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GEORGE CHSICK

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TLVs®
Threshold Limit Values
for
Chemical Substances
and
Physical Agents
in the
Workroom Environment
with
Intended Changes
for
1977



See also NIOSH
Registry of Toxic Effects
of Chemical Substances
in Library

John Garton has abstracted
pages

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Documentation of the Threshold Limit Values for Substances in Workroom Air.® A separate companion piece to the Chemical 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 copies of the Documentation of the Threshold Limit Values for Substances in Workroom Air should be directed to the Secretary-Treasurer, ACGIH.

15470

TLVs®
Threshold Limit Values
for
Chemical
Substances in
Workroom Air
Adopted by
ACGIH
for 1977



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PREFACE CHEMICAL CONTAMINANTS

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.

Tests are available (J. Occup. Med. 15: 564, 1973; Ann. N.Y. Acad. Sci., 151, Art. 2: 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).

Three categories of Threshold Limit Values (TLVs) are specified herein, as follows:

a) **Threshold Limit Value-Time Weighted Average (TLV-TWA)** — the time-weighted average concentration for a normal 8-hour workday or 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.

b) **Threshold Limit Value-Short Term Exposure Limit (TLV-STEL)** — the maximal concentration to which workers can be exposed for a period up to 15 minutes continuously without suffering from 1) irritation, 2) chronic or irreversible tissue change, or 3) narcosis of sufficient degree to increase accident proneness, impair self-rescue, or materially reduce work efficiency, provided that no more than four excursions per day are permitted, with at least 60 minutes between exposure periods, and provided that the daily TLV-TWA also is not exceeded. The STEL should be considered a maximal allowable concentration, or absolute ceiling, not to be exceeded at any time during the 15-minute excursion period. STELs are based on one or more of the following criteria: (1) Adopted TLVs including those with a "C" or "ceiling"

limit. (2) TWA-TLV Excursion Factors listed in Appendix D. (3) Pennsylvania Short-Term Limits for Exposure to Airborne Contaminants (Penna. Dept. of Hlth., Chapter 4, Art. 432, Rev. Jan. 25, 1968). (4) OSHA Occupational Safety and Health Standards, Fed. Reg. Vol. 36, No. 105, May 29, 1971. The TWA-STEL should not be used as engineering design criterion or considered as an emergency exposure level (EEL).

c) **Threshold Limit Value-Ceiling (TLV-C)** — the concentration that should not be exceeded even instantaneously.

For some substances, e.g., irritant gases, only one category, the TLV-Ceiling, may be relevant. For other substances, either two or three categories may be relevant, depending upon their physiologic action. It is important to observe that if any one of these three TLVs is exceeded, a potential hazard from that substance is presumed to exist.

The TLV-TWA should be used as guides in the control of health hazards and should not be used as fine lines between safe and dangerous concentrations.

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 D. 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 a 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

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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 amount and nature of the information available for establishing a TLV varies from substance to substance; consequently, the precision of the estimated TLV is also subject to variation and the latest *Documentation* should be consulted in order to assess the extent of the data available for a given substance.

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 nuisances, (3) in estimating the toxic potential of continuous, uninterrupted exposures or other extended work periods, (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.

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 noncompliance 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 D. It should be noted that the same factors are used by the Committee in determining the magnitude of the value of the STELs, or 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 overall exposure by the cutaneous route including mucous membranes and eye, either by airborne, 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 C.

Nuisance Particulates. In contrast to fibrogenic dusts which cause scar tissue to be formed in lungs when inhaled in excessive amounts, so-called "nuisance" dusts have a long history of little adverse effect on lungs and do not produce significant organic disease or toxic effect when exposures are kept under reasonable control. The

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nuisance dusts have also been called (biologically) "inert" dusts, but the latter term is inappropriate to the extent that there is no dust which does not evoke some cellular response in the lung when inhaled in sufficient amount. However, the lung-tissue reaction caused by inhalation of nuisance dusts has the following characteristics: (1) The architecture of the air spaces remains intact. (2) Collagen (scar tissue) is not formed to a significant extent. (3) The tissue reaction is potentially reversible.

Excessive concentrations of nuisance dusts in the workroom air may seriously reduce visibility, may cause unpleasant deposits in the eyes, ears and nasal passages (Portland Cement dust), or cause injury to the skin or mucous membranes by chemical or mechanical action per se or by the rigorous skin cleansing procedures necessary for their removal.

A threshold limit of 10 mg/m³, or 30 mppcf, of total dust < 1% quartz 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 nuisance particulates are given in Appendix E.

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, pO₂ of 135 mm Hg). Atmospheres deficient in O₂ do not provide adequate warning and most simple asphyxiants are odorless. 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 F.

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

ity, 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 overtime 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.

Biologic Limit Values (BLVs). Other means exist and may be necessary for monitoring worker exposure other than reliance on the Threshold Limit Values for industrial air, namely, the Biologic Limit Values. These values represent limiting amounts of substances (or their effects) to which the worker may be exposed without hazard to health or well-being as determined in his tissues and fluids or in his exhaled breath. The biologic measurements on which the BLVs are based can furnish two kinds of information useful in the control of worker exposure: (1) measure of the individual worker's over-all exposure; (2) measure of the worker's individual and characteristic response. Measurements of response furnish a superior estimate of the physiologic status of the worker, and may be made of (a) changes in amount of some critical biochemical constituent, (b) changes in activity of a critical enzyme, (c) changes in some physiologic function. Measurement of exposure may be made by (1) determining in blood, urine, hair, nails, in body tissues and fluids, the amount of substance to which the worker was exposed; (2) determination of the amount of the metabolite(s) of the substance in tissues and fluids; (3) determination of the amount of the substance in the exhaled breath. The biologic limits may be used as an adjunct to the TLVs for air, or in place of them. The BLVs, and their associated procedures for determining compliance with them, should thus be regarded as an effective means of providing health surveillance of the worker.

Unlisted Substances. Many substances present or handled in industrial processes do not appear on the TLV list. In a number of instances the material is rarely present as a particulate, vapor or other airborne contaminant, and a TLV is not necessary. In other cases sufficient information to warrant development of a TLV, even on a tentative basis, is not available to the Committee. Other substances, of low toxicity, could be included in Appendix E pertaining to nuisance particulates. This list (as well as Appendix F) is not meant to be all inclusive; the substances serve only as examples.

In addition there are some substances of not inconsiderable toxicity, which have been omitted primarily because only a limited number of workers (e.g., employees of a single plant) are known to have potential exposure to possibly harmful concentrations.

"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 Intended Changes." 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. The list of Intended Changes follows the Adopted Values in the TLV booklet.

Legal Status. By publication in the Federal Register (Vol. 36, No. 105, May 29, 1971) the Threshold Limit Values for 1968 are now official federal standards for industrial air.

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Substance	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
	ppm ^a	mg/m ^{3b}	ppm ^a	mg/m ^{3b}
Abate	—	10	—	20
Acetaldehyde	100	180	150	270
Acetic acid	10	25	15	37
C Acetic anhydride	5	20	—	—
Acetone	1,000	2,400	1,250	3,000
Acetonitrile	40	70	60	105
Acetylene	F	—	—	—
Acetylene dichloride, see 1, 2-Dichloroethylene .	200	790	250	1,000
Acetylene tetrabromide ..	1	14	1.25	17.5
Acrolein	0.1	0.25	0.3	0.75
Acrylamide — Skin	—	0.3	—	0.6
Acrylonitrile — Skin	20	45	30	68
Aldrin — Skin	—	0.25	—	0.75
Allyl alcohol — Skin	2	5	4	10
Allyl chloride	1	3	2	6
Allyl glycidyl ether (AGE) — Skin	5	22	10	44
Allyl propyl disulfide	2	12	3	18
Alundum (Al ₂ O ₃)	—	E	—	20
4-Aminodiphenyl — Skin ..	—	A1b	—	A1b
2-Aminoethanol, see Ethanolamine	3	6	6	12
2-Aminopyridine	0.5	2	1.5	6
Ammonia	25	18	35	27
Ammonium chloride-fume	—	10	—	20
Ammonium sulfamate (Ammate)	—	10	—	20
n-Amyl acetate	100	525	150	790
sec-Amyl acetate	125	650	150	810
Aniline — Skin	5	19	—	—
Anisidine (o-, p-isomers) — Skin	0.1	0.5	—	—
** Antimony & Compounds (as Sb)	—	(0.5)	—	—
ANTU (α-Naphthyl thiourea)	—	0.3	—	0.9

Capital letters refer to Appendices.

Footnotes (a thru h) see Page 31.

**See Notices of Intended Changes.

Substance	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
	ppm ^a	mg/m ^{3b}	ppm ^a	mg/m ^{3b}
Argon	F	—	F	F
** Arsenic & compounds (as As)	—	(0.5)	—	—
Arsine	0.05	0.2	—	—
Asbestos (all forms)	—	A1a	—	A1a
Asphalt (petroleum) fumes	—	5	—	10
Azinphos methyl — Skin	—	0.2	—	0.6
Bzygon (propoxur)	—	0.5	—	1.5
Sarium (soluble compounds)	—	0.5	—	—
Benzene — Skin	10, A2	30, A2	—	—
Benzidine production — Skin	—	A1b	—	A1b
p-Benzquinone, see Quinone	0.1	0.4	0.3	1.2
Benzoyl peroxide	—	5	—	—
Benz(a)pyrene	—	A2	—	A2
Benzyl chloride	1	5	—	—
Beryllium	—	0.002	—	0.025
Biphenyl	0.2	1	—	—
Bismuth telluride	—	10	—	20
Bismuth telluride, Se-doped	—	5	—	10
* Borates, tetra, sodium salts,	—	1	—	—
Anhydrous	—	5	—	—
Decahydrate	—	1	—	—
Pentahydrate	—	10	—	20
Boron oxide	1	10	3	30
C Boron tribromide	1	3	—	—
Bromine	0.1	0.7	0.3	2
Bromine pentafluoride	0.1	0.7	0.3	2
Bromochloromethane	200	1,050	250	1,300
Bromoform — Skin	0.5	5	—	—
Butadiene (1, 3-butadiene)	1,000	2,200	1,250	2,750
Butane	600	1,400	750	1,610

Capital letters refer to Appendices.
Footnotes (a thru h) see Page 31.
**See Notice of Intended Changes.
*1977 Addition.

