Adopted by ACGIH for 1974

Threshold Limit Values Chemical Substances in Workroom Air

IT IS INCUMBENT upon the safety professional to have available and use the most current advice and guidelines for controlling and minimizing the risk to employees of exposures to chemical and physical agents.

Threshold limit value refers to air-borne concentrations of substances, and it represents conditions under which it is believed nearly all workers may be repeatedly exposed day-after-day without adverse effect. Because of a 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.

Threshold limit values refer to time-weighted concentrations for a seven or eight-hour work-day and 40-hour work-week. They should be used as *guides* in the control of health hazards and *should not be used as fine lines between safe and dangerous concentrations.*

Threshold limits are based on the best available information from: industrial experience; experimental human and animal studies; a combination of these when possible. 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.

As the amount and nature of the information available for establishing a TLV varies from substance to substance, consequently the precision of the estimated TLV also varies. Consult the latest *Documentation* to assess the extent of the data available for a given substance.

The Air-Borne Contaminants Committee of ACGIH 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 concentration of a substance at the threshold limit, the best practice is to maintain concentrations of all atmospheric contaminants as low as is practical.

TLV's 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, as a relative index of hazard, in the evaluation of air pollution nuisances, in estimating the toxic potential of continuous, uninterrupted exposures, as proof or disproof of an existing disease or physical condition, or for the adoption by countries whose working conditions differ from those in the U.S. and where substances and processes differ.

Specific statements on the toxicity and hazard, culled from the literature, or from the collective experience of the TLV Committee members, have been referenced for further examination and a clear, summarizing statement on precisely what basis the TLV has been selected is included in most documentations. This latter has been felt by the committee to be a highly important adjunct for industrial hygienists administering the TLV's.

TLV Air-Borne Contaminants Committee for 1974
Hector P. Bleier, M.D., D.I.H.
Paul E. Caplan, P.E., M.P.H.
Herbey B. Elkins, Ph.D.
W. G. Fredrick, Sc.D.
Bernard Grabois, P.E.
Paul Gross, M.D.
John W. Knauber, M.P.H.
Jesse Lieberman, P.E.
Keith R. Long, M.D.
Frederick T. McDermott, P.E.
E. Mastromatteo, M.D.
Col. Walter W. Melvin, Jr., M.D.
Lt. Col. Marshall Steinberg, Ph.D.
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Liaison Members
David A. Padden, Labor Unions
James F. Morgan, Industry
Theodore R. Torkelson, Sc.D., Industry
Mitchell R. Zavon, M.D., Industry

Price Each

1-49	75¢
50-200	65¢

Quantities over 200, prices upon request.

Documentation of the Threshold Limit Values for Substances in Workroom Air.© A separate companion piece to the Chemical TLVs is issued 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 safe-guarding the worker. For a better understanding of the TLV's it is essential that the Documentation be consulted with the TLVs 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.

EDITOR'S NOTE: NSNEWS will publish the *Threshold Limit Values for Physical Agents in the Workroom Environment* in the November 1974 issue.

EDITOR'S NOTE: TLVs for chemical substances are listed (as they appear in the ACGIH publication) on the following pages — six ACGIH pages to one NSNEWS page, and ACGIH publication page numbers are shown.

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.

Simple tests are now available (J. Occup. Med. *9*: 537, 1967; 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). These tests may be used to screen out by appropriate job placement the hyperreactive worker and thus in effect improve the "coverage" of the TLVs.

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

Time-weighted averages permit excursions above the limit provided they are

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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 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

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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, (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,

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practical way of monitoring airborne agents for compliance with the limits, there are certain substances for which it is inappropriate. In the latter group are substances which are predominantly fast acting and whose threshold limit is more appropriately based on this particular response. Substances with this type of response are best controlled by a ceiling "C" limit that should not be exceeded. It is implicit in these definitions that the manner of sampling to determine compliance with the limits for each group must differ; a single brief sample, that is applicable to a "C" limit, is not appropriate to the time-weighted limit; here, a sufficient number of samples are needed to permit a time-weighted average concentration throughout a complete cycle of operations or throughout the work shift.

Whereas the ceiling limit places a definite boundary which concentrations should not be permitted to exceed, the time-weighted average limit requires an explicit limit to the excursions that are permissible above the listed values. The magnitude of these excursions may be pegged to the magnitude of the threshold limit by an appropriate factor shown in Appendix D. It should be noted that the same factors are used by the Committee in making a judgment whether to include or exclude a substance for a "C" listing.

