April 25-28, 1964

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 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 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 of 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. On what basis a limit is developed is given separately for each listed substance in "Documentation of Threshold Limit Values," a publication of the Threshold Limits Committee of the ACGIH.

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 appropiately 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 grab 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 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 value. 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. 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, bentonite, 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 substances in these calegories 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.

Physical Factors. It is recognized that such physical factors as heat, ultraviolet and ionizing radia-

tion, 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 acute 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 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 of physical condition, or (5) for carte blanche adoption by foreign countries.

These values are reviewed annually by the Committee on Threshold Limits for revisions 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.

Legislative Action The Conference does not consider the Threshold Limit Values appropriate matter for adoption in legislative codes and regulations, and recommends against such use.

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 tetrabromide	1	14
Acrolein	0.1	0.25
Acrylonitrile - Skin	20	45
Aldrin (1, 2, 3, 4, 10, 10-hexachloro-1, 4, 4a, 5, 8, 8 a-hexahydro-1, 4, 5, 8-dimethano-naphthalene) Skin	—	0.25
Allyl alcohol - Skin	2	5
Allyl chloride	1	3
C Allyl glycidyl ether (AGE)	10	45
Allyl propyl disulfide	2	12
Ammonia	50	35
Ammonium sulfamate (Ammate)	—	15
Amyl acetate	100	525
Amyl alcohol (isoamyl alcohol)	100	360
Aniline - Skin	5	19
Antimony & compounds (as Sb)	—	0.5
ANTU (alpha naphthyl thiourea)	—	0.3
Arsenic & Compounds (as As)	—	0.5
Arsine	0.05	0.2
Barium (soluble compounds)	—	0.5
C Benzene (benzol) - Skin	25	80
Benzidine	—	Al
Benzyl chloride	1	5
Beryllium	—	0.002
Boron oxide	—	15

* Parts of vapor or gas per million parts of 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

Substance	ppm*	Mg/M³**
C Boron trifluoride	1	3
Bromine	0.1	0.7
Butadiene (1, 3-butadiene)	1,000	2,200
2-Butanone (methyl ethyl ketone)	200	590
2-Butoxy ethanol (Butyl Cellosolve) - Skin	50	240
Butyl acetate (n-butyl acetate)	200	950
Butyl alcohol	100	300
tert. Butyl alcohol	100	300
C Butylamine	5	15
C tert. Butyl chromate (as CrO_3) - Skin	—	0.1
n-Butyl glycidyl ether (BGE)	50	270
Butyl mercaptan	10	35
p-tert. Butyltoluene	10	60
Cadmium oxide fume	—	0.1
Calcium arsenate	—	1
Camphor	—	2
Carbon dioxide	5,000	9,000
Carbon disulfide - Skin	20	60
Carbon monoxide	100	110
Carbon tetrachloride - Skin	10	65
Chlordane (1, 2, 4, 5, 6, 7, 8, 8-octachloro-3a, 4, 7, 7a. tetrahydro-4, 7-methanoindane)	—	0.5
Chlorinated camphene, 60%	—	0.5
Chlorinated diphenyl oxide	—	0.5
Chlorine	1	3
Chlorine dioxide	0.1	0.3
C Chlorine trifluoride	0.1	0.4
C Chloroacetaldehyde	1	3
Chlorobenzene (monochlorobenzene)	75	350
Chlorobromomethane	200	1,050
Chlorodiphenyl (42% chlorine) - Skin	—	1
Chlorodiphenyl (54% chlorine) - Skin	—	0.5
C Chloroform (trichloromethane)	50	240
1-Chloro-1-nitropropane	20	100
Chloropicrin	0.1	0.7
Chloroprene (2-chloro-1, 3-butadiene)	25	90