Substance	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
	ppm ^a	mg/m ^{3b}	ppm ^a	mg/m ^{3b}
Butanethiol, see Butyl mercaptan	0.5	1.5	—	—
2-Butanone	200	590	300	885
2-Butoxy ethanol (Butyl Cellosolve) — Skin	50	240	150	720
n-Butyl acetate	150	710	200	950
sec-Butyl acetate	200	950	250	1,190
tert-Butyl acetate	200	950	250	1,190
C n-Butyl alcohol — Skin	50	150	—	—
sec-Butyl alcohol	150	450	—	—
tert-Butyl alcohol	100	300	150	450
C Butylamine — Skin	5	15	—	—
C tert-Butyl chromate (as CrO ₃) — Skin	—	0.1	—	—
n-Butyl glycidyl ether (BGE)	50	270	—	—
n-Butyl lactate	5	25	—	—
Butyl mercaptan	0.5	1.5	—	—
p-tert-Butyltoluene	10	60	20	120
Cadmium, dust & salts (as Cd)	—	0.05	—	0.15
C Cadmium oxide fume (as Cd)	—	0.05	—	—
Calcium carbonate	—	E	—	20
Calcium arsenate (as As)	—	1	—	—
Calcium cyanamide	—	0.5	—	1
** Calcium hydroxide	—	5	—	—
** Calcium oxide	—	(5)	—	—
Camphor, synthetic	2	12	3	18
Caprolactam	—	1	—	3
Dust	5	20	10	40
* Captafol (Difolatan*) — Skin	—	0.1	—	—
Captan	—	5	—	15
Carbaryl (Sevin*)	—	5	—	10
Carbofuran (Furadan*)	—	0.1	—	—
Carbon black	—	3.5	—	7
Carbon dioxide	5,000	9,000	15,000	18,000
Carbon disulfide — Skin	20	60	30	90

Capital letters refer to Appendices.
**See Notice of Intended Changes.
*1977 Addition.

Substance	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
	ppm ^{m)}	mg/m ³ ^{m)}	ppm ^{m)}	mg/m ³ ^{m)}
Carbon monoxide	50	55	400	440
Carbon tetrabromide	0.1	1.4	0.3	4.2
Carbon				
tetrachloride — Skin ..	10	55	25	150
* Catechol (Pyrocatechol) ..	5	20	—	—
Cellulose (paper fiber)	—	E	—	20
Cesium hydroxide	—	2	—	—
Chloroform — Skin	—	0.5	—	2
Chlorinated				
camphene — Skin	—	0.5	—	1
Chlorinated diphenyl				
oxide	—	0.5	—	1.5
Chlorine	1	3	3	9
Chlorine dioxide	0.1	0.3	0.3	0.9
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				
malonitrile — Skin	0.05	0.4	—	—
Chlorobromomethane	200	1,050	250	1,300
2-Chloro-1, 3-butadiene,				
see β Chloroprene	25	90	35	135
Chlorodifluoromethane	1,000	3,500	1,250	4,375
Chlorodiphenyl (42%				
Chlorine) — Skin	—	1	—	—
Chlorodiphenyl (54%				
Chlorine) — Skin	—	0.5	—	1
1-Chloro, 2,				
3-epoxy-propane				
(Epichlorohydrin)	5	20	10	40
2-Chloroethanol				
(Ethylene				
chlorohydrin)	1	3	—	—
Chloroethylene (Vinyl				
chloride)	A1c	—	A1c	—

Capital letters refer to Appendices.
*1977 Addition.

Substance	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
	ppm ^{m)}	mg/m ³ ^{m)}	ppm ^{m)}	mg/m ³ ^{m)}
** Chloroform				
(Trichloromethane)	(25)	(120)	—	—
bis-Chloromethyl ether ...	0.001	A1a	—	A1a
1-Chloro-1-nitro-propane	20	100	—	—
Chloropicrin	0.1	0.7	—	—
β-Chloroprene — Skin ..	25	90	35	135
Chlorpyrifos				
(Dursban®) — Skin ...	—	0.2	—	0.6
o-Chlorostyrene	50	285	75	430
o-Chlorotoluene — Skin ..	50	250	75	375
2-Chloro-				
6-(trichloromethyl				
pyridine (N-Serve®) ...	—	10	—	20
Chromaz, certain				
insoluble forms	—	0.05A1a	—	A1a
Chromic acid and				
chromates, (as Cr.) ...	—	0.05	—	—
Chromium, Sol.				
chromic, chromous				
salts (as Cr.)	—	0.5	—	—
Clopidol (Coyden®)	—	10	—	20
Coal tar pitch volatiles				
(See Particulate				
polycyclic aromatic				
hydrocarbons)	—	A1a	—	A1a
** Cobalt metal, dust and				
fume	—	(0.1)	—	—
Copper fume	—	0.2	—	—
Dusts & Mists				
—	—	1	—	2
Corundum (Al ₂ O ₃)	—	E	—	E
Cotton dust, raw	—	0.2 ^{m)}	—	0.6
Crag® herbicide	—	10	—	20
Cresol, all				
isomers — Skin	5	22	—	—
Crotonaldehyde	2	6	6	18
Crotonate®	—	5	—	20
Cumene — Skin	50	245	75	365

m) See p. 34.

Footnotes a thru h) see Page 31.

**See Notice of Intended Changes.

Substance	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
	ppm ^a	mg/m ^{3b}	ppm ^a	mg/m ^{3b}
* Cyanamide.....	—	2	—	—
Cyanide, as CN — Skin..	—	5	—	—
.....	10	20	—	—
Cyclohexane.....	300	1,050	375	1,300
Cyclohexanol.....	50	200	—	—
Cyclohexanone.....	50	200	—	—
Cyclohexene.....	300	1,015	—	—
Cyclohexylamine — Skin	10	40	—	—
Cyclopentadiene.....	75	200	150	400
2, 4-D (2, 4-Diphenoxy- acetic acid).....	—	10	—	20
DDT (Dichlorodiphenyl- trichloroethane).....	—	1	—	3
DDVP, See Dichlorvos ...	0.1	1	0.3	3
Decaborane — Skin.....	0.05	0.3	0.15	0.9
Demeton® — Skin.....	0.01	0.1	0.03	0.3
Diacetone alcohol (4-hydroxy-4-methyl- 2-pentanone).....	50	240	75	360
1, 2-Diaminoethane, See Ethylenediamine.....	10	25	—	—
Diazinon — Skin.....	—	0.1	—	0.3
Diazomethane.....	0.2	0.4	—	—
Diborane.....	0.1	0.1	—	—
1, 2-Dibromoethane (Ethylene dibromide) — Skin.....	20	145	30	220
Dibrom®.....	—	3	—	6
2-N-Dibutylaminoethanol — Skin.....	2	14	4	28
Dibutyl phosphate.....	1	5	2	10
Dibutyl phthalate.....	—	5	—	10
C Dichloroacetylene.....	0.1	0.4	—	—
C o-Dichlorobenzene.....	50	300	—	—
p-Dichlorobenzene.....	75	450	110	675
Dichlorobenzidine — Skin.....	—	A2	—	A2
Dichlorodifluoromethane.	1,000	4,950	1,250	6,200

Capital letters refer to Appendices.
Footnotes (a thru h) see Page 31.
* 1977 Addition.

Substance	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
	ppm ^a	mg/m ^{3b}	ppm ^a	mg/m ^{3b}
1, 3-Dichloro-5, S-dimethyl hydantoin ..	—	0.2	—	0.4
1, 1-Dichloroethane.....	200	820	250	1,025
1, 2-Dichloroethane.....	50	200	75	300
1, 2-Dichloroethylene....	200	790	250	1,000
Dichloroethyl ether — Skin.....	5	30	10	60
Dichloromethane, see Methylene chloride....	200	720	250	900
** Dichloromono-fluoro- methane.....	(1,000)	(4,200)	—	—
C 1, 1-Dichloro-1- nitroethane.....	10	60	—	—
1, 2-Dichloropropane, see Propylene dichloride.....	75	350	110	525
Dichlorotetrafluoro- ethane.....	1,000	7,000	1,250	8,750
Dichlorvos (DDVP) — Skin.....	0.1	1	0.3	3
* Dicrotophos (Bidrin®) — Skin.....	—	0.25	—	—
Dicyclopentadiene.....	5	30	—	—
Dicyclopentadienyl iron ..	—	10	—	20
Dieldrin — Skin.....	—	0.25	—	0.75
Diethylamine.....	25	75	—	—
Diethylaminoethanol — Skin.....	10	50	—	—
Diethylene triamine — Skin.....	1	4	—	—
Diethyl ether, see Ethyl ether.....	400	1,200	500	1,500
Diethyl phthalate.....	—	5	—	10
Difluorodibromomethane.	100	860	150	1,290
C Diglycidyl ether (DGE)....	0.5	2.8	—	—
Dihydroxybenzene, see Hydroquinone.....	—	2	—	3
Diisobutyl ketone.....	25	150	—	—

Capital letters refer to Appendices.
* 1977 Addition.
** See Notice of Intended Changes.