"Skin" Notation. Listed substances followed by the designation "Skin" refer to the potential contribution to the overall exposure by the cutaneous route including mucuous membranes and eye, either by airborne, or more particularly, by direct contact with the substance. Vehicles can

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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 (iron oxide, carbon black), may cause unpleasant deposits in the eyes, ears

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and nasal passages (Portland Cement dust), or cause injury to the skin or mucous membranes by chemical or mechanical action per se or by the rigorous skin cleansing procedures necessary for their removal.

A threshold limit of 10 mg/m³, or 30 mppcf, of total dust < 1% quartz is recommended for substances in these categories and for which no specific threshold limits have been assigned. This limit, for a normal workday, does not apply to brief exposures at higher concentrations. Neither does it apply to those substances which may cause physiologic impairment at lower concentrations but for which a threshold limit has not yet been adopted. Some nuisance particulates are given in Appendix E.

Simple Asphyxiants — "Inert" Gases or Vapors. A number of gases and vapors, when present in high concentrations in air, act primarily as simple asphyxiants without other significant physiologic effects. A TLV may not be recommended for each simple asphyxiant because the limiting factor is the available oxygen. The minimal oxygen content should be 18 percent by volume under normal atmospheric pressure (equivalent to a partial pressure, 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.

Short-Term Limits (STLs). Because many industrial exposures are not continuous, 8-hour daily exposures, but are short-term,

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or intermittent, to which the TLVs do not necessarily apply, STLs for 5, 15, or 30 minutes for 142 substances have been put into the regulations of the Pennsylvania Department of Health (Chapter 4, Art. 432, Revised Jan. 25, 1968). These STLs represent the maximal average atmospheric concentration of a contaminant to which a worker may be exposed for the stipulated time. The concentration represents an upper limit of exposure and assumes that there is sufficient recovery between exposures before another is initiated. The daily average exposure including that provided by the STL shall be such that the TLV shall not be exceeded.

Similar STLs for a more restricted number of substances have been recommended by the American National Standards Institute. This standard-setting body refers to these short-term limits as "peaks."

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 U.S. National Institute for Occupational Safety and Health is proposing a series of these BLVs which will be issued from time to time as part of the

Criteria Documents for recommended industrial air standards.

Unlisted substances. There are a number of reasons why a substance does not appear in the Threshold Limit list; either insufficient information is available or it has not been brought to the attention of the Threshold Limits Committee from which a limit can be developed, or it is a substance that could be included in the Appendices E and F pertaining to Nuisance Particulates and Simple Asphyxiants. Substances appearing in these appendices serve as examples only; the appendices are not intended to be inclusive.

"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 are now official federal standards for industrial air.

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ADOPTED VALUES

See Documentation for basis of TLVs

Substance	ppm[a]	mg/m³[b]
Abate	—	10
Acetaldehyde	100	180
Acetic acid	10	25
C Acetic anhydride	5	20
Acetone	1,000	2,400
Acetonitrile	40	70
Acetylene	F	—
Acetylene dichloride, see 1, 2-Dichloroethylene	—	—
Acetylene tetrabromide	1	14
Acrolein	0.1	0.25
Acrylamide — Skin	—	0.3
Acrylonitrile — Skin	20	45
Aldrin — Skin	—	0.25
Allyl alcohol — Skin	2	5
Allyl chloride	1	3
Allyl glycidyl ether (AGE) — Skin	5	22
Allyl propyl disulfide	2	12
Alundum (Al_2O_3)	—	E
4-Aminodiphenyl — Skin	—	A[h]
2-Aminoethanol, see Ethanolamine	—	—
2-Aminopyridine	0.5	2
Ammonia	25	18
Ammonium chloride, fume	—	10
Ammonium sulfamate (Ammate)	—	10
n-Amyl acetate	100	525
sec-Amyl acetate	125	650
Aniline — Skin	5	19

Capital letters refer to Appendices.
Footnotes (a thru h) see Pages 32 and 33.