Substance	ppm*	Mg/M³**
Chromic acid and chromates (as CrO_3)	—	0.1
Cobalt	—	0.5
Crag (R) herbicide [sodium 2-(2, 4-dichlorophenoxy) ethanol hydrogen sulfate]	—	15
Cresol (all isomers) - Skin	5	22
Cyanide (as CN) - Skin	—	5
Cyclohexane	400	1,400
Cyclohexanol	50	200
Cyclohexanone	50	200
Cyclohexene	400	1,350
2,4-D (2,4-dichlorophenoxy -acetic acid)	—	10
DDT [2,2-bis (p-chlorophenyl) - 1,1,1-trichloroethane] - Skin	—	1
DDVP (O, O-Dimethyl-2, 2-dichloro-vinyl phosphate)	—	1
Decaborane - Skin	0.05	0.3
Diacetone alcohol (4-hydroxy-4-methyl-2-pentanone)	50	240
Diborane	0.1	0.1
1,2-Dibromoethane (ethylene dibromide)	25	190
+ C o-Dichlorobenzene	50	300
p-Dichlorobenzene	75	450
Dichlorodifluoromethane	1,000	4,950
1,1-Dichloroethane	100	400
1,2-Dichloroethane (ethylene dichloride)	50	200
1,2-Dichloroethylene	200	790
C Dichloroethyl ether	15	90
Dichloromonofluoromethane	1,000	4,200
C 1,1-Dichloro-1-nitroethane	10	60
Dichlorotetrafluoroethane	1,000	7,000
Dieldrin (1, 2, 3, 4, 10, 10-hexachloro -6, 7-epoxy-1, 4, 4a, 5, 6, 7, 8, 8a-octahydro-1, 4, 5, 8-dimethano-naphthalene) - Skin	—	0.25
Diethylamine	25	75

+1964 Addition or deletion of "C"

†1964 Revision - see Tentative Values

Substance	ppm*	Mg/M³**
Difluorodibromomethane	100	860
C Diglycidyl ether (DGE)	0.5	2.8
Diisobutyl ketone	50	290
Dimethyl acetamide - Skin	10	35
Dimethylaniline (N-dimethyl-aniline) - Skin	5	25
† Dimethylformamide - Skin	—	—
1,1-Dimethylhydrazine - Skin	0.5	1
Dimethylsulfate - Skin	1	5
Dinitrobenzene - Skin	—	1
Dinitrotoluene - Skin	—	1.5
Dinitro-o-cresol - Skin	—	0.2
Dioxane (diethylene dioxide)	100	360
Dipropylene glycol methyl ether - Skin	100	600
Endrin (1,2,3,4,10,10- hexa-chloro-6, 7-epoxy-1, 4, 4a, 5, 6, 7, 8 8a-octahydro 1,4-endo-5, 8-dimethanonaphthalene) - Skin	—	0.1
EPN (O-ethyl O-p-nitrophenyl thionobenzenephosphonate) Skin	—	0.5
Ethyl acetate	400	1,400
Ethyl acrylate - Skin	25	100
Ethyl alcohol (ethanol)	1,000	1,900
Ethylamine	25	45
C Ethylbenzene	200	870
Ethyl bromide	200	890
Ethyl chloride	1,000	2,600
Ethyl ether	400	1,200
Ethyl formate	100	300
C Ethyl mercaptan	20	52
Ethyl silicate	100	850
Ethylene chlorohydrin - Skin	5	16
Ethylenediamine	10	30
+ C Ethylene glycol dinitrate - Skin	0.2	1.2
Ethylene imine - Skin	5	9
Ethylene oxide	50	90
2-Ethoxyethanol (Cellosolve) - Skin	200	740
2-Ethoxyethanol (Cellosolve) - Skin	200	740
2-Ethoxyethylacetate (Cellosolve acetate) - Skin	100	540