Substance	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
	ppm ^a	mg/m ^{3b}	ppm ^a	mg/m ^{3b}
Diisopropylamine —				
Skin	5	20	—	—
Dimethoxymethane, see				
Methylal	1,000	3,100	1,250	3,875
Dimethyl acetamide —				
Skin	10	35	15	50
Dimethylamine	10	18	—	—
Dimethylaminobenzene,				
see Xylidene	5	25	10	50
Dimethylaniline				
(N-Dimethylaniline) —				
Skin	5	25	10	50
Dimethylbenzene, see				
Xylene	100	435	150	650
Dimethyl-1,				
2-dibromo-2-dichloroethyl				
phosphate, see				
Dibrom	—	3	—	6
Dimethylformamide —				
Skin	10	30	20	60
2, 5-Dimethylheptanone,				
see Diisobutyl ketone ..	25	150	—	—
1, 1-Dimethylhydrazine				
— Skin	0.5	1	1	2
Dimethylphthalate	—	5	—	10
* C Dimethyl sulfate —				
Skin	0.1, A2	0.5, A2	—	—
Dinitrobenzene (all				
isomers) — Skin	0.15	1	0.5	3
Dinitro-o-cresol — Skin ..	—	0.2	—	0.5
3, 5-Dinitro-o-toluidine				
(Zcalene*)	—	5	—	10
Dinitrotoluene — Skin ...	—	1.5	—	5
Dioxane, tech. grade —				
Skin	50	180	—	—
* Dioxathion (Deinav*)	—	0.2	—	—
Diphenyl, see Biphenyl ...	0.2	1	0.6	3
Diphenylamine	—	10	—	20

Capital letters refer to Appendices.

*1977 Addition.

Footnotes (a thru h) see Page 31.

Substance	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
	ppm ^a	mg/m ^{3b}	ppm ^a	mg/m ^{3b}
Diphenylmethane				
diisocyanate, see				
Methylene bisphenyl				
isocyanate (MDI)	0.02	0.2	0.02	0.2
Dipropylene glycol				
methyl ether — Skin ..	100	600	150	900
Diquat	—	0.5	—	1
Di-sec, octyl phthalate				
(DI-2-ethylhexyl-				
phthalate)	—	5	—	10
Disulfuram	—	2	—	5
Disyston — Skin	—	0.1	—	0.3
2, 6-Di-tert.				
butyl-p-cresol	—	10	—	20
* Diuron	—	10	—	—
Dylonate	—	0.1	—	—
Emery	—	E	—	20
Endosulfan (Thiodan*)				
— Skin	—	0.1	—	0.3
Endrin — Skin	—	0.1	—	0.3
Epichlorohydrin — Skin ...	5	20	10	40
EPN — Skin	—	0.5	—	1.5
1, 2-Epoxypropane, see				
Propylene oxide	100	240	150	360
2, 3-Epoxy-1-propanol,				
see Glycidol	50	150	65	190
Ethane	F	—	F	—
Ethanethiol, see Ethyl				
mercaptan	0.5	1	1.5	3
Ethanolamine	3	6	6	12
Ethion (Nialate*) — Skin	—	0.4	—	—
2-Ethoxyethanol — Skin ..	100	370	150	560
2-Ethoxyethyl acetate				
(Cellosolve acetate) —				
Skin	100	540	150	810
Ethyl acetate	400	1,400	—	—
Ethyl acrylate — Skin ...	25	100	—	—
Ethyl alcohol (Ethanol) ...	1,000	1,900	—	—
Ethylamine	10	18	—	—

Footnotes (a thru h) see Page 31.

*1977 Addition.

Substance	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
	ppm ^a	mg/m ^{3b}	ppm ^a	mg/m ^{3b}
Ethyl sec-amyl ketone (4-Methyl-3-heptanone).....	25	130	—	—
Ethyl benzene.....	100	435	125	545
Ethyl bromide.....	200	890	250	1,110
Ethylbutyl ketone (3-Heptanone).....	50	230	75	345
Ethyl chloride.....	1,000	2,600	1,250	3,250
Ethyl ether.....	400	1,200	500	1,500
Ethyl formate.....	100	300	150	450
Ethyl mercaptan.....	0.5	1	—	—
Ethyl silicate.....	(100)	(850)	—	—
Ethylene.....	F	—	F	—
C Ethylene chlorohydrin — Skin.....	1	3	—	—
Ethylene diamine.....	10	25	—	—
Ethylene dibromide, see 1, 2-Dibromoethane ...	20	145	30	220
Ethylene dichloride, see 1, 2-Dichloroethane ...	50	200	75	300
Ethylene glycol, Particulate.....	—	10	—	20
Vapor.....	100	260	125	325
C Ethylene glycol dinitrate and/or Nitroglycerin — Skin.....	0.2 ^a	—	—	—
Ethylene glycol monomethyl ether acetate (Methyl cellosolve acetate) — Skin.....	25	120	40	180
Ethylene oxide.....	50	90	75	135
Ethylenimine — Skin.....	0.5	1	—	—
Ethylene chloride, see 1, 1-Dichloroethane ...	200	320	250	400
C Ethylene norbornene ...	5	25	—	—
N-Ethylmorpholine — Skin.....	20	94	20	94
Fensulfothion (Dasanit) ..	—	0.1	—	—
Ferbam.....	—	10	—	20

Capital letters refer to Appendices.

Substance	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
	ppm ^a	mg/m ^{3b}	ppm ^a	mg/m ^{3b}
Ferrovandium dust	—	1	—	0.3
Fluoride (as F).....	—	2.5	—	—
Fluorine.....	1	2	2	4
Fluorotrichloromethane ..	1,000	5,600	1,250	7,000
C Formaldehyde.....	2	3	—	—
Formamide.....	20	30	30	45
Formic acid.....	5	9	5	9
Furfural — Skin.....	5	20	15	60
Furfuryl alcohol — Skin ..	5	20	10	40
Gasoline.....	—	82	—	82
Germanium tetrahydride ..	0.2	0.6	0.6	1.8
Glass, fibrous ^a or dust ..	—	E	—	E
**C Glutaraldehyde, activated or unactivated.....	—	(0.25)	—	—
Glycerin mist.....	—	E	—	E
Glycidol (2, 3-Epoxy- 1-propanol).....	50	150	75	225
Glycol monoethyl ether, see 2-Ethoxyethanol ...	100	370	150	560
Graphite (Synthetic).....	—	E	—	—
Guthion*, see Azinphos-methyl.....	—	0.2	—	0.6
Gypsum.....	—	E	—	20
Hafnium.....	—	0.5	—	1.5
Helium.....	F	—	F	—
Heptachlor — Skin.....	—	0.5	—	1.5
Heptane (n-Heptane).....	400	1,600	500	2,000
Hexachlorocyclopenta- diene.....	0.01	0.11	0.03	0.33
Hexachloroethane — Skin.....	1	10	3	30
Hexachloronaphthalene — Skin.....	—	0.2	—	0.6
Hexafluoroacetone.....	0.1	0.7	0.3	2.1
Hexane (n-hexane).....	100	360	125	450
2-Hexanone, see Methyl butyl ketone — Skin ..	25	100	40	150
Hexone (Methyl isobutyl ketone) — Skin.....	100	410	125	510

Capital letters refer to Appendices.

**See Notice of Intended Changes.

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Substance	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
	ppm ^a	mg/m ^{3b}	ppm ^a	mg/m ^{3b}
sec-Hexyl acetate	50	300	—	—
C Hexylene glycol	25	125	—	—
* Hydrazine — Skin	0.1	0.1	—	—
Hydrogen	F	—	F	—
Hydrogenated terphenyls	0.5	5	—	—
Hydrogen bromide	3	10	—	—
C Hydrogen chloride	5	7	—	—
Hydrogen cyanide —				
Skin	10	11	15	16
Hydrogen fluoride	3	2	—	—
Hydrogen peroxide	1	1.4	2	2.8
Hydrogen selenide	0.05	0.2	—	—
Hydrogen sulfide	10	15	15	27
Hydroquinone	—	2	—	4
Indene	10	45	15	27
Indium & Compounds				
(25 In)	—	0.1	—	0.3
C Iodine	0.1	1	—	—
Iodoform	0.2	3	0.4	0.6
Iron oxide fume	83	5	—	10
Iron pentacarbonyl	0.01	0.08	—	—
Iron salts, soluble (as				
Fe)	—	1	—	2
Isoamyl acetate	100	525	125	655
Isoamyl alcohol	100	360	125	450
Isobutyl acetate	150	700	187	875
Isobutyl alcohol	50	150	75	225
C Isophorone	5	25	—	—
* Isophorone				
diisocyanate — Skin ..	0.01	0.05	—	—
Isopropyl acetate	250	950	310	1,185
Isopropyl alcohol — Skin	400	980	500	1,225
Isopropylamine	5	12	10	24
Isopropyl ether	250	1,050	310	1,320
Isopropyl glycidyl ether				
(IGE)	50	240	75	360
Kaolin	—	E	—	20
Ketene	0.5	0.9	1.5	2.7

Capital letters refer to Appendices.
*1977 Addition.