Substance	ppm[a]	mg/m³[b]
Anisidine (o, p-isomers) — Skin	0.1	0.5
Antimony & compounds (as Sb)	—	0.5
ANTU (alpha naphthyl thiourea)	—	0.3
Argon	F	—
**Arsenic & compounds (as As)	—	0.5
Arsine	0.05	0.2
Asphalt (petroleum) fumes	—	5
Azinphos methyl — Skin	—	0.2
*Bagon (Propaxur)	—	0.5
Barium (soluble compounds)	—	0.5
** Benzene — Skin	—	—
Benzidine — Skin	—	A[h]
p-Benzoquinone, see Quinone	—	—
Benzoyl peroxide	—	5
Benzyl chloride	1	5
Beryllium	—	0.002
Biphenyl, see Diphenyl	—	—
Bismuth telluride	—	10
Bismuth telluride (Se-doped)	—	5
Boron oxide	—	10
Boron tribromide	1	10
C Boron trifluoride	1	3
Bromine	0.1	0.7
Bromine pentafluoride	0.1	0.7
Bromoform — Skin	0.5	5

Capital letters refer to Appendices.
Footnotes (a thru h) see Pages 32 and 33.
*1974 Addition.
**See Notice of Intended Changes.

Substance	ppm[a]	mg/m³[b]
Butadiene (1, 3-butadiene)	1,000	2,200
** Butane	—	—
Butanethiol, see Butyl mercaptan	—	—
2-Butanone	200	590
2-Butoxy ethanol (Butyl Cellosolve) — Skin	50	240
Butyl acetate (n-butyl acetate)	150	710
sec-Butyl acetate	200	950
tert-Butyl acetate	200	950
** n-Butyl alcohol — Skin	—	—
sec-Butyl alcohol	150	450
tert-Butyl alcohol	100	300
C Butylamine — Skin	5	15
C tert-Butyl chromate (as CrO_3) — Skin	—	0.1
n-Butyl glycidyl ether (BGE)	50	270
** Butyl lactate	—	—
Butyl mercaptan	0.5	1.5
p-tert-Butyltoluene	10	60
** Cadmium (Metal dust and soluble salts)	—	—
*C Cadmium oxide fume (as Cd)	—	0.05
Calcium carbonate	—	E
Calcium arsenate	—	1
Calcium oxide	—	5
Camphor (Synthetic)	2	12
Caprolactam Dust	—	1
Vapor	5	20

Capital letters refer to Appendices.
*1974 Addition.
**See Notice of Intended Changes.

Substance	ppm[a]	mg/m³[b]
Carbaryl (Sevin®)	—	5
Carbon black	—	3.5
Carbon dioxide	5,000†	9,000
Carbon disulfide — Skin.	20	60
Carbon monoxide	50	55
Carbon tetrachloride — Skin	10	65
Cellulose (paper fiber)	—	E
Chlordane — Skin	—	0.5
Chlorinated camphene — Skin	—	0.5
Chlorinated diphenyl oxide	—	0.5
Chlorine	1	3
Chlorine dioxide	0.1	0.3
C Chlorine trifluoride	0.1	0.4
C Chloroacetaldehyde	1	3
α-Chloroacetophenone (phenacylchloride)	0.05	0.3
Chlorobenzene (monochlorobenzene)	75	350
o-Chlorobenzylidene malononitrile (OCBM) — Skin	0.05	0.4
Chlorobromomethane	200	1,050
2-Chloro-1, 3-butadiene see Chloroprene	—	—
Chlorodiphenyl (42% Chlorine) — Skin	—	1
Chlorodiphenyl (54% Chlorine) — Skin	—	0.5
1-Chloro, 2, 3- epoxy-propane, see Epichlorhydrin	—	—

Capital letters refer to Appendices.
†See 1974 Revised Documentation.

Substance	ppm[a]	mg/m³[b]
2-Chloroethanol, see Ethylene chlorohydrin.	—	—
Chloroethylene, see Vinyl chloride	—	—
* Chloroform (Trichloromethane)	25	120
* bis-Chloromethyl ether	0.001	A[le]
1-Chloro-1-nitropropane	20	100
Chloropicrin	0.1	0.7
Chloroprene (2-chloro-1, 3-butadiene) — Skin	25	90
* 0-Chlorotoluene	50	250
Chromates, certain insoluble forms	—	A[le]
Chromic acid and chromates (as CrO_3)	—	0.1
Chromium, sol. chromic, chromous salts as Cr	—	0.5
Coal tar pitch volatiles (benzene soluble fraction: anthracene, BaP, phenanthrene, acridine, chrysene, pyrene)	A[le]	0.2
Cobalt, metal fume & dust	—	0.1
** Copper fume	—	—
Dusts and Mists	—	1
Corundum (Al_2O_3)	—	E
* Cotton Dust (raw)	—	0.2[m]
Crag® herbicide	—	10
Cresol (all isomers) — Skin	5	22
Crotonaldehyde	2	6

Capital letters refer to Appendices.
Footnotes (a thru h) see Pages 32 and 33.
*1974 Addition.
**See Notice of Intended Changes.
m) see p. 35.