Substance	ppm*	Mg/M³**
Ferbam (ferric dimethyl dithiocarbamate)	—	15
Ferrovanadium dust	—	1
Fluoride (as F)	—	2.5
Fluorine	0.1	0.2
Fluorotrichloromethane	1,000	5,600
C Formaldehyde	5	6
Furfural	5	20
Furfuryl alcohol	50	200
Gasoline	500	2,000
Glycidol (2, 3-Epoxy-1-propanol)	50	150
Heptachlor (1, 4, 5, 6, 7, 8, 8a-heptachloro-3a, 4, 7, 7a-tetrahydro-4, 7-methanoindane	—	0.5
Heptane (n-heptane)	500	2,000
Hexane (n-hexane)	500	1,800
Hexanone (methyl butyl ketone)	100	410
sec-Hexyl acetate	50	295
Hexone (methyl isobutyl ketone)	100	410
+ 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	—	—
Hydroquinone	—	2
C Iodine	0.1	1
Iron oxide fume	—	15
Isophorone	25	140
Isopropylamine	5	12
Isopropyl glycidyl ether (IGE)	50	240
Ketene	0.5	0.9
Lead	—	0.2
Lead arsenate	—	0.15
Lindane (hexachlorcyclohexane, gamma isomer)	—	0.5
Lithium hydride	—	0.025

+1964 Addition or deletion of "C"
†1964 Revision - see Tentative Values

Substance	ppm*	Mg/M³**
Magnesium oxide fume	—	15
Malathion (O,O-dimethyl dithiophosphate of diethyl mercaptosuccinate) - Skin	—	15
C Manganese	—	5
Mercury - Skin	—	0.1
Mercury (organic compounds) - Skin	—	0.01
Mesityl oxide	25	100
Methoxychlor (2, 2-di-p-methoxy-phenyl-1, 1, 1-trichloroethane)	—	15
Methyl acetate	200	610
Methyl acetylene	1,000	1,650
Methyl acrylate - Skin	10	35
Methylal (dimethoxymethane)	1,000	3,100
Methyl alcohol (methanol)	200	260
C Methyl bromide - Skin	20	80
Methyl cellosolve (2-methoxy-ethanol) - Skin	25	80
Methyl cellosolve acetate (ethylene glycol monomethyl ether acetate) - Skin	25	120
C Methyl chloride	100	210
Methyl chloroform (1, 1, 1-trichloroethane)	350	1,900
Methylcyclohexane	500	2,000
Methylcyclohexanol	100	470
Methylcyclohexanone	100	460
Methyl formate	100	250
Methyl isobutyl carbinol (methyl amyl alcohol)	25	100
† Methyl mercaptan	—	—
+ C = Methyl styrene	100	480
Methylene chloride (dichloromethane)	500	1,750
Monomethyl aniline — Skin	2	9
Molybdenum (soluble compounds)	—	5
(insoluble compounds)	—	15

+1964 Addition or deletion of "C"
†1964 Revision - see Tentative Values

Substance	ppm*	Mg/M³**
Naphtha (coal tar)	200	800
Naphtha (petroleum)	500	2,000
β - Naphthylamine	—	A2
Nickel carbonyl	0.001	0.007
Nicotine - Skin	—	0.5
† Nitric acid	—	—
p-Nitroaniline - Skin	1	6
Nitrobenzene - Skin	1	5
Nitroethane	100	310
C Nitrogen dioxide	5	9
C Nitroglycerin - + EGDN - Skin	0.2	2
Nitromethane	100	250
1-Nitropropane	25	90
2-Nitropropane	25	90
N - Nitrosodimethylamine (Dimethylnitrosamine) - Skin	A3	—
Nitrotoluene - Skin	5	30
Octane	500	2,350
Oil mist (mineral)	—	5
Osmium tetroxide	—	0.002
Ozone	0.1	0.2
Parathion (O, O-diethyl O-p-nitrophenyl thiophosphate) - Skin	—	0.1
Pentaborane	0.005	0.01
Pentachloronaphthalene - Skin	—	0.5
Pentachlorophenol - Skin	—	0.5
Pentane	1,000	2,950
Pentanone (methyl propyl kelone)	200	700
Perchloroethylene (tetrachloroethylene)	100	670
Perchloromethyl mercaptan	0.1	0.8
Perchloryl fluoride	3	13.5
Phenol - Skin	5	19
Phenyl glycidyl ether (PGE)	50	310
Phenylhydrazine - Skin	5	22
Phosdrin (2-carbomethoxy-1-methyl vinyl dimethyl phosphate)	—	0.1