Substance	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
	ppm ^a	mg/m ^{3b}	ppm ^a	mg/m ^{3b}
Lead, inorg., fumes &				
dusts (as Pb)	—	0.15	—	0.45
Lead arsenate (as Pb)	—	0.15	—	0.45
Lead Chromate (as Cr) ...	—	0.05, A2	—	—
Limestone	—	E	—	20
Lindane — Skin	—	0.5	—	1.5
Lithium hydride	—	0.025	—	—
L.P.G. (Liquified				
petroleum gas)	1,000	1,800	1,250	2,250
Magnetite	—	E	—	20
Magnesium oxide fume ..	—	10	—	—
Malathion — Skin	—	10	—	—
Maleic anhydride	0.25	1	—	—
C Manganese &				
Compounds (as Mn) ..	—	5	—	—
Manganese				
cyclopentadienyl				
tricarbonyl (as Mn) —				
Skin	—	0.1	—	0.3
Marble	—	E	—	20
Mercury (Alkyl				
compounds) — Skin,				
As Hg	0.001	0.01	0.003	0.03
Mercury (All forms				
except alkyl) as Hg	—	0.05	—	0.15
Mesityl oxide	25	100	—	—
Methane	F	—	F	—
Methanethiol, see Methyl				
mercaptan	0.5	1	—	—
* Methomyl (Lannate*) —				
Skin	—	2.5	—	—
Methoxychlor	—	10	—	—
2-Methoxyethanol —				
Skin (Methyl				
cellosolve)	25	80	35	120
Methyl acetate	200	610	250	760
Methyl acetylene				
(propyne)	1,000	1,650	1,250	2,060

*1977 Addition.
Capital letters refer to Appendices.

Substance	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
	ppm ^a	mg/m ³ ^b	ppm ^a	mg/m ³ ^b
Methyl acetylene-propadiene mixture (MAPP)	1,000	1,800	1,250	2,250
Methyl acrylate — Skin ..	10	35	—	—
Methyl acrylonitrile — Skin	1	3	2	6
Methylal (dimethoxymethane) ..	1,000	3,100	1,250	3,875
Methyl alcohol (methanol) — Skin	200	260	250	325
Methylamine	10	12	—	—
Methyl amyl alcohol, see Methyl isobutyl carbinol	25	100	40	150
Methyl 2-cyanoacrylate ..	2	8	4	16
Methyl isoamyl ketone	100	475	150	710
Methyl n-amyl ketone (2-Heptanone)	100	465	150	710
Methyl bromide — Skin ..	15	60	—	—
Methyl butyl ketone, see 2-Hexanone	25	100	40	150
Methyl cellosolve — Skin ..	25	80	35	120
Methyl cellosolve acetate — Skin, see Ethylene glycol monomethyl ether acetate	25	120	35	150
Methyl chloride	100	210	125	260
Methyl chloroform	350	1,900	450	2,375
Methylcyclohexene	400	1,600	500	2,000
Methylcyclohexanol	50	235	75	350
o-Methylcyclohexanone — Skin	50	230	75	345
Methylcyclopentadienyl manganese tricarbonyl (as Mn) — Skin	0.1	0.2	0.3	0.6
Methyl demeton — Skin ..	—	0.5	—	1.5
C Methylene bisphenyl isocyanate (MDI)	0.02	0.2	—	—

Capital letters refers to Appendices.

Substance	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
	ppm ^a	mg/m ³ ^b	ppm ^a	mg/m ³ ^b
* Methylene chloride (dichloromethane)	200	720	250	900
4, 4'-Methylene bis (2-chloroaniline) — Skin	0.02, A2	—	A2	—
C Methylene bis (4-cyclohexylisocyanate)	0.01	0.11	—	—
Methyl ethyl ketone (MEK), see 2-Butanone	200	590	250	740
C Methyl ethyl ketone peroxide	0.2	1.5	—	—
Methyl formate	100	250	150	375
Methyl iodide — Skin	5	28	10	56
Methyl isobutyl carbinol — Skin	25	100	40	150
Methyl isobutyl ketone, see Hexone	100	410	125	510
Methyl isocyanate — Skin	0.02	0.05	—	—
Methyl mercaptan	0.5	1	—	—
Methyl methacrylate	100	410	125	510
Methyl parathion — Skin	—	0.2	—	0.6
Methyl propyl ketone, see 2-Pentanone	200	700	250	875
C Methyl silicate	5	30	—	—
C α-Methyl styrene	100	480	—	—
Molybdenum (as Mo) Soluble compounds ...	—	5	—	10
Insoluble compounds ..	—	10	—	20
* Monocrotophos (Azodrin®)	—	0.25	—	—
Monomethyl aniline — Skin	2	9	4	18
C Monomethyl hydrazine — Skin	0.2	0.35	—	—
Morpholine — Skin	20	70	30	105
Naphthalene	10	50	15	75

Capital letters refer to Appendices.
Footnotes (a thru h) see Page 31.
*1977 Addition.

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Substance	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
	ppm ^{a1}	mg/m ^{3b}	ppm ^{a1}	mg/m ^{3b}
β-Naphthylamine	—	A1b	—	A1b
Neon	F	—	F	—
* Nickel carbonyl	0.05	0.35	—	—
Nickel metal	—	1	—	—
Nickel, soluble compounds (as Ni)	—	0.1	—	0.3
Nicotine — Skin	—	0.5	—	1.5
Nitric acid	2	5	4	10
Nitric oxide	25	30	35	45
p-Nitroaniline — Skin	1	6	2	12
Nitrobenzene — Skin	1	5	2	10
p-Nitrochlorobenzene — Skin	—	1	—	2
4-Nitrodiphenyl	—	A1b	—	A1b
Nitroethane	100	310	150	465
C Nitrogen dioxide	5	9	—	—
Nitrogen trifluoride	10	29	15	45
Nitroglycerin ^{a2} — Skin ...	0.2	2	—	—
Nitromethane	100	250	150	375
1-Nitropropane	25	90	35	135
2-Nitropropane	25	90	—	—
N-Nitrosodimethylamine (dimethylnitrosoamine) — Skin	—	A2	—	A2
Nitrotoluene — Skin	5	30	10	60
Nitrotrichloromethane, see Chloropicrin	0.1	0.7	0.3	2
Nonane	200	1,050	250	1,300
Octachloronaphthalene — Skin	—	0.1	—	0.3
Octane	300	1,450	375	1,800
Oil mist	—	5 ^{a1}	—	10
Osmium tetroxide (as Os)	0.0002	0.002	0.0006	0.006
Oxalic acid	—	1	—	2
Oxygen difluoride	0.05	0.1	0.15	0.3
Ozone	0.1	0.2	0.3	0.6
Paraffin wax fume	—	2	—	6

Capital letters refer to Appendices.
Footnotes (a thru h) see Page 31.
*1977 Addition.

Substance	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
	ppm ^{a1}	mg/m ^{3b}	ppm ^{a1}	mg/m ^{3b}
** Paraquat — Skin	—	(0.5)	—	—
Parathion — Skin	—	0.1	—	0.3
Particulate polycyclic aromatic hydrocarbons (PPAH) as benzene solubles ...	—	0.2, A1a	—	A1a
Pentaborane	0.005	0.01	0.015	0.03
Pentachloronaphthalene ..	—	0.5	—	1.5
Pentachlorophenol — Skin	—	0.5	—	1.5
Pentaerythritol	—	E	—	20
Pentane	600	1,800	750	2,250
2-Pentanone	200	700	250	875
Perchloroethylene — Skin	100	670	150	1,000
Perchloromethyl mercaptan	0.1	0.8	—	—
Perchloryl fluoride	3	14	6	28
Petroleum distillates (naphtha)	*B3	—	83	—
Phenol — Skin	5	19	10	38
Phenothiazine — Skin	—	5	—	10
p-Phenylene diamine — Skin	—	0.1	—	—
Phenyl ether (vapor)	1	7	2	14
Phenyl ether-Diphenyl mixture (vapor)	1	7	2	14
Phenylethylene, see Styrene	100	420	125	525
Phenyl glycidyl ether (PGE)	10	60	15	90
Phenylhydrazine — Skin ..	5	22	10	44
C Phenylphosphine	0.05	0.25	—	—
Phorate (Thimet®) — Skin	—	0.05	—	0.15
Phosdrin (Mevinphos®) — Skin	0.01	0.1	0.03	0.3
Phosgene (carbonyl chloride)	0.10	0.4	—	—

Capital letters refer to Appendices.
**See Notice of Intended Changes.

Substance	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
	ppm ^{a)}	mg/m ^{3b)}	ppm ^{a)}	mg/m ^{3b)}
Phosphine	0.3	0.4	1	1
Phosphoric acid	—	1	—	3
Phosphorus (yellow)	—	0.1	—	0.3
Phosphorus pentachloride	—	1	—	3
Phosphorus pentasulfide	—	1	—	3
Phosphorus trichloride	0.5	3	—	—
• Phthalic anhydride	1	6	4	24
• m-Phthalodinitrile	—	5	—	—
Picloram (Tordon®)	—	10	—	20
Picric acid — Skin	—	0.1	—	0.3
Pival® (2-Pivalyl-1, 3- indandione)	—	0.1	—	0.3
Plaster of Paris	—	E	—	20
Platinum (Soluble salts) as Pt	—	0.002	—	—
Polychlorobiphenyls, see Chlorodiphenyls	—	—	—	—
Polytetrafluoroethylene decomposition products	—	81	—	81
• Potassium hydroxide	—	2	—	—
Propane	F	—	F	—
β-Propiolactone	—	A2	—	A2
Propargyl alcohol — Skin	1	2	3	6
n-Propyl acetate	200	840	250	1,050
Propyl alcohol — Skin	200	500	250	625
n-Propyl nitrate	25	110	40	140
Propylene	F	—	F	—
Propylene dichloride (1, 2-Dichloropropane)	75	350	115	525
Propylene glycol monomethyl ether	100	360	150	450
Propylene imine — Skin	2	5	—	—
Propylene oxide	100	240	150	360
Propyne, see Methyl-acetylene	1,000	1,650	1,250	2,050
Pyrethrum	—	5	—	10

Capital letters refer to Appendices.
*1977 Addition.

