JOHN E. FOX

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

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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.

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

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

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/m^3, 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, pO_2 of 135 mm Hg). Atmospheres deficient in O_2 do not provide adequate warning and most simple asphyxiants are odorless. Several simple asphyxiants 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, humidity, abnormal pressure (altitude) and the like may place added stress on the body so that the effects from exposure at a threshold limit may be altered. Most of these stresses act adversely to increase the toxic response of a substance. Although most threshold limits have built-in safety factors to guard against adverse effects to moderate deviations from normal environments, the safety factors of most substances are not of such a magnitude as to take care of gross deviations. For example, continuous work at temperatures above 90°F, or 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 TWA ppm[a]	ADOPTED VALUES TWA mg/m³[b]	TENTATIVE VALUES STEL ppm[a]	TENTATIVE VALUES STEL mg/m³[b]
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_2O_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 TWA ppm[a]	TWA mg/m³[b]	TENTATIVE VALUES STEL ppm[a]	STEL mg/m³[b]
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
Baygon (propoxur)	—	0.5	—	1.5
Barium (soluble compounds)	—	0.5	—	—
Benzene — Skin	10, A2	30, A2	—	—
Benzidine production — Skin	—	A1b	—	A1b
p-Benzoquinone, 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, Anhydrous	—	1	—	—
Decahydrate	—	5	—	—
Pentahydrate	—	1	—	—
Boron oxide	—	10	—	20
Boron tribromide	1	10	3	30
C Boron trifluoride	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 TWA ppm[a]	TWA mg/m³[b]	TENTATIVE VALUES STEL ppm[a]	STEL mg/m³[b]
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 Dust	—	1	—	3
Vapor	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

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Substance	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	TENTATIVE VALUES STEL ppm[a]	STEL mg/m³[b]
Carbon monoxide	50	55	400	440
Carbon tetrabromide	0.1	1.4	0.3	4.2
Carbon tetrachloride — Skin	10	65	25	160
* Catechol (Pyrocatechol)	5	20	—	—
Cellulose (paper fiber)	—	E	—	20
Cesium hydroxide	—	2	—	—
Chlordane — 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 malonoitrile — 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 (Epichlorhydrin)	5	20	10	40
2-Chloroethanol (Ethylene chlorohydrin)	1	3	—	—
Chloroethylene (Vinyl chloride)	A1c	—	A1c	—

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*1977 Addition.

Substance	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	TENTATIVE VALUES STEL ppm[a]	STEL mg/m³[b]
** 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
Chromates, 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_2O_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
Crufomate®	—	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 TWA ppm[a]	ADOPTED VALUES TWA mg/m³[b]	TENTATIVE VALUES STEL ppm[a]	TENTATIVE VALUES STEL mg/m³[b]
* Cyanamide	—	2	—	—
Cyanide, as CN — Skin	—	5	—	—
Cyanogen	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 Dichloracetylene	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

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*1977 Addition.

Substance	ADOPTED VALUES TWA ppm[a]	ADOPTED VALUES TWA mg/m³[b]	TENTATIVE VALUES STEL ppm[a]	TENTATIVE VALUES STEL mg/m³[b]
1, 3-Dichloro-5, 5-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
** Dichloromonofluoro-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	—	—

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Substance	ADOPTED VALUES TWA ppm[a]	ADOPTED VALUES TWA mg/m³[b]	TENTATIVE VALUES STEL ppm[a]	TENTATIVE VALUES STEL mg/m³[b]
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, 6-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	—	0.6
3, 5-Dinitro-o-toluamide (Zoalene®)	—	5	—	10
Dinitrotoluene — Skin	—	1.5	—	5
Dioxane, tech. grade — Skin	50	180	—	—
* Dioxathion (Delnav®)	—	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 TWA ppm[a]	ADOPTED VALUES TWA mg/m³[b]	TENTATIVE VALUES STEL ppm[a]	TENTATIVE VALUES STEL mg/m³[b]
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-Ditert. butyl-p-cresol	—	10	—	20
* Diuron	—	10	—	—
Dyfonate	—	0.1	—	—
Emery	—	E	—	20
Endosulfan (Thiodan®) — Skin	—	0.1	—	0.3
Endrin — Skin	—	0.1	—	0.3
Epichlorhydrin — 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 TWA ppm[a]	TWA mg/m³[b]	TENTATIVE VALUES STEL ppm[a]	STEL mg/m³[b]
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[d]	—	—	—
Ethylene glycol monomethyl ether acetate (Methyl cellosolve acetate) — Skin	25	120	40	180
Ethylene oxide	50	90	75	135
Ethylenimine — Skin	0.5	1	—	—
Ethylidene chloride, see 1, 1-Dichloroethane	200	320	250	400
C Ethylidene 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 TWA ppm[a]	TWA mg/m³[b]	TENTATIVE VALUES STEL ppm[a]	STEL mg/m³[b]
Ferrovanadium 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	—	B2	—	B2
Germanium tetrahydride	0.2	0.6	0.6	1.8
Glass, fibrous[e] 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
Hexachlorocyclopentadiene	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.

Substance	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	TENTATIVE VALUES STEL ppm[a]	STEL mg/m³[b]
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 (as In)	—	0.1	—	0.3
C Iodine	0.1	1	—	—
Iodoform	0.2	3	0.4	0.6
Iron oxide fume	B3	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	0.06	—	—
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 TWA ppm[a]	TWA mg/m³[b]	TENTATIVE VALUES STEL ppm[a]	STEL mg/m³[b]
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
Magnesite	—	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.

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Substance	ADOPTED VALUES TWA ppm[a]	ADOPTED VALUES TWA mg/m³[b]	TENTATIVE VALUES STEL ppm[a]	TENTATIVE VALUES STEL mg/m³[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 see 2-Methoxyethanol	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-Methycyclohexanone — 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 TWA ppm[a]	ADOPTED VALUES TWA mg/m³[b]	TENTATIVE VALUES STEL ppm[a]	TENTATIVE VALUES STEL mg/m³[b]
* Methylene chloride (dichloromethane)	200	720	250	900
4, 4'-Methylene bis (2-chloraniline) — 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.

Substance	ADOPTED VALUES TWA ppm[a]	ADOPTED VALUES TWA mg/m³[b]	TENTATIVE VALUES STEL ppm[a]	TENTATIVE VALUES STEL mg/m³[b]
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[d] — 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[h]	—	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 TWA ppm[a]	ADOPTED VALUES TWA mg/m³[b]	TENTATIVE VALUES STEL ppm[a]	TENTATIVE VALUES STEL mg/m³[b]
** 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)	[g]B3	—	B3	—
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 TWA ppm[a]	TWA mg/m³[b]	TENTATIVE VALUES STEL ppm[a]	STEL mg/m³[b]
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	—	B1	—	B1
C 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 TWA ppm[a]	TWA mg/m³[b]	TENTATIVE VALUES STEL ppm[a]	STEL mg/m³[b]
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 TWA ppm[a]	TWA mg/m³[b]	TENTATIVE VALUES STEL ppm[a]	STEL mg/m³[b]
C Subtilisins (Proteolytic enzymes as 100% pure crystalline enzyme)	—	0.00006[o]	—	—
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®	0.01	0.1	0.03	0.3
2, 4, 5-T	—	10	—	20
Tantalum	—	5	—	10
TEDP — Skin	—	0.2	—	0.6
Teflon® decomposition products	—	B1	—	B1
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[h]	—	0.3

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

Substance	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	TENTATIVE VALUES STEL ppm[a]	STEL mg/m³[b]
Tetrahydrofuran	200	590	250	700
Tetramethyl lead (as Pb) — Skin	—	0.150[h]	—	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®	—	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 TWA ppm[a]	ADOPTED VALUES TWA mg/m³[b]	TENTATIVE VALUES STEL ppm[a]	TENTATIVE VALUES STEL mg/m³[b]
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
Trifluoromonobromomethane	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-Trinitrophenylmethylnitramine, see Tetryl	—	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	840
Uranium (natural) soluble & insoluble compounds, as U	—	0.2	—	0.6
Vanadium (V_2O_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 TWA ppm[a]	ADOPTED VALUES TWA mg/m³[b]	TENTATIVE VALUES STEL ppm[a]	TENTATIVE VALUES STEL mg/m³[b]
Warfarin	—	0.1	—	0.3
* Welding fumes (Total particulate)	—	5, B3	—	B3
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, SiO_2	
Crystalline	
Quartz	TLV in mppcf[i]: $\frac{300^{j}}{\%\ \text{quartz} + 10}$ TLV for respirable dust in mg/m³: $\frac{10\ \text{mg/m}^{3k)}}{\%\ \text{Respirable quartz} + 2}$ TLV for "total dust," respirable and nonrespirable: $\frac{30\ \text{mg/m}^3}{\%\ \text{quartz} + 3}$
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[i]

****See Notice of Intended Changes.**

SILICATES (< 1% quartz)	
Asbestos, all forms†	5 fibers/cc > 5μm in length[n]; A1a
Graphite (natural)	15 mppcf
Mica	20 mppcf
Mineral wool fiber	10 mg/m³
Perlite	30 mppcf
Portland Cement	30 mppcf
Soapstone	20 mppcf
Talc (nonasbestiform)	20 mppcf
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/m³[j]
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.

i) Millions of particles per cubic foot of air, based on impinger samples counted by light-field technics.
j) 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.
k) 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.
l), 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, 1964.