Substance	ppm[a]	mg/m³[b]
Cumene — Skin	50	245
Cyanide (as CN) — Skin.	—	5
Cyanogen	10	—
Cyclohexane	300	1,050
Cyclohexanol	50	200
Cyclohexanone	50	200
Cyclohexene	300	1,015
* Cyclohexylamine—Skin.	10	40
Cyclopentadiene	75	200
2, 4-D	—	10
DDT	—	1
DDVP, see Dichlorvos	—	—
Decaborane — Skin	0.05	0.3
Demeton® — Skin	0.01	0.1
Diacetone alcohol (4-hydroxy-4-methyl-2-pentanone)	50	240
1, 2-Diaminoethane, see Ethylenediamine	—	—
Diazinon — Skin	—	0.1
Diazomethane	0.2	0.4
Diborane	0.1	0.1
1, 2-Dibromoethane (ethylene dibromide) — Skin	20	145
Dibrom®	—	3
2-N Dibutylaminoethanol — Skin	2	14
Dibutyl phosphate	1	5
Dibutylphthalate	—	5
C Dichloracetylene	0.1	0.4
C o-Dichlorobenzene	50	300
p-Dichlorobenzene	75	450

Capital letters refer to Appendices.
*1974 Addition.

Substance	ppm[a]	mg/m³[b]
Dichlorobenzidine — Skin	—	A[lk]
Dichlorodifluoromethane	1,000	4,950
1, 3-Dichloro-5, 5-dimethyl hydantoin	—	0.2
1, 1-Dichloroethane	200	320
1, 2-Dichloroethane	50	200
1, 2-Dichloroethylene	200	790
Dichloroethyl ether — Skin	5	30
Dichloromethane, see Methylene chloride	—	—
Dichloromonofluoromethane	1,000	4,200
C 1, 1-Dichloro-1-nitroethane	10	60
1, 2-Dichloropropane, see Propylenedichloride	—	—
Dichlorotetrafluoroethane	1,000	7,000
Dichlorvos (DDVP) — Skin	0.1	1
Dieldrin — Skin	—	0.25
Diethylamine	25	75
Diethylamino ethanol — Skin	10	50
Diethylene triamine — Skin	1	4
Diethylether, see Ethyl ether	—	—
Difluorodibromomethane	100	860
C Diglycidyl ether (DGE)	0.5	2.8
Dihydroxybenzene, see Hydroquinone	—	—

Capital letters refer to Appendices.
Footnotes (a thru h) see Pages 32 and 33.

Substance	ppm[a]	mg/m³[b]
Diisobutyl ketone	25	150
Diisopropylamine — Skin	5	20
Dimethoxymethane, see Methylal	—	—
Dimethyl acetamide — Skin	10	35
Dimethylamine	10	18
Dimethylaminobenzene, see Xylidene	—	—
Dimethylaniline (N-dimethylaniline) — Skin	5	25
Dimethylbenzene, see Xylene	—	—
Dimethyl 1, 2-dibromo-2-dichloroethyl phosphate, see DiBrom	—	—
Dimethylformamide — Skin	10	30
2, 6-Dimethylheptanone, see Diisobutyl ketone.	—	—
1, 1-Dimethylhydrazine — Skin	0.5	1
Dimethylphthalate	—	5
** Dimethylsulfate — Skin.	—	—
Dinitrobenzene (all isomers) — Skin	0.15	1
Dinitro-o-cresol — Skin.	—	0.2
Dinitrotoluene — Skin	—	1.5
* Dioxane, technical grade —Skin	50	180
Diphenyl	0.2	1

Capital letters refer to Appendices.
Footnotes (a thru h) see Pages 32 and 33.
**See Notice of Intended Changes.