Substance	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
	ppm ^{a)}	mg/m ^{3b)}	ppm ^{a)}	mg/m ^{3b)}
Pyridine	5	15	10	30
Quinone	0.1	0.4	0.3	1
RDX — Skin	—	1.5	—	3
Resorcinol	10	45	20	90
Rhodium, Metal fume and dusts (as Rh)	—	0.1	—	0.3
Soluble salts	—	0.001	—	0.003
Ronnel	—	10	—	—
Rosin core solder pyrolysis products (as formaldehyde)	—	0.1	—	0.3
Rotenone (commercial) ..	—	5	—	10
Rouge	—	E	—	20
* Rubber solvent	400	1,600	—	—
Selenium compounds (as Se)	—	0.2	—	—
Selenium hexafluoride, as Se	0.05	0.4	0.05	0.4
Sevin® (see Carbaryl)	—	5	—	10
Silane (see Silicon tetrahydride)	0.5	7	—	—
Silicon	—	E	—	20
Silicon carbide	—	E	—	20
Silicon tetrahydride (Silane)	0.5	0.7	1	1.5
Silver, metal and soluble compounds, as Ag	—	0.01	—	0.03
C Sodium azide	0.1	0.3	—	—
Sodium fluoroacetate (1080) — Skin	—	0.05	—	0.15
C Sodium hydroxide	—	2	—	—
Starch	—	E	—	20
Stibine	0.1	0.5	0.3	1.5
Stoddard solvent	100	575	150	720
Strychnine	—	0.15	—	0.45
Styrene, monomer (Phenylethylene)	100	420	125	525
** Succinaldehyde (see Glutaraldehyde)	—	(0.25)	—	—

Capital letters refer to Appendices.
*1977 Addition.
**See Notice of Intended Changes.

Substance	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
	ppm ^{a)}	mg/m ^{3b)}	ppm ^{a)}	mg/m ^{3b)}
C Subtilisins (Proteolytic enzymes as 100% pure crystalline enzyme)	—	0.00006 ^{a)}	—	—
Sucrose	—	E	—	20
Sulfur dioxide	5	13	—	—
Sulfur hexafluoride	1,000	6,000	1,250	7,500
Sulfuric acid	—	1	—	—
Sulfur monochloride	1	6	3	18
Sulfur pentafluoride	0.025	0.25	0.075	0.75
Sulfur tetrafluoride	0.1	0.4	0.3	1
Sulfuryl fluoride	5	20	10	40
Systox, see Demeton ^{a)}	0.01	0.1	0.03	0.3
2, 4, 5-T	—	10	—	20
Tantalum	—	5	—	10
TEDP — Skin	—	0.2	—	0.6
Teflon ^{a)} decomposition products	—	81	—	81
Tellurium	—	0.1	—	—
Tellurium hexafluoride, as Te	0.02	0.2	—	—
TEPP — Skin	0.004	0.05	0.012	0.15
C Terphenyls	1	9	—	—
1, 1, 1, 2-Tetrachloro-2, 2-difluoroethane	500	4,170	625	5,210
1, 1, 2, 2-Tetrachloro-1, 2-difluoroethane	500	4,170	625	5,210
1, 1, 2, 2-Tetrachloroethane — Skin	5	35	10	70
Tetrachloroethylene, see Perchloroethylene	100	670	150	1,000
Tetrachloromethane, see Carbon tetrachloride	10	65	20	130
Tetrachloronaphthalene	—	2	—	4
Tetraethyl lead (as Pb) — Skin	—	0.100 ^{a)}	—	0.3

Capital letters refer to Appendices.
Footnotes (a thru h) see Page 31.
a) See Page 34.

Substance	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
	ppm ^{a)}	mg/m ^{3b)}	ppm ^{a)}	mg/m ^{3b)}
Tetrahydrofuran	200	590	250	700
Tetramethyl lead (as Pb) — Skin	—	0.150 ^{a)}	—	0.45
Tetramethyl succinonitrile — Skin	0.5	3	1.5	9
Tetranitromethane	1	8	—	—
Tetryl (2, 4, 6-trinitrophenyl-methylnitramine) — Skin	—	1.5	—	3.0
Thallium, soluble compounds (as Tl) — Skin	—	0.1	—	—
4, 4'-Thiobis (6-tert. butyl-m-cresol)	—	10	—	20
Thiram ^{a)}	—	5	—	10
Tin, inorganic compounds, except SnH ₄ and SnO ₂ , (as Sn)	—	2	—	4
Tin, organic compounds (as Sn) — Skin	—	0.1	—	0.2
Tin oxide	—	E	—	20
Titanium dioxide	—	E	—	20
Toluene (toluol) — Skin	100	375	150	560
C Toluene-2, 4-diisocyanate (TDI) ...	0.02	0.14	—	—
o-Toluidine	5	22	10	44
Toxaphene, see Chlorinated camphene	—	0.5	—	1.5
Tributyl phosphate	—	5	—	5
1, 1, 1-Trichloroethane, see Methyl chloroform	350	1,900	440	2,380
1, 1, 2-Trichloroethane — Skin	10	45	20	90
Trichloroethylene	100	535	150	800
** Trichloromethane, see Chloroform	(25)	(120)	—	—
Trichloronaphthalene	—	5	—	10
1, 2, 3-Trichloropropane	50	300	150	450

Capital letters refer to Appendices.
** See Notice of Intended Changes.

Substance	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
	ppm ^{a)}	mg/m ^{3b)}	ppm ^{a)}	mg/m ^{3b)}
1, 1, 2-Trichloro 1, 2, 2-trifluoroethane	1,000	7,600	1,250	9,500
Triethylamine	25	100	40	150
Tricyclohexyltin hydroxide (Plictran*)	—	5	—	10
Trifluoromethanobromo- methane	1,000	6,100	1,200	7,625
Trimethyl benzene	25	120	35	180
2, 4, 6-Trinitrophenol, see Picric acid	—	0.1	—	0.3
2, 4, 6-Trinitrophenyl- methylnitramine, see Telryl	—	1.5	—	3.0
** Trinitrotoluene (TNT) — Skin	—	(1.5)	—	—
Triorthocresyl phosphate	—	0.1	—	0.3
Triphenyl phosphate	—	3	—	6
Tungsten & compounds, as W	—	—	—	—
Soluble	—	1	—	3
Insoluble	—	5	—	10
Turpentine	100	560	150	340
Uranium (natural) soluble & insoluble compounds, as U	—	0.2	—	0.6
Vanadium (V ₂ O ₅), as V	—	—	—	—
C Dust	—	0.5	—	1.5
Fume	—	0.05	—	—
Vinyl acetate	10	30	20	60
Vinyl benzene, see Styrene	100	420	150	630
Vinyl bromide	(250)	(1,100)	—	—
** Vinyl chloride	(200)	(510)	—	—
Vinyl cyanide, see Acrylonitrile	20	45	30	70
* Vinyl cyclohexene dioxide	10	60	—	—
Vinylidene chloride	10	40	20	80
Vinyl toluene	100	480	150	720

*1977 Addition.

**See Notice of Intended Changes.

Substance	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
	ppm ^{a)}	mg/m ^{3b)}	ppm ^{a)}	mg/m ^{3b)}
Warfarin	—	0.1	—	0.3
* Welding fumes (Total particulate)	—	5, 83	—	83
Wood dust (nonallergenic)	—	5	—	10
Xylene (o-, m-, p-isomers) — Skin	100	435	150	655
*C m-Xylene α, α'-diamine	—	0.1	—	—
Xylidene — Skin	5	25	10	50
Yttrium	—	1	—	3
Zinc chloride fume	—	1	—	2
* Zinc chromate (as Cr)	—	0.05, A2	—	—
Zinc oxide fume	—	5	—	10
Zinc stearate	—	E	—	20
Zirconium compounds (as Zr)	—	5	—	10

*1976 Addition

Capital letters refer to Appendices.

- 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 substance per cubic meter of air.
- d) An atmospheric concentration of not more than 0.02 ppm, or personal protection may be necessary to avoid headache for intermittent exposure.
- e) < 7 μm in diameter.
- f) As sampled by method that does not collect vapor.
- g) According to analytically determined composition.
- h) For control of general room air, biologic monitoring is essential for personnel control.

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, 1969. 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. A report, Basic Radiation Protection Criteria, published by the National Committee on Radiation Protection, revises and modernizes the concept of the NCRP standards of 1954, 1957 and 1958; obtainable as NCRP Rept. No. 39, P. O. Box 30175, Washington, D.C. 20014.