(2) Interim Guide for Respirable Mass Sampling, AIHA Aerosol Technology Committee, AHIA 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/m³[b]
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 (chromate), 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
† Hexachlorobutadiene	A2	A2

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

Substance	ppm[a]	mg/m³[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/m³ Total dust (all sampled sizes) 2 mg/m³ Respirable dust (< 5 μm)
Diatomaceous earth, natural	1.5 mg/m³, 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_2O_3, 0.05 mg/m³ as As SO_2, C 5.0 ppm Sb_2O_3, 0.5 mg/m³ (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/m³ (as Cr)
Nickel sulfide roasting, fume & dust	1.0 mg/m³(as Ni)
Particulate Polycyclic Aromatic Hydrocarbons (PPAH)	0.2 mg/m³, 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/m³
Benzene — Skin	10 ppm
Benz(a)pyrene	——
Beryllium	2.0 μg/m³
Cadmium oxide production	0.05 mg/m³
Chloroform	10 ppm
Chromates of lead and zinc (as Cr)	0.05 mg/m³
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
Epichlorhydrin	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 sultone	——
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 trichlorethylene 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 μg, 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, ≤ 50 mg; mouse, ≤ 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., ≥ 1.5g T.D.

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

Arsenic trioxide, man, dose unknown, 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: Algoflon, Fluon, Halon, Teflon, Tetran.

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/m*^{3}

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 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/m^3. That which does, should be controlled.

*Not otherwise classified.

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,

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

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

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

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. Furthurmore, 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/m^3.

(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.)

$$\text{TLV of mixture} = \frac{1}{\frac{f_a}{TLV_a} + \frac{f_b}{TLV_b} + \frac{f_c}{TLV_c} + \ldots \frac{f_n}{TLV_n}}$$

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).

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

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

		Excursion Factor
TLV>0–1	(ppm or mg/m³),	= 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 astronomic. On the other hand, fast-acting substances that rapidly produce disabling narcosis, e.g., H_2S, or intolerable irritation or asphyxiation, NH_3, SO_2, CO_2, 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_2O_3)
Calcium carbonate
Calcium silicate
Cellulose (paper fiber)
Portland Cement
Corundum (Al_2O_3)
Emery
Glass, fibrous[b] or dust
Glycerin Mist
Graphite (synthetic)
Gypsum
Vegetable oil mists
(except castor, cashew nut, or similar irritant oils)
Kaolin
Limestone
Magnesite
Marble
Mineral Wool Fiber
Pentaerythritol
Plaster of Paris
Rouge
Silicon
Silicon Carbide
Starch
Sucrose
Tin Oxide
Titanium Dioxide
Zinc Stearate
Zinc oxide dust

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

r) <7μm in diameter

APPENDIX F
Some Simple Asphyxiants[s]

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/m^3.†

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/m^3 of respirable dust. Thus, an approximate ratio of 6 mppcf to 1 mg/m^3 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/cm^3 (2500 mg/cm^3). Pulmonary significant dust densities may vary from 1.2 gm/cm^3 for coal dust to 3.1 gms/cm^3 for Portland Cement. Silica densities vary from 2.2 (amorphous) to 2.3 (cristobalite and tridymite) to 2.5 (alpha-quartz.) gms per cm^3.

   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 μm or 1.5 $\times$ 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
   $= 4/3 \cdot \pi \cdot (0.75 \times 10^{-4})^3$
   $= 1.77 \times 10^{-12}$ cm^3

   b) wt. per particle = vol. $\times$ density
   $= 1.77 \times 10^{-12}$ cm$^3 \times 2.5 \times 10^3$ mg/cm^3
   $= 4.425 \times 10^{-9}$ mg/particle

   c) 1 particle/ft.^{3} = 35.5 part./m^3
   (since 35.5 cu ft = 1 cu m.)
   10^6 part./ft^3 = mppcf = 35.5×10^6 part./m^3

   wt. of 1 mppcf $\equiv$ 35.5×10^6 part./m$^3 \times$ 4.425×10^{-9} mg/part.

   1 mppcf $\equiv$ 0.157 mg/m^3
   or
   6.37 mppcf $\equiv$ 1 mg/m^3
   or approximately 6 mpccf $\equiv$ 1 mg/m^3.

4. Equivalent TLVs in mppcf and mg/m^3 (respirable mass) for Mineral Dusts.

Substance	Threshold Limit Value		
	Count mppcf	Resp. Mass mg/m³	Total Mass* mg/m³
Silica (SiO_2)			
Amorphous	20	(3)**	(6)
Cristobalite	1.5	0.05	0.15
Fused silica	3	0.1	0.3
Quartz	3	0.1	0.3
Tridymite	1.5	0.05	0.15
Coal Dust	(12)	2	(4)
Diatomaceous earth, natural	—	1.5	—
Graphite	15	(2.5)	(5)
Mica	20	(3)	(6)
Mineral wool fiber	—	(5)	10
Nuisance particulates	30	(5)	10
Perlite	30	(5)	(10)
Portland Cement	30	(5)	(10)
Soapstone	20	(3)	(6)
Talc (nonasbestiform)	20	(3)	(6)
Tripoli	(3)	0.1	(0.3)

*Unless otherwise specified, respirable mass is presumed to equal approximately 50% of total mass.

**All values in parentheses ( ) represent newly calculated values based on equivalence of 6 mppcf ≡ 1 mg/m³ respirable mass and respirable mass ≡ 50% total mass.

TLVs®
Threshold Limit Values for Physical Agents Adopted by ACGIH for 1977

1977 TLV PHYSICAL AGENTS COMMITTEE

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PREFACE

PHYSICAL AGENTS

These threshold limit values refer to levels of physical agents 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 variations in individual susceptibility, exposure of an occasional individual at, or even below, the threshold limit may not prevent annoyance, aggravation of a pre-existing condition, or physiological damage.

These 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.

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) in the evaluation or control of the levels of physical agents in the community, (2) as proof or disproof of an existing physical disability, or (3) for adoption by countries whose working conditions differ from those in the United States of America.

These values are reviewed annually by the Committee on Threshold Limits for Physical Agents 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 physical agents to be added to the list. The suggestions should be accompanied by substantiating evidence.

As Legislative Code — The Conference recognizes that the Threshold Limit Values may be adopted in legislative codes and regulations. If so used, the intent of the concepts contained in the Preface should be maintained and provisions should be made to keep the list current.

THRESHOLD LIMIT VALUES

HEAT STRESS

These Threshold Limit Values refer to heat stress conditions under which it is believed that nearly all workers may be repeatedly exposed without adverse health effects. The TLVs shown in Table 1 are based on the assumption that nearly all acclimatized, fully clothed workers with adequate water and salt intake should be able to function effectively under the given working conditions without exceeding a deep body temperature of 38°C (WHO technical report series #412, 1969 *Health Factors Involved in Working Under Conditions of Heat Stress*; F. N. Dukes-Dobos and A. Henschel: *"Development of Permissible Heat Exposure Limits for Occupational Work."* ASHRAE Journal, Vol. 15: No. 9, September 1973, pp. 57–62.)