Substance	ppm[a]	mg/m³[b]
Diphenyl amine	—	10
Diphenylmethane diisocyanate see Methylene bisphenyl isocyanate (MDI)	—	—
Dipropylene glycol methyl ether — Skin.	100	600
Diquat	—	0.5
Di-sec, octyl phthalate (Di-2-ethylhexyl-phthalate)	—	5
* Disyston—Skin	—	0.1
Emery	—	E
Endosulfan (Thiodan®) — Skin	—	0.1
Endrin — Skin	—	0.1
Epichlorhydrin — Skin	5	19
EPN — Skin	—	0.5
1, 2-Epoxypropane, see Propyleneoxide	—	—
2, 3-Epoxy-1-propanol, see Glycidol	—	—
Ethane	F	—
Ethanethiol, see Ethylmercaptan	—	—
Ethanolamine	3	6
2-Ethoxyethanol—Skin.	100	370
2-Ethoxyethylacetate (Cellosolve acetate) — Skin	100	540
Ethyl acetate	400	1,400
Ethyl acrylate — Skin	25	100
Ethyl alcohol (ethanol)	1,000	1,900
Ethylamine	10	18

Capital letters refer to Appendices.
*1974 Addition.

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Substance	ppm[a]	mg/m³[b]
Ethyl sec-amyl ketone (5-methyl-3-heptanone)	25	130
Ethyl benzene	100	435
Ethyl bromide	200	890
Ethyl butyl ketone (3-Heptanone)	50	230
Ethyl chloride	1,000	2,600
Ethyl ether	400	1,200
Ethyl formate	100	300
Ethyl mercaptan	0.5	1
Ethyl silicate	100	850
Ethylene	F	—
Ethylene chlorohydrin — Skin	5	16
Ethylenediamine	10	25
Ethylene dibromide, see 1, 2-Dibromoethane	—	—
Ethylene dichloride, see 1, 2-Dichloroethane	—	—
Ethylene glycol, particulate	—	10
Ethylene glycol, vapor	100	260
C Ethylene glycol dinitrate and/or Nitroglycerin — Skin	0.2[d]	—
Ethylene glycol monomethyl ether acetate (Methyl cellosolve acetate) — Skin	25	120
Ethylene imine — Skin	0.5	1
Ethylene oxide	50	90
Ethylidine chloride, see 1, 1-Dichloroethane	—	—
*C Ethylidene norbornene	5	25

Capital letters refer to Appendices.
Footnotes (a thru h) see Pages 32 and 33.
*1974 Addition.

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Substance	ppm[a]	mg/m³[b]
N-Ethylmorpholine — Skin	20	94
Ferbam	—	10
Ferrovanadium dust	—	1
Fluoride (as F)	—	2.5
Fluorine	1	2
Fluorotrichloromethane	1,000	5,600
C Formaldehyde	2	3
Formic acid	5	9
Furfural — Skin	5	20
* Furfuryl alcohol	5	20
Gasoline	—	B[g]
Germanium tetrahydride	0.2	0.6
Glass, fibrous[c] or dust	—	E
Glycerin mist	—	E
Glycidol (2, 3-Epoxy-1-propanol)	50	150
Glycol monoethyl ether, see 2-Ethoxyethanol	—	—
Graphite, (Synthetic)	—	E
Guthion,® see Azinphosmethyl	—	—
Gypsum	—	E
Hafnium	—	0.5
Helium	F	—
Heptachlor — Skin	—	0.5
** Heptane (n-heptane)	—	—
* Hexachlorocyclopentadiene	0.01	0.11
Hexachloroethane — Skin	1	10
Hexachloronaphthalene — Skin	—	0.2

Capital letters refer to Appendices.
Footnotes (a thru h) see Pages 32 and 33.
*1974 Addition.
**See Notice of Intended Changes.

20

Substance	ppm[a]	mg/m³[b]
Hexafluoroacetone	0.1	0.7
** Hexane (n-hexane)	—	—
2-Hexanone	100	410
Hexone (Methyl isobutyl ketone)	100	410
sec-Hexyl acetate	50	300
Hydrazine — Skin	1	1.3
Hydrogen	F	—
Hydrogen bromide	3	10
C Hydrogen chloride	5	7
Hydrogen cyanide — Skin	10	11
Hydrogen fluoride	3	2
Hydrogen peroxide	1	1.4
Hydrogen selenide	0.05	0.2
Hydrogen sulfide	10	15
Hydroquinone	—	2
Indene	10	45
Indium and compounds, as In	—	0.1
C Iodine	0.1	1
** Iron oxide fume	—	—
Iron pentacarbonyl	0.01	0.08
Iron salts, soluble, as Fe	—	1
Isoamyl acetate	100	525
Isoamyl alcohol	100	360
Isobutyl acetate	150	700
** Isobutyl alcohol	—	—
** Isophorone	—	—
Isopropyl acetate	250	950
Isopropyl alcohol — Skin	400	980
Isopropylamine	5	12
Isopropylether	250	1,050
Isopropyl glycidyl ether (IGE)	50	240