MINERAL DUSTS

Substance
SILICA, SiO₂
Crystalline
Quartz

TLV in mppcf ⁿ :	
300 ⁿ	
% quartz + 10	
TLV for respirable dust in mg/m ³ :	
10 mg/m ³ ⁿ	
% Respirable quartz + 2	
TLV for "total dust," respirable and nonrespirable:	
30 mg/m ³	
% quartz + 3	
Cristobalite	Use one-half the value calculated from the count or mass formulae for quartz.
Tridymite	Use one-half the value calculated from formulae for quartz.
Silica, fused	Use quartz formulae.
Tripoli	Use respirable ⁿ mass quartz formula
**Amorphous	20 mppcf ⁿ

**See Notice of Intended Changes.

SILICATES (< 1% quartz)

Asbestos, all forms⁺

5 fibers/cc >
5 μm in
lengthⁿ; A1a
15 mppcf
20 mppcf
10 mg/m³
30 mppcf
30 mppcf
20 mppcf
20 mppcf

Graphite (natural)

Mica

Mineral wool fiber

Perlite

Portland Cement

Soapstone

Talc (nonasbestiform)

Talc (fibrous), use Asbestos limit.

Tremolite, see Asbestos.

COAL DUST

2 mg/m³ (respirable dust fraction < 5% quartz).

If > 5% quartz, use respirable mass formula.

NUISANCE PARTICULATES

(see Appendix E)

30 mppcf or 10 mg/m³ⁿ

of total dust < 1% quartz, or, 5 mg/m³ respirable dust.

Conversion factors:

mppcf × 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 techniques.
- The percentage of quartz in the formula is the amount determined from airborne samples, except in those instances in which other methods have been shown to be applicable.
- Both concentration and percent quartz for the application of this limit are to be determined from the fraction passing a size-selector with the following characteristics:

⁺A more stringent TLV for crocidolite may be required.

i), n) See p. 34.

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

- l) containing <1% quartz; if quartz content > 1%, use formulae for quartz.
- m) Lint-free dust as measured by the vertical-elutriator, cotton-dust sampler described in the Transactions of the National Conference on Cotton Dust, J. R. Lynch, pg. 33, May 2, 1970.
- n) As determined by the membrane filter method at 400-450X magnification (4 mm objective) phase contrast illumination.
- o) Based on "high volume" sampling.
- p) "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. E. and Gross, P., Pulmonary Deposition and Retention of Inhaled Aerosols, p. 149. Academic Press, New York, New York, 1954.
- (2) Interim Guide for Respirable Mass Sampling, AHA Aerosol Technology Committee, AHA J. 31: 2, 1970, p. 133.

NOTICE OF INTENDED CHANGES (for 1977)

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. If, after two years no evidence comes to light that questions the appropriateness of the values herein, the values will be reconsidered for the "Adopted" list. Documentation is available for each of these substances.

Substance	ppm ^{a)}	mg/m ^{3b)}
Aliphatic solvent "140 Flash"	25	150
+ Aluminum metal and oxide.....	—	10
+ Aluminum pyro powders	—	5
+ Aluminum welding fumes	—	5
+ Aluminum, soluble salts.....	—	2
+ Aluminum alkyls (NOC)*.....	—	2
+ 3-Amino 1, 2, 4-triazole.....	A2	—
+ Antimony, soluble salts (as Sb)	—	2
Antimony trioxide, handling & use (as Sb).....	—	0.5
Antimony trioxide production (as Sb).....	—	0.05, A2
Arsenic trioxide production (as As).....	—	0.05, A1a
Atrazine	—	10
+ Benomyl	—	10
+ Bromacil	—	10
Butyl acrylate	10	55
C Cadmium oxide production (as Cd).....	—	0.05, A2
Calcium hydroxide.....	—	5
Calcium oxide.....	—	2
Carbonyl fluoride	5	15
Chloroform.....	10, A2	50
+ Chloromethyl methyl ether....	A1b	A1b
Chromite ore processing (chromite), as Cr	—	0.05, A1a
+ Cobalt metal, dust & fume (as Co)	—	0.05
+ Cyclopentane.....	300	850
Dichloromonofluoromethane..	500	2,100
Dimethyl carbamyl chloride...	A2	A2
+ Ethyl silicate.....	10	85
+C Glutaraldehyde.....	0.2	0.8
+ Hexachlorocyclopentadiene.....	A2	A2

Capital letters refer to Appendices.
+1977 Revision or Addition.
*Not otherwise classified.

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Substance	ppm ^(a)	mg/m ³ ^(b)
Hexamethyl phosphoramide — Skin	A2	A2
+ Lead chromate (as Cr)	—	0.05, A2
+ Manganese fume (as Mn)	—	1
Manganese tetroxide	—	1
4, 4'-Methylene dianiline	—	A2
N, Methyl-2-pyrrolidone	100	400
Nickel sulfide roasting (as Ni)	—	1, A1a
Paraquat, respirable sizes	—	0.1
+ Phenyl-beta-naphthylamine ...	A2	A2
Phenyl mercaptan	0.5	2
Phosgene	0.1	0.4
m-Phthalodinitrile	—	5
C Propylene glycol dinitrate-Skin	0.2	2
Thioglycolic acid	1	5
C 1, 2, 4-Trichlorobenzene	5	40
Trimethyl phosphite	0.5	2.6
C 2, 4, 6-Trinitrotoluene (TNT) .	—	0.5
Valeraldehyde	50	175
+ Vinyl bromide	5	22
Vinyl chloride	Pending, A1c	—
+ VM & P Naphtha	300	1,350

NOTICE OF INTENDED CHANGES
MINERAL DUSTS

Substance	TLV
Silica, amorphous	5 mg/m ³ Total dust (all sampled sizes) 2 mg/m ³ Respirable dust (< 5 μm)
Diatomaceous earth, natural	1.5 mg/m ³ , Respirable dust

Capital letters refer to Appendices.
+1977 Addition.

APPENDIX A
CARCINOGENS

The Committee lists below those substances in industrial use that have proven carcinogenic in man, or have induced cancer in animals under appropriate experimental conditions. Present listing of those substances carcinogenic for man takes three forms: Those for which a TLV has been assigned (1a), those for which environmental conditions have not been sufficiently defined to assign a TLV (1b), and (1c), those whose reassignment of a TLV is awaiting more definitive data, and hence should be treated as a 1b carcinogen.

A1a. *Human Carcinogens.* Substances, or substances associated with industrial processes, recognized to have carcinogenic or cocarcinogenic potential, with an assigned TLV:

	TLV
Arsenic trioxide production	As ₂ O ₃ , 0.05 mg/m ³ as As
	SO ₂ , C 5.0 ppm
	Sb ₂ O ₃ , 0.5 mg/m ³ (as Sb)
Asbestos, all forms*	5 fibers/cc, > 5 μm in length
bis (Chloromethyl) ether	0.001 ppm
Chromite ore processing (chromate),	0.05 mg/m ³ (as Cr)
Nickel sulfide roasting, fume & dust	1.0 mg/m ³ (as Ni)
Particulate Polycyclic Aromatic Hydrocarbons (PPAH)	0.2 mg/m ³ , as benzene solubles

1b. *Human Carcinogens.* Substances, or substances associated with industrial processes, recognized to

*Cigarette smoking can enhance the incidence of bronchogenic carcinoma from this and others of these substances or processes.

have carcinogenic potential without an assigned TLV:

4-Aminodiphenyl (p-Xenylamine)
Benzidine production
beta-Naphthylamine
4-Nitrodiphenyl

- 1c. *Human Carcinogens*. Substances with recognized carcinogenic potential awaiting reassignment of TLV pending further data acquisition:

Vinyl chloride

For the substances in 1b, no exposure or contact by any route — respiratory, skin or oral, as detected by the most sensitive methods — shall be permitted.

"No exposure or contact" means hermitizing the process or operation by the best practicable engineering methods. The worker should be properly equipped to insure virtually no contact with the carcinogen.

- A2. *Industrial Substances Suspect of Carcinogenic Potential for MAN*. Chemical substances or substances associated with industrial processes, which are suspect of inducing cancer, based on either (1) limited epidemiologic evidence, exclusive of clinical reports of single cases, or (2) demonstration of carcinogenesis in one or more animal species by appropriate methods.

Antimony trioxide production*	0.05 mg/m ³
Benzene — Skin	10 ppm
Benz(a)pyrene	—
Beryllium	2.0 µg/m ³
Cadmium oxide production	0.05 mg/m ³
Chloroform	10 ppm
Chromates of lead and zinc (as Cr)	0.05 mg/m ³
3, 3'-Dichlorobenzidine	—
Dimethylcarbamyl chloride	—

*Cigarette smoking can enhance the incidence of respiratory cancers from this or others of these substances or processes.

1, 1-Dimethyl hydrazine	0.5 ppm
Dimethyl sulfate	1 ppm
Epichlorohydrin	5 ppm
Hexamethyl phosphoramide — Skin	—
Hydrazine	0.1 ppm
4, 4'-Methylene bis (2-chloroaniline) — Skin	0.02 ppm
4, 4'-Methylene dianiline	—
Monomethyl hydrazine	0.2 ppm
Nitrosamines	—
Propane sulfone	—
beta-Propiolactone	—
Vinyl cyclohexene dioxide	10 ppm

For the above, worker exposure by all routes should be carefully controlled to levels consistent with the animal and human experience data (see Documentation), including those substances with a listed TLV.

- A3. *Guidelines for the Classification of Experimental ANIMAL Carcinogens*. The following guidelines are offered in the present state of knowledge as an aid in classifying substances in the occupational environment found to be carcinogenic in experimental animals. A need was felt by the Threshold Limits Committee for such a classification in order to take the first step in developing an appropriate TLV for occupational exposure.

Determination of Approximate Threshold of Response Requirement. In order to determine in which category to classify an experimental carcinogen for the purpose of assigning an industrial air limit (TLV), an approximate threshold of neoplastic response must be determined. Because of practical experimental difficulties, a precisely defined threshold cannot be attained. For the purposes of standard-setting, this is of little moment, as an appropriate risk, or safety, factor can be applied to the approximate threshold, the magnitude of which

is dependent on the degree of potency of the carcinogenic response.