Since measurement of deep body temperature is impractical for monitoring the workers' heat load, the measurement of environmental factors is required which most nearly correlate with deep body temperature and other physiological responses to heat. At the present time Wet Bulb-Globe Temperature Index (WBGT) is the simplest and most suitable technique to measure the environmental factors. WBGT values are calculated by the following equations:

1. Outdoors with solar load:
   WBGT = 0.7WB + 0.2GT + 0.1 DB
2. Indoors or Outdoors with no solar load:
   WBGT = 0.7WB + 0.3GT

where:

WBGT = Wet Bulb-Globe Temperature Index
WB = Natural Wet-Bulb Temperature
DB = Dry-Bulb Temperature
GT = Globe Thermometer Temperature

The determination of WBGT requires the use of a black globe thermometer, a natural (static) wet-bulb thermometer, and a dry-bulb thermometer.

TABLE 1

Permissible Heat Exposure Threshold Limit Values
(Values are given in °C. WBGT)

	Work Load		
Work — Rest Regimen	Light	Moderate	Heavy
Continuous work	30.0	26.7	25.0
75% Work — 25% Rest, Each hour	30.6	28.0	25.9
50% Work — 50% Rest, Each hour	31.4	29.4	27.9
25% Work — 75% Rest, Each hour	32.2	31.1	30.0

Higher heat exposures than shown in Table 1 are permissible if the workers have been undergoing medical surveillance and it has been established that they are more tolerant to work in heat than the average worker. Workers should not be permitted to continue their work when their deep body temperature exceeds 38.0°C.

APPENDIX G

HEAT STRESS

I. *Measurement of the Environment*

The instruments required are a dry-bulb, a natural wet-bulb, a globe thermometer, and a stand. The measurement of the environmental factors shall be performed as follows:

A. The range of the dry and the natural wet bulb thermometer shall be −5°C to 50°C with an accuracy of ±0.5°C. The dry bulb thermometer must be shielded

from the sun and the other radiant surfaces of the environment without restricting the airflow around the bulb. The wick of the natural wet-bulb thermometer shall be kept wet with distilled water for at least 1/2 hour before the temperature reading is made. It is not enough to immerse the other end of the wick into a reservoir of distilled water and wait until the whole wick becomes wet by capillarity. The wick shall be wetted by direct application of water from a syringe 1/2 hour before each reading. The wick shall extend over the bulb of the thermometer, covering the stem about one additional bulb length. The wick should always be clean and new wicks should be washed before using.

B. A globe thermometer, consisting of a 15 cm. (6-inch) diameter hollow copper sphere, painted on the outside with a matte black finish or equivalent shall be used. The bulb or sensor of a thermometer (range −5°C to 100°C with an accuracy of ±0.5°C) must be fixed in the center of the sphere. The globe thermometer shall be exposed at least 25 minutes before it is read.

C. A stand shall be used to suspend the three thermometers so that they do not restrict free air flow around the bulbs, and the wet-bulb and globe thermometers are not shaded.

D. It is permissible to use any other type of temperature sensor that gives identical reading to a mercury thermometer under the same conditions.

E. The thermometers must be so placed that the readings are representative of the condition where the men work or rest, respectively.

The methodology outlined above is more fully explained in the following publications:

1. "Prevention of Heat Casualties in Marine Corps Recruits, 1955–1960, with Comparative Incidence Rates and Climatic Heat Stresses in other Training Categories," by Captain David Minard, MC, USN, Research Report No. 4, Contract No. MR005.01–0001.01, Naval Medical Research Institute, Bethesda, Maryland, 21 February 1961.

2. "Heat Casualties in the Navy and Marine Corps, 1959–1962, with Appendices on the Field Use of the Wet Bulb-Globe Temperature Index," by Captain David Minard, MC, USN, and R. L. O'Brien, HMC, USN. Research Report No. 7, Contract No. MR 005.01–0001.01, Naval Medical Research Institute, Bethesda, Maryland, 12 March 1964.

3. Minard, D.: Prevention of Heat Casualties in Marine Corps Recruits. Military Medicine *126(4)*: 261–272, 1961.

II. *Work Load Categories*

Heat produced by the body and the environmental heat together determine the total heat load. Therefore, if work is to be performed under hot environmental conditions, the workload category of each job shall be established and the heat exposure limit pertinent to the work load evaluated against the applicable standard in order to protect the worker from exposure beyond the permissible limit.

A. The work load category may be established by ranking each job into light, medium, and heavy categories on the basis of type of operation. Where the work load is ranked into one of said three categories, i.e.

(1) light work (up to 200 Kcal/hr or 800 Btu/hr): e.g., sitting or standing to control machines, performing light hand or arm work,

(2) moderate work (200–350 Kcal/hr or 800–1400 Btu/hr): e.g., walking about with moderate lifting and pushing,

(3) heavy work (350–500 Kcal/hr or 1400–2000 Btu/hr): e.g., pick and shovel work,

the permissible heat exposure limit for that work load shall be determined from Table 1.

B. The ranking of the job may be performed either by measuring the worker's metabolic rate while performing his job or by estimating his metabolic rate by the use of the scheme shown in Table 2. Tables available in the literature listed below and in other publications as well may also be utilized. When this method is used the permissible heat exposure limit can be determined by Figure 1.

1. Per-Olaf Astrand and Kaare Rodahl: "Textbook of Work Physiology" McGraw-Hill Book Company, New York, San Francisco, 1970.

2. "Ergonomies Guide to Assessment of Metabolic and Cardiac Costs of Physical Work." Amer. Ind. Hyg. Assoc. J. *32:* 560, 1971.

3. Energy Requirements for Physical Work. Purdue Farm Cardiac Project. Agricultural Experiment Station. Research Progress Report No. 30, 1961.

4. J. V. G. A. Durnin and R. Passmore: "Energy, Work and Leisure." Heinemann Educational Books, Ltd., London, 1967.

TABLE 2

Assessment of Work Load

Average values of metabolic rate during different activities.

A. Body position and movement	Kcal./min.
Sitting	0.3
Standing	0.6
Walking	2.0–3.0
Walking up hill	add 0.8 per meter (yard) rise

B. Type of Work		Average Kcal./min.	Range Kcal./min.
Hand work			
	light	0.4	0.2–1.2
	heavy	0.9	
Work with one arm			
	light	1.0	0.7–2.5
	heavy	1.8	
Work with both arms			
	light	1.5	1.0–3.5
	heavy	2.5	
Work with body			
	light	3.5	2.5–15.0
	moderate	5.0	
	heavy	7.0	
	very heavy	9.0	

Light hand work: writing, hand knitting

Heavy hand work: typewriting

Heavy work with one arm: hammering in nails (shoemaker, upholsterer)

Light work with two arms: filing metal, planing wood, raking of a garden

Moderate work with the body: cleaning a floor, beating a carpet

Heavy work with the body: railroad track laying, digging, barking trees

Sample Calculation: Using a heavy hand tool on an assembly line

A. Walking along	2.0 Kcal./min.
B. Intermediate value between heavy work with two arms and light work with the body	3.0 Kcal./min.
	5.0 Kcal./min.
C. Add for basal metabolism	1.0 Kcal./min.
Total	6.0 Kcal./min.

Adapted from Lehmann, G. E., A. Muller and H. Spitzer: Der Kalorienbedarf bei gewerblicher Arbeit. Arbeitsphysiol. *14:* 166, 1950.

III. *Work-Rest Regimen*

The permissible exposure limits specified in Table 1 and Figure 1 are based on the assumption that the WBGT value of the resting place is the same or very close to that of the work place. Where the WBGT of the work area is different from that of the rest area a time-weighted average value should be used for both environmental and metabolic heat. When time-weighted average values are used the appropriate curve on Figure 1 is the solid line labeled "continuous."

The time-weighted average metabolic rate (M) shall be determined by the equation:

$$\text{Av. } M = \frac{(M_1) \times (t_1) + (M_2) \times (t_2) + \ldots + (M_n) \times (t_n)}{(t_1) + (t_2) + \ldots + (t_n)}$$

Where M_1 M_2, M_n are estimated or measured metabolic rates for the various activities of the worker during the total time period. t_1, t_2, t_n are the elapsed times in minutes spent at the corresponding metabolic rate as determined by a time study.