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

21

Substance	ppm[a]	mg/m³[b]
Kaolin	—	E
Ketene	0.5	0.9
Lead, inorg., fumes and dusts	—	0.15
Lead arsenate	—	0.15
Limestone	—	E
Lindane	—	0.5
Lithium hydride	—	0.025
L.P.G. (Liquified petroleum gas)	1,000	1,800
Magnesite	—	E
Magnesium oxide fume	—	10
Malathion — Skin	—	10
Maleic anhydride	0.25	1
C Manganese and compounds, as Mn	—	5
* Manganese cyclopentadienyl tricarbonyl (as Mn) — Skin	—	0.1
Marble	—	E
Mercury (Alkyl compounds) — Skin	0.001	0.01
Mercury (All forms except alkyl)	—	0.05
Mesityl oxide	25	100
Methane	F	—
Methanethiol, see Methyl mercaptan	—	—
Methoxychlor	—	10
2-Methoxyethanol — Skin (Methyl cellosolve)	25	80
Methyl acetate	200	610
Methyl acetylene (propyne)	1,000	1,650

Capital letters refer to Appendices.
*1974 Addition.

22

Substance	ppm[a]	mg/m³[b]
Methyl acetylene-propadiene mixture (MAPP)	1,000	1,800
Methyl acrylate — Skin	10	35
Methyl acrylonitrile — Skin	1	3
Methylal (dimethoxymethane)	1,000	3,100
Methyl alcohol (methanol) — Skin	200	260
Methylamine	10	12
Methyl amyl alcohol, see Methyl isobutyl carbinol	—	—
Methyl 2-cyanoacrylate	2	8
Methyl isoamyl ketone	100	475
Methyl (n-amyl) ketone (2-Heptanone)	100	465
Methyl bromide — Skin	15	60
Methyl butyl ketone, see 2-Hexanone	—	—
Methyl cellosolve — Skin see 2-Methoxyethanol	—	—
Methyl cellosolve acetate — Skin, see Ethylene glycol monomethyl ether acetate	—	—
Methyl chloride	100	210
Methyl chloroform	350	1,900
** Methylcyclohexane	—	—
Methylcyclohexanol	50	235
o-Methylcyclohexanone — Skin	50	230
Methylcyclopentadienyl manganese tricarbonyl (as Mn) — Skin	0.1	0.2

**See Notice of Intended Changes.

23

Substance	ppm[a]	mg/m³[b]
Methyl demeton — Skin	—	0.5
Methyl ethyl ketone (MEK), see 2-Butanone	—	—
*C Methyl ethyl ketone peroxide	0.2	1.5
Methyl formate	100	250
Methyl iodide — Skin	5	28
Methyl isobutyl carbinol — Skin	25	100
Methyl isobutyl ketone, see Hexone	—	—
Methyl isocyanate — Skin	0.02	0.05
Methyl mercaptan	0.5	1
Methyl methacrylate	100	410
Methyl parathion — Skin	—	0.2
Methyl propyl ketone, see 2-Pentanone	—	—
C Methyl silicate	5	30
C α Methyl styrene	100	480
C Methylene bisphenyl isocyanate (MDI)	0.02	0.2
** Methylene chloride (dichloromethane)	—	—
* 4,4'-Methylene bis (2-chloraniline) — Skin	0.02	A[g]
*C Methylene bis (4-cyclohexylisocyanate)	0.1	0.11
Molybdenum (soluble compounds)	—	5
(insoluble compounds)	—	10

Capital letters refer to Appendices.
Footnotes (a thru h) see Pages 32 and 33.
*1974 Addition.
**See Notice of Intended Changes.