+1964 Addition or deletion of "C"
†1964 Revision - see Tentative Values

Substance	ppm*	Mg/M³**
† Phosgene (carbonyl chloride)	—	—
Phosphine	0.3	0.4
Phosphoric acid	—	1
Phosphorus (yellow)	—	0.1
Phosphorus pentachloride	—	1
Phosphorus pentasulfide	—	1
Phosphorus trichloride	0.5	3
Picric acid - Skin	—	0.1
Platinum (Soluble Salts)	—	0.002
Propyl acetate	200	840
Propyl alcohol (isopropyl alcohol)	400	980
Propyl ether (isopropyl ether)	500	2,100
n-Propyl nitrate	25	110
Propylene dichloride (1, 2-dichloropropane)	75	350
Propylene imine - Skin	25	60
Propylene oxide	100	240
Pyrethrum	—	5
Pyridine	5	15
Quinone	0.1	0.4
Rotenone (commercial)	—	5
† Selenium compounds (as Se)	—	—
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
2, 4, 5T (2, 4, 5 trichlorophenoxyacetic acid)	—	10
TEDP (tetraethyl dithionopyrophosphate) - Skin	—	0.2

†1964 Addition or deletion of "C"
‡1964 Revision - see Tentative Values

Substance	ppm*	Mg/M³**
Teflon (R) decomposition products	—	A4
TEPP (tetraethyl pyrophosphate) - Skin	—	0.05
Tellurium	—	0.1
1, 1, 2, 2-Tetrachloroethane - Skin	5	35
Tetrahydrofuran	200	590
Tetranitromethane	1	8
Tetryl (2, 4, 6-trinitrophenylmethylnitramine) - Skin	—	1.5
Thallium (soluble compounds) - Skin	—	0.1
Thiram (tetramethyl thiuram disulfide)	—	5
Titanium dioxide	—	15
† Toluene (toluol)	200	750
o-Toluidine - Skin	5	22
C Tolylene-2, 4-diisocyanate	0.02	0.14
Trichloroethylene	100	520
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
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
C Vinyl chloride (chloroethylene)	500	1,300
Vinyl toluene	100	480
Warfarin (3-[α acetonylbenzyl]-4-hydroxycoumarin)	—	0.1
C Xylene (xylol)	200	870
Xylidine - Skin	5	25

†1964 Addition or deletion of "C"
‡1964 Revision - see Tentative Values

Substance	ppm*	Mg/M³**
Yttrium	—	—
Zinc oxide fume	—	5
Zirconium compounds (as Zr)	—	5

Radioactivity: For permissible concentrations of radio-isotopes 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 by volume at 25°C and 760 mm. Hg pressure.

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

§ Numbers. See Appendix A

†1964 Revision - see Tentative Values

MINERAL DUSTS

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
SILICATES (less than 1% crystalline silica)	
Asbestos	5
Mica	20
Soapstone	20
Talc	20
Portland Cement	50
"Inert" or Nuisance Particulates	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.

TENTATIVE VALUES

Substance	ppm*	Mg/M³**
++Anisidine (o, p-isomers)		0.5
++Benzoyl peroxide		5
Calcium oxide		5
++Carbaryl (Sevin) (R)		5
Copper Fume		0.1
Dusts & Mists		1.0
++Cotton Dust (raw)		1
++Cyclopentadiene	75	200
Demeton (Systox) (R)		0.1
++1, 3-Dichloro-5, 5-dimethyl hydantoin		0.2
++Dimethyl 1, 2-dibromo-2, 2-dichloroethyl phosphate, (Dibrom) (R)		3
++Dimethylamine	10	18
+ Dimethylformamide - Skin	10	30
++Di sec. octyl phthalate (Di-2-ethylhexyl-phthalate)	—	5
Epichlorhydrin	5	19
Ethanolamine	3	6
Graphite	—	15mppcf
Hafnium	—	0.5
++Hexachloroethane - Skin	1	9.7
+Hydrogen Sulfide	10	15
++L. P. G. (Low pressure gas) (Liquid petroleum gas)	1,000	—
++Maleic anhydride	—	8
++Methane	1,000	—
++Methyl acetylene-propadiene mixture, (MAPP)	1,000	—
Methylamine	25	31
+ Methyl mercaptan	10	20
Methyl methacrylate	100	410
C Methylene bis phenylisocyanate	0.02	0.2
Mineral wool, fibrous glass	—	2
++Monomethyl hydrazine - Skin	0.2	0.35
++Morpholine - Skin	20	70