The time-weighted average WBGT shall be determined by the equation:

$$\text{Av. WBGT} = \frac{(\text{WBGT}_1) \times (t_1) + (\text{WBGT}_2) \times t_2 + \ldots + (\text{WBGT}_n) \times (t_n)}{(t_1) + (t_2) + \ldots + (t_n)}$$

where WBGT_1, WBGT_2, WBGT_n are calculated values of WBGT for the various work and rest areas occupied during total time periods. t_1, t_2, t_n are the elapsed times in minutes spent in the corresponding areas which are determined by a time study. Where exposure to hot environmental conditions is continuous for several hours or the entire work day, the time-weighted averages shall be calculated as hourly time-weighted average i.e., $t_1 + t_2 + \ldots t_n = 60$ minutes. Where the exposure is intermittent, the time-weighted averages shall be calculated as two-hour time-weighted averages, i.e., $t_1 + t_2 + \ldots t_n = 120$ minutes.

The permissible exposure limits for continuous work are applicable where there is a work-rest regimen of a 5-day work week and an 8-hour work day with a short morning and afternoon break (approximately 15 minutes) and a longer lunch break (approximately 30 minutes). Higher exposure limits are permitted if additional resting time is allowed. All breaks, including unscheduled pauses and administrative or operational waiting periods during work may be counted as rest time when additional rest allowance must be given because of high environmental temperatures.

It is a common experience that when the work on a job is self-paced, the workers will spontaneously limit their hourly work load to 30–50% of their maximum physical performance capacity. They do this either by setting an appropriate work speed or by interspersing unscheduled breaks. Thus the daily average of the workers' metabolic rate seldom exceeds 330 kcal/hr. However, within an 8-hour work shift there may be

periods where the workers' hourly average metabolic rate will be higher.

IV. *Water and Salt Supplementation*

During the hot season or when the worker is exposed to artificially generated heat, drinking water shall be made available to the workers in such a way that they are stimulated to frequently drink small amounts, i.e., one cup every 15–20 minutes (about 150 ml or 1/4 pint).

The water shall be kept reasonably cool (10°–15°C or 50.0°–60.0°F) and shall be placed close to the workplace so that the worker can reach it without abandoning the work area.

The workers should be encouraged to salt their food abundantly during the hot season and particularly during hot spells. If the workers are unacclimatized, salted drinking water shall be made available in a concentration of 0.1% (1g NaCl to 1.0 liter or 1 level tablespoon of salt to 15 quarts of water). The added salt shall be completely dissolved before the water is distributed, and the water shall be kept reasonably cool.

V. *Other Considerations*

A. Clothing: The permissible heat exposure TLVs are valid for light summer clothing as customarily worn by workers when working under hot environmental conditions. If special cothing is required for performing a particular job and this clothing is heavier or it impedes sweat evaporation or has higher insulation value, the worker's heat tolerance is reduced, and the permissible heat exposure limits indicated in Table 1 and Figure 1 are not applicable. For each job category where special clothing is required, the permissible heat exposure limit shall be established by an expert.

B Acclimatization and Fitness: The recommended heat stress TLVs are valid for acclimated workers who are physically fit.

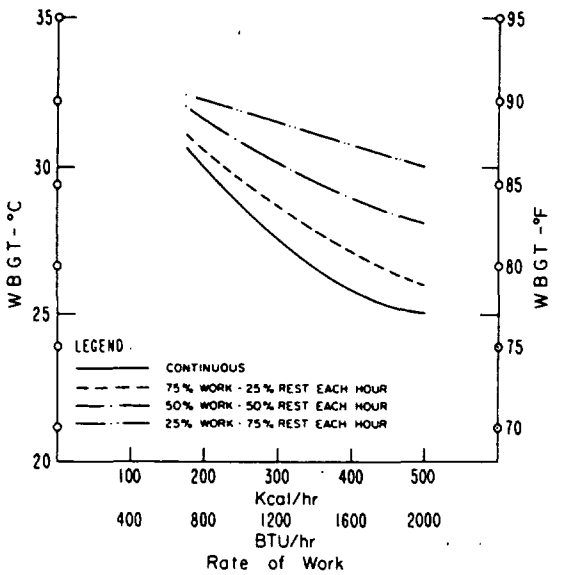

Figure 1 — Permissible Heat Exposure Threshold Limit Value

IONIZING RADIATION

See U.S. Department of Commerce National Bureau of Standards, Handbook 59, "Permissible Dose from External Sources of Ionizing Radition," 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 4867, Washington, D.C. 20008.

LASERS

The threshold limit values are for exposure to laser radiation under conditions to which nearly all workers may be exposed without adverse effects. The values

should be used as guides in the control of exposures and should not be regarded as fine lines between safe and dangerous levels. They are based on the best available information from experimental studies.

Limiting Apertures

The TLVs expressed as radiant exposure or irradiance in this section may be averaged over an aperture of 1 mm except for TLVs for the eye in the spectral range of 400–1400 nm, which should be averaged over a 7 mm limiting aperture (pupil); and except for all TLVs for wavelengths between 0.1–1 mm where the limiting aperture is 10 mm. No modification of the TLVs is permitted for pupil sizes less than 7 mm.

The TLVs for "extended sources" apply to sources which subtend an angle greater than α (Table 5) which varies with exposure time. This angle is *not* the beam divergence of the source.

Correction Factors A and B (C_A and C_B) for Eye Exposure

All TLVs in Tables 3 and 4 are to be used as given for wavelengths 400 nm to 700 nm. At all wavelengths greater than 1.06 μm and less than 1.4 μm the TLVs are to be increased by a factor of 5. TLV at wavelengths between 700 nm and 1.06 μm are to be increased by a uniformly extrapolated factor as shown in Figure 2. For certain exposure durations at wavelengths between 700–800 nm, correction factor C_B is applied.

Repetitively Pulsed Lasers

Since there are few experimental data for multiple pulses, caution must be used in the evaluation of such exposures. The protection standards for irradiance or radiant exposure in multiple pulse trains have the following limitations:

(1) The exposure from any single pulse in the train is limited to the protection standard for a single comparable pulse.

(2) The average irradiance for a group of pulses is limited to the protection standard as given in Tables 3, 4, or 6 of a single pulse of the same duration as the entire pulse group.

(3) When the Instantaneous Pulse Repetition Frequency (PRF) of any pulses within a train exceeds one, the protection standard applicable to each pulse is reduced as shown in Figure 6 for pulse durations less than 10^{-5} second. For pulses of greater duration, the following formula should be followed:

$$\text{Standard}\left(\begin{matrix}\text{single pulse}\\ \text{in train}\end{matrix}\right) = \frac{\text{Standard (pulse } n\tau)}{n}$$

where:

n = number of pulses in train
τ = duration of a single pulse in the train
Standard $(n\tau)$ = protection standard of one pulse having a duration equal to $n\tau$ seconds.

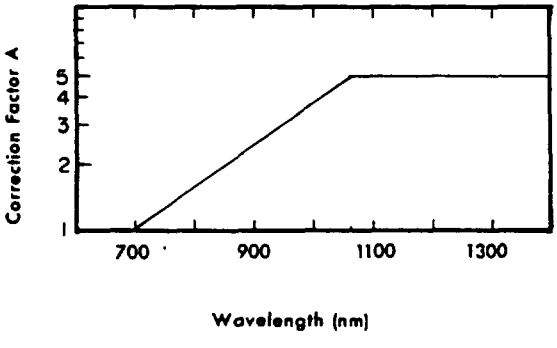

Figure 2 — TLV correction factors for laser wavelengths (eye).