To obtain the best 'practical' threshold of neoplastic response, dosage decrements should be less than logarithmic. This becomes particularly important at levels greater than 10 ppm (or corresponding mg/m³). Accordingly, after a range-finding determination has been made by logarithmic decreases, two additional dosage levels are required within the levels of "effect" and "no effect" to approximate the true threshold of neoplastic response.

The second step should attempt to establish a metabolic relationship between animal and man for the particular substance found carcinogenic in animals. If the metabolic pathways are found comparable, the substance should be classed highly suspect as a carcinogen for man. If no such relation is found, the substance should remain listed as an experimental animal carcinogen until evidence to the contrary is found.

Proposed Classification of Experimental Animal Carcinogens. Substances occurring in the occupational environment found carcinogenic for animals may be grouped into three classes, those of high, intermediate and low potency. In evaluating the incidence of animal cancers, significant incidence of cancer is defined as a neoplastic response which represents, in the judgment of the Committee, a significant excess of cancers above that occurring in negative controls.

EXCEPTIONS: No substance is to be considered an occupational carcinogen of any practical significance which reacts by the respiratory route at or above 1000 mg/m³ for the mouse, 2000 mg/m³ for the rat; by the dermal route, at or above 1500 mg/kg for the mouse, 3000 mg/kg for the rat; by the gastrointestinal route at or above 500 mg/kg/d for a lifetime, equivalent to about 100 g T.D. for the rat, 10g T.D. for the mouse.

These dosage limitations exclude such substances as dioxane and trichloroethylene from consideration as carcinogens.

Examples: Dioxane — rats, hepatocellular and nasal tumors from 1015 mg/kg/d, oral

Trichloroethylene — female mice, tumors (30/98 @ 900 mg/kg/d), oral

A3a. INDUSTRIAL SUBSTANCES OF HIGH CARCINOGENIC POTENCY IN EXPERIMENTAL ANIMALS

1. A substance to qualify as a carcinogen of high potency must fulfill one of the three following conditions in two animal species:

1a. *Respiratory.* Elicit cancer from (1) dosages below 1 mg/m³ (or equivalent ppm) via the respiratory tract in 6-7-hour daily repeated inhalation exposures throughout lifetime; or (2) from a single intratracheally administered dose not exceeding 1 mg of particulate, or liquid, per 100 ml or less of animal minute respiratory volume;

Examples: bis-Chloromethyl ether, malignant tumors, rats, @ 0.47 mg/m³ (0.1 ppm) in 2 years;

Hexamethyl phosphoramide, nasal squamous cell carcinoma, rats, @ 0.05 ppm, in 13 months

OR

1b. *Dermal.* Elicit cancer within 20 weeks by skin-painting, twice weekly at 2 mg/kg body weight or less per application for a total dose equal to or less than 1.5 mg, in a biologically inert vehicle;

Examples: 7, 12-Dimethylbenz(a)anthracene — skin tumors @ 0.12-0.8 mg T.D. in four weeks

Benz(a)pyrene, mice 12 μ g,
3X/wk for 18 mos. T.D. 2.6
mg, 90.9% skin tumors

OR

- 1c. *Gastrointestinal*. Elicit cancer by daily intake via the gastrointestinal tract, within six months, with a six-month holding period, at a dosage below 1 mg/kg body weight per day; total dose, rat, $\leq$ 50 mg; mouse, $\leq$ 3.5 mg;

Examples: 7, 12-Dimethylbenz(a)anthracene — mammary tumors from 10 mg 1X

3-Methylcholanthrene —
Tumors @ 3 sites from 8 mg
in 89 weeks

Benz(a)pyrene, mice, 3.9%
leukemias, from 30 mg T.D.
198 days

2. Elicit cancer by all three routes in at least two animal species at dose levels prescribed for high or intermediate potency.

A3b. *INDUSTRIAL SUBSTANCES OF INTERMEDIATE CARCINOGENIC POTENCY IN EXPERIMENTAL ANIMALS*

To qualify as a carcinogen of intermediate potency, a substance should elicit cancer in two animal species at dosages intermediate between those described in A3a and A3c by two routes of administration.

Example: Carbamic acid Ethyl Ester

Dermal, mammary tumors, mice,
100%, 63 weeks, 500–1400 mg T.D.
Gastrointestinal, various type tumors,
mice 42 weeks, 320 mg T.D.

Gastrointestinal, various type tumors,
rats, 60 weeks, 110–930 mg T.D.

A3c. *INDUSTRIAL SUBSTANCES OF LOW CARCINOGENIC POTENCY IN EXPERIMENTAL ANIMALS*

To qualify as a carcinogen of low potency, a substance should elicit cancer in one animal species by any one of three routes of administration at the following prescribed dosages and conditions:

- 1a. *Respiratory*. Elicit cancer from (1) dosages greater than 10 mg/m³ (or equivalent ppm) via the respiratory tract in 6–7-hour, daily repeated inhalation exposures, for 12 months' exposure and 12 months' observation period; or (2) from intratracheally administered dosages totaling more than 10 mg of particulate or liquid per 100 ml or more of animal minute respiratory volume;

Examples: Beryl (beryllium aluminum silicate)
malig. lung tumors, rats, @ 15
mg/m³ @ 17 months

Benzidine, var. tumors, rats,
10–20 mg/m³ @ > 13 mos.

OR

- 1b. *Dermal*. Elicit cancer by skin-painting of mice in twice weekly dosages of > 10 mg/kg body weight in a biologically inert vehicle for at least 75 weeks, i.e., $\geq$ 1.5g T.D.

Examples: Shale tar, mouse, 0.1 ml $\times$ 50 –
g T.D. 59/60 skin tumors

Arsenic trioxide, man, dose un-
known, but estimated to be high

- 1c. *Gastrointestinal*. Elicit cancer from daily oral dosages of 50 mg/kg/day or greater during the lifetime of the animal.

APPENDIX B

SUBSTANCES OF VARIABLE COMPOSITION

- B1 *Polytetrafluoroethylene* decomposition products*.
Thermal decomposition of the fluorocarbon chain in

*Trade Names: Algoron, Fluon, Halon, Teflon, Tefran.

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.

- B2 *Gasoline*: The composition of gasoline 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); Runion, *ibid.* 36, 338, 1975).

- B3 *Welding Fumes — Total Particulate (NOC)**
TLV. 5 mg/m³

Welding fumes cannot be classified simply. The composition and quantity of both are dependent on the alloy being welded and the process and electrodes used. Reliable analysis of fumes cannot be made without considering the nature of the welding process and system being examined; reactive metals and alloys such as aluminum and titanium are arc-welded in a protective, inert atmosphere such as argon. These arcs create relatively little fume, but an intense radiation which can produce ozone. Similar processes are used to arc-weld steels, also creating a relatively low level of fumes. Ferrous alloys also are arc-welded in oxidizing environments which generate considerable fume, and can produce carbon monoxide instead of ozone. Such fumes generally are composed of discreet particles of amorphous slags containing iron, manganese, silicon and other metallic constituents depending on the alloy system involved. Chromium and nickel compounds are found in fumes when stainless steels are arc-welded. Some coated and flux-cored electrodes are formulated with fluorides and the

*Not otherwise classified.

fumes associated with them can contain significantly more fluorides than oxides. Because of the above factors, arc-welding fumes frequently must be tested for individual constituents which are likely to be present to determine whether specific TLV's are exceeded. Conclusions based on total fume concentration are generally adequate if no toxic elements are present in welding rod, metal, or metal coating and conditions are not conducive to the formation of toxic gases.

Most welding, even with primitive ventilation, does not produce exposures inside the welding helmet above 5 mg/m³. That which does, should be controlled.

APPENDIX C MIXTURES

C.1 THRESHOLD LIMIT VALUES FOR MIXTURES

When two or more hazardous substances are present, their combined effect, rather than that of either individually, should be given primary consideration. In the absence of information to the contrary, the effects of the different hazards should be considered as additive. That is, if the sum of the following fractions,

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

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

Exceptions to the above rule may be made when there is a 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 $\left(\frac{C_1}{T_1} + \text{or} + \frac{C_2}{T_2} \text{ etc.}\right)$ itself has a value exceeding unity (See Example 1A.c.).

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.

C.1A Examples of THRESHOLD LIMIT VALUES FOR MIXTURES

The following formulae apply only when the components in a mixture have similar toxicologic effects; they should not be used for mixtures with widely differing reactivities, e.g. hydrogen cyanide & sulfur dioxide. In such case the formula for Independent Effects (1A.c.) should be used.

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

a. *Additive effects.* (Note: It is essential that the atmosphere be analyzed both qualitatively and quantitatively for each component present, in order to evaluate compliance or noncompliance with this calculated TLV.)

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

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Example No. 1A.a.: Air contains 5 ppm of carbontetrachloride (TLV = 10 ppm) 20 ppm of 1, 2-dichloroethane (TLV = 50 ppm) and 10 ppm of 1, 2-dibromoethane (TLV = 20 ppm)

Atmospheric concentration of mixture = 5 + 20 + 10 = 35 ppm of mixture

$$\frac{5}{10} + \frac{20}{50} + \frac{10}{20} = \frac{25 + 20 + 25}{50} = 1.4$$

Threshold Limit is exceeded. Furthermore, the TLV of this mixture may be calculated by reducing the total fraction to 1.0; i.e.

$$\text{TLV of mixture} = \frac{35}{1.4} = 25 \text{ ppm}$$

1A.b. Special case when the source of contaminant is a liquid mixture and the atmospheric composition is assumed to be similar to that of the original material; e.g. on a time-weighted average exposure basis, all of the liquid (solvent) mixture eventually evaporates.