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

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

+1964 Revision.

++1964 Additions.

Substance	ppm*	Mg/M³**
Naphthalene	10	50
—Nickel, metal and soluble compounds	—	1
+Nitric Acid	2	5
—p-Nitrochlorobenzene	—	1
—Nitrogen trifluoride	10	29
C —Oxygen difluoride	0.05	0.1
—p-Phenylene diamine-Skin	—	0.1
+Phosgene	0.1	0.4
—Phthalic anhydride	2	12
—Propane	1,000	1,800
β Propiolactone	—	A5
+Selenium compounds	—	0.2
+Silver, metal and soluble compounds	—	0.01
Tantalum	—	5
+1, 1, 1, 2-Tetrachloro-2, 2-difluoroethane	500	4,170
1, 1, 2, 2-Tetrachloro-1, 2-difluoroethane	500	4,170
Tetraethyl lead-Skin	—	0.075
Tin (inorganic compounds)	—	2
(organic compounds as Sn) - Skin	—	0.1
+Yttrium	—	1

* Parts of vapor or gas per million parts of 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

+1964 Revisions.

—1964 Additions.

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.

A⁴ Teflon © decomposition products. At least one identified component of Teflon decomposition products is extremely toxic, but in the absence of more complete toxicity information and suitable analytic methods, a definite Threshold Limit Value is not recommended at this time; 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.

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,

$$\frac{C_1}{T_1} + \frac{C_2}{T_2} + \ldots \frac{Cn}{Tn}$$

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).

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

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).

$$\frac{C}{100} + \frac{C}{350} = \frac{C}{T}$$

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

$$C \quad C_1 = \frac{1}{2} C$$

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

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

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

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

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

(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) $p_1 = F_1 p_1^*$.

Combine (3) and (4) to obtain

(5) $C_1 = aF_1p_1^*$.

Combining (1), (2.1), and (5), we obtain

(5) $\frac{F_1p_1^*}{T} + \frac{F_2p_2^*}{T} + \ldots + \frac{F_np_n^*}{T} = \frac{F_1p_1^*}{T_1} + \frac{F_2p_2^*}{T_2} + \ldots + \frac{F_np_n^*}{T_n}$ and solving for T,

(5.1) $$T = \frac{F_1p_1^* + F_2p_2^* + \ldots + F_np_n^*}{\frac{F_1p_1^*}{T_1} + \frac{F_2p_2^*}{T_2} + \ldots + \frac{F_np_n^*}{T_n}}$$

or

(5.2) $$T = \frac{\sum_{i=1}^{i=n} F_ip_i^*}{\sum_{i=1}^{i=n} \frac{F_ip_i^*}{T_i}}$$

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
Trichloro-ethylene (1)	131.4	1.46 g/ml	100	73mm Hg	0.527
Methylchlo-roform (2)	133.42	1.33 g/ml	350	125mm Hg	0.473

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

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

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's 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:

$$\frac{C}{TLV} = \frac{0.8}{20} + \frac{0.2}{2.5}$$

$$TLV = \frac{20}{2.4} = 8.4 \text{ mppcf}$$

Essentially the same result will be obtained if the limit of the more (most) toxic componet 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:

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

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 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	Maganese-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 433 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

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.