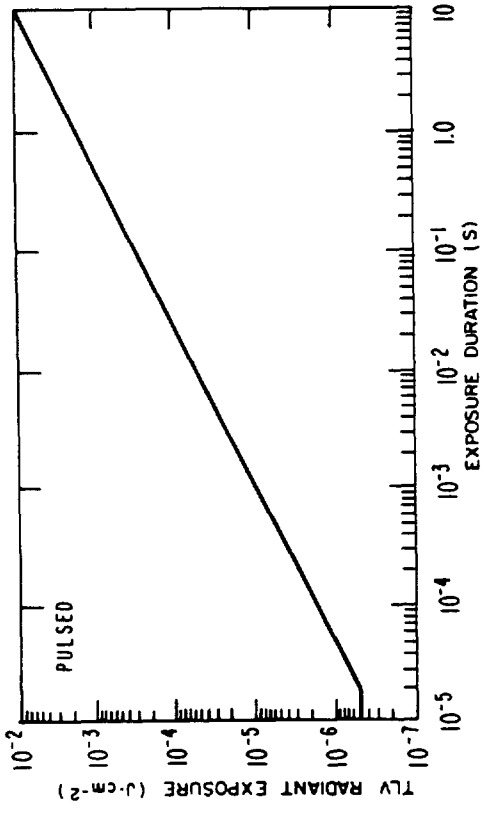

Figure 3a — TLV for intrabeam (direct) viewing of laser beam (400–700 nm).

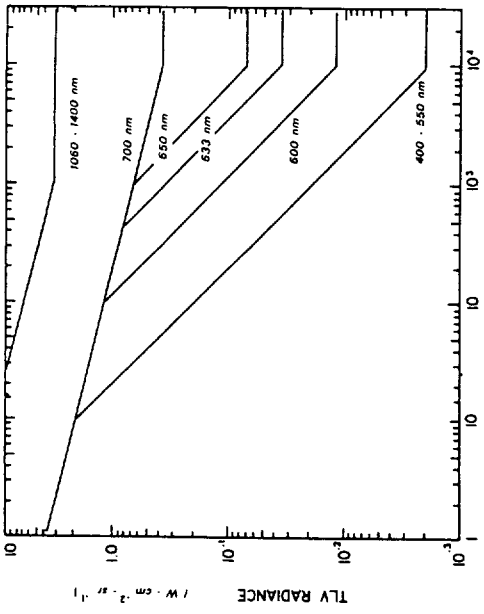

Figure 3b — TLV for intrabeam (direct) viewing of CW laser beam (400–1400 nm).

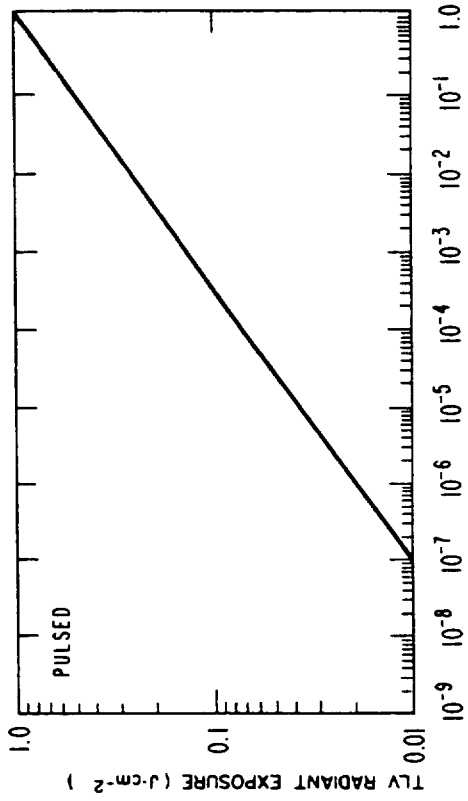

Figure 4a — TLV for laser exposure of skin and eyes for far-infrared radiation (wavelengths greater than 1.4 μm).

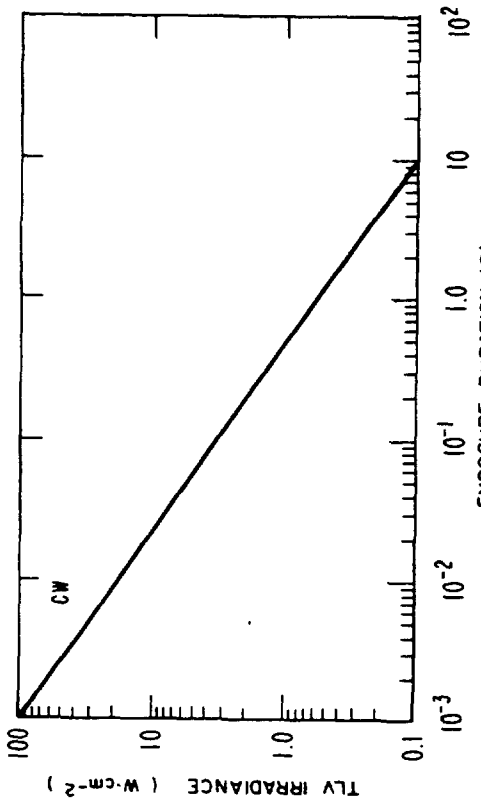

Figure 4b — TLV for CW laser exposure of skin and eyes for far-infrared radiation (wavelengths greater than 1.4 μm).

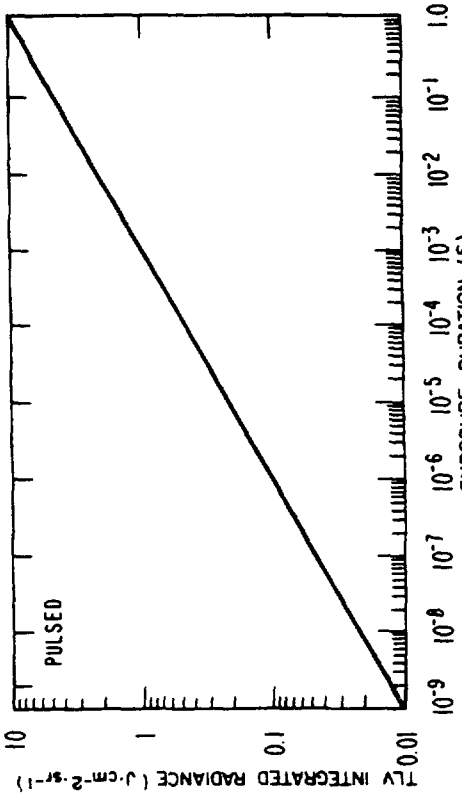

Figure 5a — TLV for extended sources or diffuse reflections of laser radiation (400–700 nm).

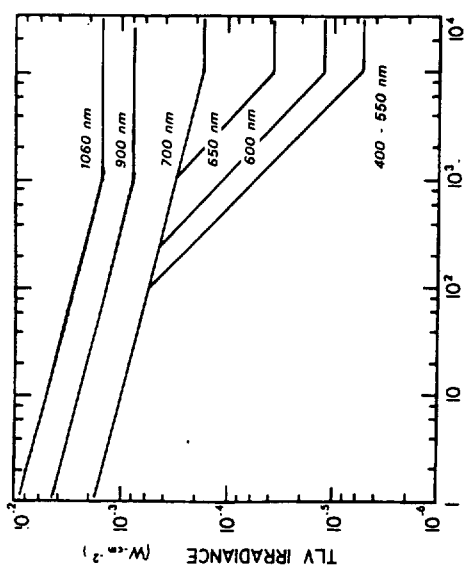

Figure 5b — TLV for extended sources or diffuse reflections of laser radiation (400–1400 nm), CW.

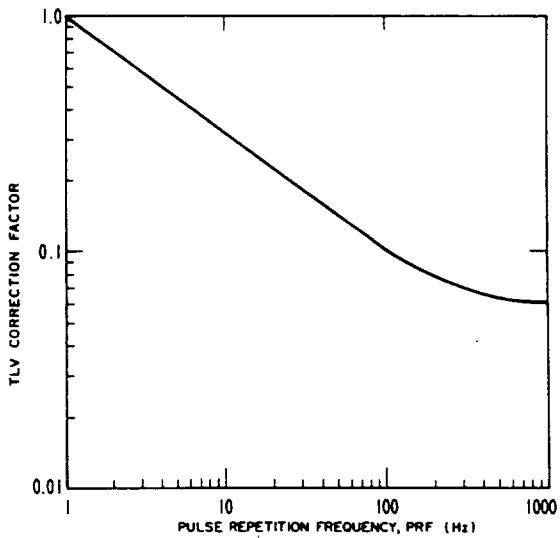

Figure 6 — Multiplicative correction factor for repetitively pulsed lasers having pulse durations less than 10^{-5} second. TLV for a single pulse of the pulse train is multiplied by the above correction factor. Correction factor for PRF greater than 1000 H_z is 0.06.