Additive effects (approximate solution)

1. The percent composition (by weight) of the liquid mixture is known, the TLVs of the constituents must be listed in mg/m³.

(Note: In order to evaluate compliance with this TLV, field sampling instruments should be calibrated, in the laboratory, for response to this specific quantitative and qualitative air-vapor mixture, and also to fractional concentrations of this mixture; e.g., 1/2 the TLV; 1/10 the TLV; 2 × the TLV; 10 × the TLV; etc.)

TLV of mixture =

$$\frac{1}{\frac{f_a}{\text{TLV}_a} + \frac{f_b}{\text{TLV}_b} + \frac{f_c}{\text{TLV}_c} + \dots + \frac{f_n}{\text{TLV}_n}}$$

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Example No. 1: Liquid contains (by weight)

50% heptane: TLV = 400 ppm or 1600 mg/m³

1 mg/m³ = 0.25 ppm

30% methylene chloride: TLV = 200 ppm or 720 mg/m³

1 mg/m³ = 0.28 ppm

20% perchloroethylene: TLV = 100 ppm or 670 mg/m³

1 mg/m³ = 0.15 ppm

$$\text{TLV of Mixture} = \frac{1}{\frac{0.5}{1600} + \frac{0.3}{720} + \frac{0.2}{670}}$$

$$= \frac{1}{0.00031 + 0.00042 + 0.00030}$$

$$= \frac{1}{0.00103} = 970 \text{ mg/m}^3$$

of this mixture

50% or (970) (0.5) = 485 mg/m³ is heptane

30% or (970) (0.3) = 291 mg/m³ is methylene chloride

20% or (970) (0.2) = 194 mg/m³ is perchloroethylene

These values can be converted to ppm as follows:

heptane: 485 mg/m³ × 0.25 = 121 ppm

methylene chloride: 291 mg/m³ × 0.28 = 81 ppm

perchloroethylene: 194 mg/m³ × 0.15 = 29 ppm

TLV of mixture = 121 + 81 + 29 = 231 ppm, or 970 mg/m³

1A.c. Independent effects.

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

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

Threshold limit is not exceeded.

1B. TLV for Mixtures of Mineral Dusts.

For mixtures of biologically active mineral dusts the general formula for mixtures may be used.

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

$$\text{TLV} = \frac{1}{\frac{0.8}{20} + \frac{0.2}{2.7}} = 9 \text{ mppcf}$$

TLV of nonasbestiform talc (pure) = 20 mppcf

TLV of quartz (pure) =

$$\frac{300}{100 + 10} = \frac{300}{110} = 2.7 \text{ mppcf}$$

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:

25% quartz — TLV (pure) = 2.7 mppcf

25% amorphous silica — TLV (pure) = mppcf

50% talc TLV (pure) = 20 mppcf

$$\text{TLV} = \frac{1}{\frac{0.25}{2.7} + \frac{0.25}{20} + \frac{0.5}{20}} = 8 \text{ mppcf}$$

The limit for 25% quartz approximates 9 mppcf.

APPENDIX D PERMISSIBLE EXCURSIONS FOR TIME-WEIGHTED AVERAGE (TWA) LIMITS

The Excursion TLV Factor in the Table automatically defines the magnitude of the permissible excursion above the limit for those substances not given a "C" designation; i.e., the TWA limits. Examples in the Table show that nitrobenzene, the TLV for which is 1 ppm, should never be allowed to exceed 3 ppm. Similarly, carbon tetrachloride, TLV = 10 ppm, should never be allowed to exceed 20 ppm. By contrast, those substances with a "C" designation are not subject to the excursion factor and must be kept at or below the TLV ceiling.

These limiting excursions are to be considered to provide a "rule-of-thumb" guidance for listed substances generally, and may not provide the most appropriate excursion for a particular substance e.g., the permissible excursion for CO is 400 ppm for 15 minutes.

For appropriate excursions for 142 substances consult Pa. Rules & Regs., Chap. 4, Art. 432, and "Acceptable Concentrations," ANSI.

Substance	TLV	Excursion Factor	Max. Conc. Permitted for short time
Nitrobenzene	1	3	3
Carbon tetrachloride	10	2	20
Trimethyl benzene	25	1.5	40
Acetone	1000	1.25	1250
Boron trifluoride	C 1	—	1
Butylamine	C 5	—	5

EXCURSION FACTORS

For all substances not bearing C notation

TLV	(ppm or mg/m ³)	Excursion Factor	
TLV > 0-1			= 3
TLV > 1-10			= 2
TLV > 10-100			= 1.5
TLV > 100-1000			= 1.25

The number of times the excursion above the TLV is permitted is governed by conformity with the Time-Weighted Average TLV.

INTERPRETATION OF MEASURED PEAK CONCENTRATIONS

With increasing use of rapid, direct-reading analytical instruments for airborne contaminants in the work area,

the question of interpretation of essentially "instantaneous" peaks arises. Although no general statement can be made covering all occupational substances, the following guidelines should prove helpful, assuming peak excursions conform to time-weighted average TLV as stated above.

The toxicologic importance of momentary peak concentrations depends on whether the substance is fast or slow acting. If slow acting, as for quartz, lead, or carbon monoxide, momentary peaks are of no toxicologic concern provided, of course, they are not astronomical. On the other hand, fast-acting substances that rapidly produce disabling narcosis, e.g., H₂S, or intolerable irritation or asphyxiation, NH₃, SO₂, CO₂, or initiate sensitization — the organic isocyanates, even "instantaneous" peaks appreciably above the permissible excursion, should not be permitted, unless information exists to the contrary. Other more specific excursions will be developed in the future.

APPENDIX E

Some Nuisance Particulates^a
TLV, 30 mppcf or 10mg/m³

Alundum (Al ₂ O ₃)	Kaolin
Calcium carbonate	Limestone
Calcium silicate	Magnesite
Cellulose (paper fiber)	Marble
Portland Cement	Mineral Wool Fiber
Corundum (Al ₂ O ₃)	Pentaerythritol
Emery	Plaster of Paris
Glass, fibrous ^a or dust	Rouge
Glycerin Mist	Silicon
Graphite (synthetic)	Silicon Carbide
Gypsum	Starch
Vegetable oil mists	Sucrose
(except castor, cashew	Tin Oxide
nut, or similar irritant	Titanium Dioxide
oils)	Zinc Stearate
	Zinc oxide dust

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

r) <7 μ m in diameter

APPENDIX F Some Simple Asphyxiants**

Acetylene	Hydrogen
Argon	Methane
Butane	Neon
Ethane	Propane
Ethylene	Propylene
Helium	

s) As defined on pg. 6.

APPENDIX G

Calculations for Conversion of Particle Count Concentration (by Standard Light Field — Midget Impinger Techniques), in mppcf, to Respirable Mass Concentration (by Respirable Sampler) in mg/m³.†

1. In 1967, Jacobsen and Tomb,† derived an empirical relationship of 5.6 mppcf to 1 milligram of respirable dust per cubic meter of air, based on 23 sets of samples, mostly coal dust. The following calculation results in an equivalence of 6.37 mppcf to 1 mg/m³ of respirable dust. Thus, an approximate ratio of 6 mppcf to 1 mg/m³ of respirable dust is suggested for conversion of TLVs from a count to a mass basis when the density and mass median diameter have not been determined.

††Relationship Between Gravimetric Respirable Dust Concentration and Midget Impinger Number Concentration.†† by Murray Jacobson and T. F. Tomb, AIHAJ, 28: Nov.—Dec. 1967.

2. Basic assumptions:

- a) Average density for silica containing dusts $\approx$ 2.5 gms/cm³ (2500 mg/cm³). Pulmonary significant dust densities may vary from 1.2 gm/cm³ for coal dust to 3.1 gms/cm³ for Portland Cement. Silica densities vary from 2.2 (amorphous) to 2.3 (cristobalite and tridymite) to 2.5 (alpha-quartz.) gms per cm³.
- b) The mass median diameter (mmd) of particles collected in midget impinger samplers and counted by the standard light field technique, and collected in a respirable sampler is approximately 1.5 μ m or 1.5×10^{-4} cm. This assumption is, of course, quite arbitrary since the mmd of all dust clouds is quite variable, depending on many independent parameters, such as source of dust, age of dust cloud, meteorological conditions, etc.

3. Calculation:

- a) vol. per particle: $4/3 \pi r^3$; $r = 0.75 \times 10^{-4}$ cm
 $= 4/3 \cdot \pi \cdot (0.75 \times 10^{-4})^3$
 $= 1.77 \times 10^{-12}$ cm³
- b) wt. per particle = vol. $\times$ density
 $= 1.77 \times 10^{-12}$ cm³ $\times$ 2.5 $\times 10^3$ mg/cm³
 $= 4.425 \times 10^{-9}$ mg/particle
- c) 1 particle/ft.³ = 35.5 part./m³
(since 35.5 cu ft = 1 cu m.)
 10^6 part./ft.³ = mppcf = 35.5×10^6 part./m³
wt. of 1 mppcf = 35.5×10^6 part./m³ $\times$
 4.425×10^{-9} mg/particle.
1 mppcf = 0.157 mg/m³
or
6.37 mppcf = 1 mg/m³
or approximately 6 mppcf = 1 mg/m³.

4. Equivalent TLVs in mppcf and mg/m³ (respirable mass) for Mineral Dusts.