TABLE 3

Threshold Limit Value for Direct Ocular Exposures
(Intrabeam Viewing) from a Laser Beam

Spectral Region	Wave Length	Exposure Time, (t) Seconds	TLV
UVC	200 nm to 280 nm	10^{-3} to 3×10^{4}	3 mJ • cm^{-2}
UVB	280 nm to 302 nm	"	3 "
	303 nm	"	4 "
	304 nm	"	6 "
	305 nm	"	10 "
	306 nm	"	16 "
	307 nm	"	25 "
	308 nm	"	40 "
	309 nm	"	63 "
	310 nm	"	100 "
	311 nm	"	160 "
	312 nm	"	250 "
	313 nm	"	400 "
	314 nm	"	630 "
	315 nm	"	1.0 J • cm^{-2}

TABLE 3 (Cont.)

UVA	315 nm to 400 nm	10 to 10^{3}	1.0 J • cm^{-2}
	" "	10^{3} to 3×10^{4}	1.0 mW • cm^{-2}
Light	400 nm to 700 nm	10^{-9} to 1.8×10^{-5}	5×10^{-7}J • cm^{-2}
	400 nm to 700 nm	1.8×10^{-5} to 10	1.8 (t/ $\sqrt[4]{t}$) mJ • cm^{-2}
	400 nm to 549 nm	10 to 10^{4}	10 mJ • cm^{-2}
	550 nm to 700 nm	10 to T_1	1.8 (t/ $\sqrt[4]{t}$) mJ • cm^{-2}
	550 nm to 700 nm	T_1 to 10^{4}	10 C_B mJ • cm^{-2}
	400 nm to 700 nm	10^{4} to 3×10^{4}	C_B μW • cm^{-2}
IR-A	700 nm to 1059 nm	10^{-9} to 1.8×10^{-5}	5 $C_A \times 10^{-7}$ J • cm^{-2}
	700 nm to 1059 nm	1.8×10^{-5} to 10^{3}	1.8 C_A (t/ $\sqrt[4]{t}$) mJ • cm^{-2}
	1060 nm to 1400 nm	10^{-9} to 10^{-4}	5×10^{-6} J • cm^{-2}
	1060 nm to 1400 nm	10^{-4} to 10^{3}	9(t/ $\sqrt[4]{t}$) mJ • cm^{-2}
	700 nm to 1400 nm	10^{3} to 3×10^{4}	320 C_A μW • cm^{-2}
IR-B & C	1.4 μm to 10^{3} μm	10^{-9} to 10^{-7}	10^{-2} J • cm^{2}
	" "	10^{-7} to 10	0.56 $\sqrt[4]{t}$ J • cm^{-2}
	" "	10 to 3×10^{4}	0.1 W • cm^{-2}

C_A – See Fig. 2, Laser TLV listing.
$C_B = 1$ for λ = 400 to 550 nm; $C_B = 10^{[0.015\ (\lambda - 550)]}$ for λ = 550 to 700 nm.
$T_1 = 10$ s for λ = 400 to 550 nm; $T_1 = 10 \times 10^{[0.02\ (\lambda - 550)]}$ for λ = 550 to 700 n.

TABLE 4

Threshold Limit Values for Viewing a Diffuse Reflection
of a Laser Beam or an Extended Source Laser

Spectral Region	Wave Length	Exposure Time, (t) Seconds	TLV
UV	200 nm to 400 nm	10^{-3} to 3×10^{4}	Same as Table 3
Light	400 nm to 700 nm	10^{-9} to 10	$10\ \sqrt[4]{t}$ J • cm^{-2} • sr^{-1}
	400 nm to 549 nm	10 to 10^{4}	21 J • cm^{-2} • sr^{-1}
	550 nm to 700 nm	10 to T_1	$3.83\ (t/\sqrt[4]{t})$ J • cm^{-2} • sr^{-1}
	550 nm to 700 nm	T_1 to 10^{4}	$21/C_B$ J cm^{-2} • sr^{-1}
	400 nm to 700 nm	10^{4} to 3×10^{4}	$2.1/C_B \times 10^{-3}$ W • cm^{-2} • sr^{-1}
IR-A	700 nm to 1400 nm	10^{-9} to 10	$10\ C_A\ \sqrt[4]{t}$ J • cm^{-2} • sr^{-1}
	700 nm to 1400 nm	10 to 10^{3}	$3.83\ C_A\ (t/\sqrt[4]{t})$ J • cm^{-2} • sr^{-1}
	700 nm to 1400 nm	10^{3} to 3×10^{4}	0.64 C_A W • cm^{-2} • sr^{-1}
IR-B & C	1.4 μm to 1 mm	10^{-9} to 3×10^{4}	Same as Table 3

C_A, C_B, and T_1 are the same as in footnote to Table 3.

TABLE 5

Limiting Angle to Extended Source
Which May Be Used for Applying Extended Source TLVs

Exposure Duration(s)	Angle α (mrad)
10^{-9}	8.0
10^{-8}	5.4
10^{-7}	3.7
10^{-6}	2.5
10^{-5}	1.7
10^{-4}	2.2
10^{-3}	3.6
10^{-2}	5.7
10^{-1}	9.2
1.0	15
10	24
10^{2}	24
10^{3}	24
10^{4}	24

TABLE 6

Threshold Limit Value for Skin Exposure from a Laser Beam

Spectral Region	Wave Length	Exposure Time, (t) Seconds	TLV
UV	200 nm to 400 nm	10^{-3} to 3 × 10^{4}	Same as Table 3
Light & IR-A	400 nm to 1400 nm	10^{-9} to 10^{-7}	2 $C_A \times 10^{-2}$ J • cm^{-2}
	"	10^{-7} to 10	1.1 $C_A \sqrt{t}$ J • cm^{-2}
IR-B & C	1.4 μm to 1 mm	10^{-9} to 3 × 10^{4}	Same as Table 3

C_A = 1.0 for λ = 400–700 nm; see Figure 2 Laser TLV list for greater wavelength values.

NOTE: To aid in the determination of TLV's for exposure durations requiring calculations of fractional powers Figures 3, 4, 5 and 6 may be used.

MICROWAVES*

These Threshold Limit Values refer to microwave energy in the frequency range of 100 MHz to 100 GHz and represent conditions under which it is believed that nearly all workers may be repeatedly exposed without adverse effect.

These values should be used as guides in the control of exposure of microwaves and should not be regarded as a fine line between safe and dangerous levels.

Recommended Values

The Threshold Limit Value for occupational microwave energy exposure where power densities are known and exposure time controlled is as follows:

1. For average power density levels up to but not exceeding 10 milliwatts per square centimeter, total exposure time shall be limited to the 8-hour workday (continuous exposure).
2. For average power density levels from 10 milliwatts per square centimeter up to but not exceeding 25 milliwatts per square centimeter, total exposure time shall be limited to no more than 10 minutes for any 60 minute period during an 8-hour workday (intermittent exposure).
3. For average power density levels in excess of 25 milliwatts per square centimeter, exposure is not permissible.

NOTE: For repetitively pulsed sources the average power density may be calculated by multiplying the peak power density by the duty cycle. The duty cycle is equal to the pulse duration in seconds times the pulse repetition rate in hertz.

*See Notice of Intended Changes, Page 89; Notice of Intent to Study, page 94.

NOISE

These threshold limit values refer to sound pressure levels and durations of exposure that represent conditions under which it is believed that nearly all workers may be repeatedly exposed without adverse effect on

their ability to hear and understand normal speech. The medical profession has defined hearing impairment as an average hearing threshold level in excess of 25 decibels (ANSI-S3.6-1969) at 500, 1000, and 2000 Hz, and the limits which are given have been established to prevent a hearing loss in excess of this level. The values should be used as guides in the control of noise exposure and, due to individual susceptibility, should not be regarded as fine lines between safe and dangerous levels.

Continuous or Intermittent

The sound level shall be determined by a sound level meter, conforming as a minimum to the requirements of the American National Standard Specification for Sound Level Meters, S1.4 (1971) Type S2A, and set to use the A-weighted network with slow meter response. Duration of exposure shall not exceed that shown in Table 7.

These values apply to total duration of exposure per working day regardless of whether this is one continuous exposure or a number of short-term exposures but does not apply to impact or impulsive type of noise.

When the daily noise exposure is composed of two or more periods of noise exposure of different levels, their combined effect should be considered, rather than the individual effect of each. If the sum of the following fractions:

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

exceeds unity, then, the mixed exposure should be considered to exceed the threshold limit value, C_1 indicates the total duration of exposure at a specific noise level, and T_1 indicates the total duration of exposure permitted at that level. All on-the-job noise exposures of 80 dBA or greater shall be used in the above calculations.

Table 7
Threshold Limit Values

Duration per day Hours	Sound Level dBA[a)]
16	80
8	85
4	90
2	95
1	100
1/2	105
1/4	110
1/8	115*

*No exposure to continuous or intermittent in excess of 115 dBA

a) Sound level in decibels as measured on a sound level meter, conforming as a minimum to the requirements of the American National Standard Specification for Sound Level Meters, S1.4 (1971) Type S2A, and set to use the A-weighted network with slow meter response.

IMPULSIVE OR IMPACT NOISE

It is recommended that exposure to impulsive or impact noise shall not exceed the limits listed in Table 8 or taken from Figure 7. No exposures in excess of 140 decibels peak sound pressure level are permitted. Impulsive or impact noise is considered to be those variations in noise levels that involve maxima at intervals of greater than one per second. Where the intervals are less than one second, it should be considered continuous.

Table 8
Threshold Limit Values
Impulsive or Impact Noise

Sound Level dB*	Permitted Number of Impulses or Impacts per day
140	100
130	1000
120	10,000

*It should be recognized that the application of the TLV for noise will not protect all workers from the adverse effects of noise exposure. A hearing conservation program with audiometric testing is necessary when workers are exposed to noise at or above the TLV levels.
**Decibels peak sound pressure level.

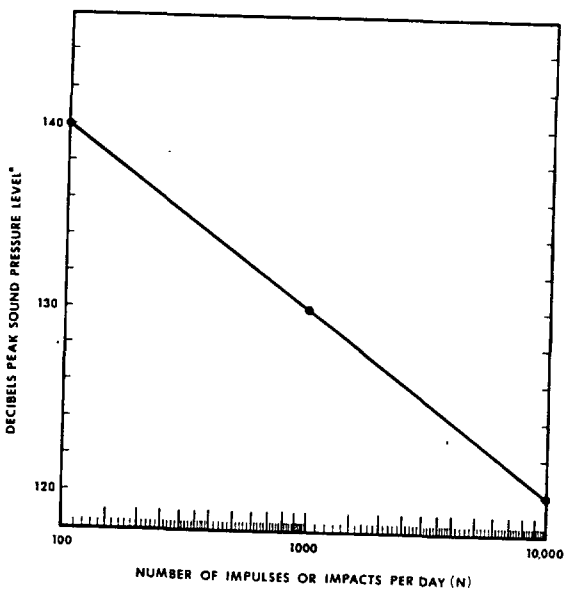

Figure 7 —

ULTRAVIOLET RADIATION*

These threshold limit values refer to ultraviolet radiation in the spectral region between 200 and 400 nm and represent conditions under which it is believed that nearly all workers may be repeatedly exposed without adverse effect. These values for exposure of the eye or the skin apply to ultraviolet radiation from arcs, gas, and vapor discharges, fluorescent, and incandescent sources, and solar radiation, but do not apply to ultraviolet lasers.* These levels should not be used for determining exposure of photosensitive individuals to ultraviolet radiation. These values should be used as guides in the control of exposure to continuous sources where the exposure duration shall not be less than 0.1 sec.

These values should be used as guides in the control of exposure to ultraviolet sources and should not be regarded as a fine line between safe and dangerous levels.

Recommended Values:

The threshold limit value for occupational exposure to ultraviolet radiation incident upon skin or eye where irradiance values are known and exposure time is controlled are as follows:

1. For the near ultraviolet spectral region (320 to 400 nm) total irradiance incident upon the unprotected skin or eye should not exceed 1 mw/cm^2 for periods greater than 10^3 seconds (approximately 16 minutes) and for exposure times less than 10^3 seconds should not exceed one J/cm^2.
2. For the actinic ultraviolet spectral region (200 — 315 nm), radiant exposure incident upon the unprotected skin or eye should not exceed the values given in Table 9 within an 8-hour period.
3. To determine the effective irradiance of a broadband source weighted against the peak of the spectral effectiveness curve (270 nm), the following weighting formula should be used:

$$E_{eff} = \sum E_\lambda S_\lambda \Delta\lambda$$

*See Laser TLVs.

where:

E_{eff} = effective irradiance relative to a monochromatic source at 270 nm in W/cm² (J/s/cm²)

E_λ = spectral irradiance in W/cm²/nm

S_λ = relative spectral effectiveness (unitless)

$\Delta\lambda$ = band width in nanometers

4. Permissible exposure time in seconds for exposure to actinic ultraviolet radiation incident upon the unprotected skin or eye may be computed by dividing 0.003 J/cm² by E_{eff} in W/cm². The exposure time may also be determined using Table 10 which provides exposure times corresponding to effective irradiances in μW/cm².

TABLE 9

Relative Spectral Effectiveness by Wavelength

Wavelength (nm)	TLV (mJ/cm²)**	Relative Spectral Effectiveness S_λ
200	100	0.03
210	40	0.075
220	25	0.12
230	16	0.19
240	10	0.30
250	7.0	0.43
254	6.0	0.5
260	4.6	0.65
270	3.0	1.0
280	3.4	0.88
290	4.7	0.64
300	10	0.30
305	50	0.06
310	200	0.015
315	1000	0.003

**1 m J/cm² = 10^{-3} J/cm²

TABLE 10

Permissible Ultraviolet Exposures

Duration of Exposure Per Day	Effective Irradiance, E_{eff} (μW/cm²)***
8 hrs.	0.1
4 hrs.	0.2
2 hrs.	0.4
1 hr.	0.8
30 min.	1.7
15 min.	3.3
10 min.	5
5 min.	10
1 min.	50
30 sec.	100
10 sec.	300
1 sec.	3,000
0.5 sec.	6,000
0.1 sec.	30,000

All the preceding TLVs for ultraviolet energy apply to sources which subtend an angle less than 80°. Sources which subtend a greater angle need to be measured only over an angle of 80°.

***1 μW/cm² = 10^{-6} W/cm²

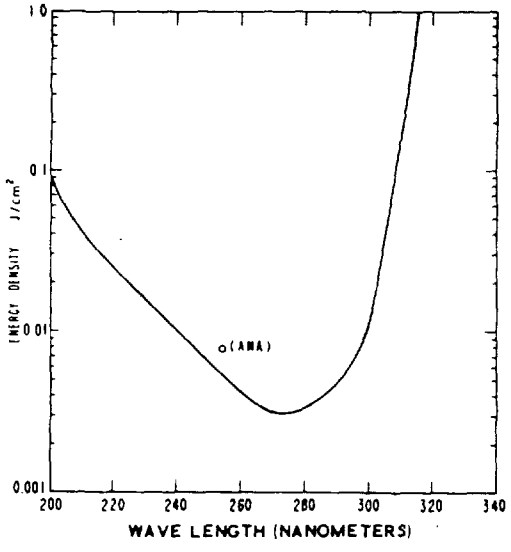

Figure 8 — Threshold Limit Values for Ultraviolet Radiation

Conditioned (tanned) individuals can tolerate skin exposure in excess of the TLV without erythemal effects. However, such conditioning may not protect persons against skin cancer.

NOTICE OF INTENDED CHANGES (for 1977)

These physical agents, 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 one year. If after one year no evidence comes to light that questions the appropriateness of the values herein the values will be reconsidered for the "Adopted" list.

MICROWAVES

These Threshold Limit Values refer to microwave energy in the frequency range of 300 MHz to 300 GHz and represent conditions under which it is believed that nearly all workers may be repeatedly exposed without adverse effect.

Under conditions of moderate to severe heat stress, the recommended values may need to be reduced.* Therefore, these values should be used as guides in the control of exposure to microwave energy and should not be regarded as a fine line between safe and dangerous levels.

Recommended Values:

The Threshold Limit Value for occupational exposure to microwave energy, where power density or field intensity is known and exposure time is controlled, is as follows:

1. For exposure to continuous wave (CW) sources, the power density level shall not exceed 10 milliwatts per square centimeter (mW/cm^2) for continuous exposure, and the total exposure time shall be limited to an 8-hour workday. This power density is approximately equivalent to a free-space electric field strength of 200 volts-per-meter rms (V/m) and a free-space magnetic field strength of 0.5 ampere-per-meter rms (A/m).
2. Exposures to CW power density levels greater than 10 mW/cm^2 are permissible up to a maximum of 25 mW/cm^2 based upon an average energy density of 1 milliwatt-hour per square centimeter (mWh/cm^2) averaged over any 0.1 hour period. For example, at 25 mW/cm^2, the permissible exposure duration is approximately 2.4 minutes in any 0.1 hour period.
3. For repetitively pulsed microwave sources, the average field strength or power density is calculated by multiplying the peak-pulse value by the duty cycle. The duty cycle is equal to the pulse duration in sec-

*Mumford, W.W., "Heat Stress Due to R. F. Radiation," Proceedings of IEEE, Vol. 57, No. 2, Feb. 1969, pp. 171–178.

onds times the pulse repetition rate in Hertz. Exposure during an 8-hour workday shall not exceed the following values which are averaged over any 0.1 hour period:

Power Density	10 mW/cm²
Energy Density	1 mWh/cm²
Mean Squared Electric Field Strength	40,000 V²/m²
Mean Squared Magnetic Field Strength	0.25 A²/m²

4. Exposure is not permissible in CW or repetitively pulsed fields with an average power density in excess of 25 mW/cm² or approximate equivalent free-space field strengths of 300 V/m or 0.75 A/m.

NOTICE OF INTENT TO ESTABLISH THRESHOLD LIMIT VALUES

LIGHT AND NEAR-INFRARED RADIATION

These Threshold Limit Values refer to visible and near-infrared radiation in the wavelength range of 400 nm to 1400 nm and represent conditions under which it is believed that nearly all workers may be exposed without adverse effect. These values should be used as guides in the control of exposure to light and should not be regarded as a fine line between safe and dangerous levels.

Recommended Values:

The Threshold Limit Value for occupational exposure to broad-band light and near-infrared radiation for the eye apply to exposure in any eight-hour workday and require knowledge of the spectral radiance (L_λ) and total irradiance (E) of the source as measured at the position(s) of the eye of the worker. Such detailed spectral data of a white light source is generally only required if the luminance of the source exceeds 1 cd cm^{-2}. At luminances less than this value the TLV would not be exceeded.

The TLV's are:

1. To protect against retinal thermal injury, the spectral radiance of the lamp weighted against the function R

(Table 11) should not exceed:

$$\sum_{400}^{1400} L_\lambda R_\lambda \Delta\lambda \leq \sqrt{t}/\alpha t \qquad (1)$$

where L_λ is in W cm^{-2} sr^{-1} and t is the viewing duration (or pulse duration if the lamp is pulsed) limited to 1 μs to 10 s, and α is the angular subtense of the source in radians. If the lamp is oblong, α refers to the longest dimension that can be viewed. For instance, at a viewing distance r = 100 cm from a tubular lamp of length l = 50 cm, the viewing angle is:

$$\alpha = l/r = 50/100 = 0.5 \text{ rad} \qquad (2)$$

2. To protect against retinal injury from chronic blue-light exposure the integrated spectral radiance of the lamp weighted against the blue-light hazard function B_λ (Table 11) should not exceed:

$$\sum_{400}^{1400} L_\lambda t B_\lambda \Delta\lambda \leq 100 \text{ Jcm}^{-2} \text{ sr}^{-1} \ (t \leq 10^4 \text{s}) \qquad (3a)$$

$$\sum_{400}^{1400} L_\lambda B_\lambda \Delta\lambda \leq 10^{-2} \text{ Wcm}^{-2} \text{ sr}^{-1} \ (t > 10^4 \text{s}) \qquad (3b)$$

For a source radiance L which exceeds 2 mW cm^{-2} sr^{-1} in the blue spectral region, the permissible exposure duration t_{max} in seconds is simply:

$$t_{max} = 100 \text{ J cm}^{-2} \text{ sr}^{-1}/\text{L (blue)} \qquad (4)$$

The latter limits are greater than the maximum permissible exposure limits for 440 nm laser radiation (see Laser TLV) because a 2–3 mm pupil is assumed rather than a 7 mm pupil for the Laser TLV.

3. *Infrared Radiation:* To avoid possible delayed effects upon the lens of the eye (cataractogenesis), the infrared radiation ($\lambda > 770$ nm) should be limited to 10 $mWcm^{-2}$. For an infrared heat lamp or any near-infrared source where a strong visual stimulus is absent, the near infrared (770–1400 nm) radiance as viewed by the eye should be limited to:

$$\sum_{770}^{1400} E_\lambda \Delta_\lambda = 600/\alpha \qquad (5)$$

for extended duration viewing conditions. This limit is based upon a 7 mm pupil diameter.

TABLE 11

SPECTRAL WEIGHTING FUNCTIONS FOR ASSESSING RETINAL HAZARDS FROM BROAD — BAND OPTICAL SOURCES

Wavelength (nm)	Blue-Light Hazard Function B_λ	Burn Hazard Function R_λ
400	0.10	1.0
405	0.20	2.0
410	0.40	4.0
415	0.80	8.0
420	0.90	9.0
425	0.95	9.5
430	0.98	9.8
435	1.0	10
440	1.0	10
445	0.97	9.7
450	0.94	9.4
455	0.90	9.0
460	0.80	8.0
465	0.70	7.0
470	0.62	6.2
475	0.55	5.5
480	0.45	4.5
485	0.40	4.0
490	0.22	2.2
495	0.16	1.6
500–600	$10^{[(450-\lambda)/50]}$	1.0
600–700	0.001	1.0
700–1060	0.001	$10^{[(700-\lambda)/515]}$
1060–1400	0.001	0.2

AIRBORNE UPPER SONIC AND ULTRASONIC ACOUSTIC RADIATION

These threshold limit values refer to sound pressure levels that represent conditions under which it is believed that nearly all workers may be repeatedly exposed without adverse effect. The values listed in Table 15 should be used as guides in the control of noise exposure and, due to individual susceptibility, should not be regarded as fine lines between safe and dangerous levels. The levels for the third octave bands centered below 20 kHz are below those which cause subjective effects. Those levels for 1/3 octaves above 20 kHz are for prevention of possible hearing losses from subharmonics of these frequencies.

TABLE 12

Permissible Ultrasound Exposure Levels

Mid-Frequency of Third-Octave Band kHz	One-Third Octave — Band Level in dB reference 0.0002 dynes/cm²
10	80
12.5	80
16	80
20	105
25	110
31.5	115
40	115
50	115

NOTICE OF INTENT TO STUDY

These agents comprise those which the Physical Agents Committee of ACGIH proposes to study during this year to determine the feasibility of establishing proposed TLVs in 1977 Comments and suggestions, accompanied by substantitive evidence, are solicited.

1. *Radiofrequency Radiation*. Specifically, that portion of the spectrum from 10 MHz to 100 MHz.
2. *Microwave Radiation*. Specifically from 100 GHz to 300 GHz.
3. *Magnetic Fields*. Both pulsed and continuous.
4. *Laser Radiation*. Specifically ultraviolet radiation for pulsed exposures, and repetitively pulsed light and infrared-A laser exposures.
5. *Ultrasonic Energy*. Specifically, acoustic energy at frequencies above 10 kHz.
6. *Vibration*. Segmental and whole-body.

The American Conference of Governmental Industrial Hygienists was organized in 1938 by a group of governmental industrial hygienists who desired a medium for the free exchange of ideas, experiences and the promotion of standards and techniques in industrial health. The Conference is not an official Government Agency.

It is an organization devoted to the development of administrative and technical aspects of worker health protection. The association has contributed substantially to the development and improvement of official industrial health services to industry and labor. The committees on Industrial Ventilation and Threshold Limit Values are recognized throughout the world for their expertise and contributions to industrial hygiene.

Membership is limited to professional personnel in governmental agencies or educational institutions engaged in occupational safety and health programs. The more than 1600 members from across the United States and around the world give the organization an international scope.

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