24

Substance	ppm[a]	mg/m³[b]
Monomethyl aniline — Skin	2	9
C Monomethyl hydrazine — Skin	0.2	0.35
Morpholine — Skin	20	70
Naphtha (coal tar)	100	400
Naphthalene	10	50
β-Naphthylamine	—	A[1a]
Neon	F	—
Nickel carbonyl	0.001 A[1a]	0.007
Nickel, metal and insoluble compounds (as Ni)	—	1
** Nickel, soluble compounds (as Ni)	—	—
Nicotine — Skin	0.075	0.5
Nitric acid	2	5
Nitric oxide	25	30
p-Nitroaniline — Skin	1	6
Nitrobenzene — Skin	1	5
p-Nitrochlorobenzene — Skin	—	1
4-Nitrodiphenyl	—	A[1a]
Nitroethane	100	310
C Nitrogen dioxide	5	9
Nitrogen trifluoride	10	29
Nitroglycerin — Skin	0.2	2
Nitromethane	100	250
1-Nitropropane	25	90
2-Nitropropane	25	90
N-Nitrosodimethylamine (dimethylnitrosoamine) — Skin	—	A[2]
Nitrotoluene — Skin	5	30

Capital letters refer to Appendices.
Footnotes (a thru h) see Pages 32 and 33.
**See Notice of Intended Changes.

Substance	ppm[a]	mg/m³[b]
Nitrotrichloromethane, see Chloropicrin	—	—
Nitrous oxide	F	—
Octachloronaphthalene — Skin	—	0.1
** Octane	—	—
Oil mist, particulate	—	5[f]
Oil mist, vapor	[e]B[2]	—
Osmium tetroxide	0.0002	0.002
Oxalic acid	—	1
Oxygen difluoride	0.05	0.1
Ozone	0.1	0.2
* Paraffin wax fume	—	0.2
Paraquat — Skin	—	0.5
Parathion — Skin	—	0.1
Pentaborane	0.005	0.01
Pentachloronaphthalene — Skin	—	0.5
Pentachlorophenol — Skin	—	0.5
Pentaerythritol	—	E
** Pentane	—	—
2-Pentanone	200	700
Perchloroethylene	100	670
Perchloromethyl mercaptan	0.1	0.8
Perchloryl fluoride	3	14
Petroleum Distillates (naphtha)	[e]B[2]	—
Phenol — Skin	5	19
Phenothiazine — Skin	—	5
p-Phenylene diamine — Skin	—	0.1

Capital letters refer to Appendices.
Footnotes (a thru h) see Pages 32 and 33.
*1974 Addition.
**See Notice of Intended Changes.

Substance	ppm[a]	mg/m³[b]
Phenyl ether (vapor)	1	7
Phenyl ether-Diphenyl mixture (vapor)	1	7
Phenylethylene, see Styrene	—	—
Phenyl glycidyl ether (PGE)	10	60
Phenylhydrazine — Skin	5	22
C Phenylphosphine	0.05	0.25
* Phorate (Thimet®) — Skin	—	0.05
Phosdrin (Mevinphos)® — Skin	0.01	0.1
** Phosgene (carbonyl chloride)	—	—
Phosphine	0.3	0.4
Phosphoric acid	—	1
Phosphorus (yellow)	—	0.1
Phosphorus pentachloride	—	1
Phosphorus pentasulfide	—	1
Phosphorus trichloride	0.5	3
Phthalic anhydride	2	12
Picric acid — Skin	—	0.1
Pival® (2-Pivalyl-1, 3-indandione)	—	0.1
Plaster of Paris	—	E
Platinum (Soluble Salts) as Pt	—	0.002
Polychlorobiphenyls, see Chlorodiphenyls	—	—
Polytetrafluoroethylene decomposition products	—	B[1]
*C Potassium hydroxide	—	2

Capital letters refer to Appendices.
*1974 Addition.
**See Notice of Intended Changes.

Substance	ppm[a]	mg/m³[b]
Propane	F	—
β Propiolactone	—	A[2]
Propargyl alcohol — Skin	1	2
n-Propyl acetate	200	840
Propyl alcohol — Skin	200	500
n-Propyl nitrate	25	110
Propylene dichloride (1, 2-Dichloropropane)	75	350
Propylene glycol monomethyl ether	100	360
Propylene imine — Skin	2	5
Propylene oxide	100	240
Propyne, see Methylacetylene	—	—
Pyrethrum	—	5
Pyridine	5	15
Quinone	0.1	0.4
RDX — Skin	—	1.5
Rhodium, Metal fume and dusts (as Rh)	—	0.1
Soluble salts	—	0.001
Ronnel	—	10
Rosin Core Solder, pyrolysis products (as formaldehyde)	—	0.1
Rotenone (commercial)	—	5
Rouge	—	E
Selenium compounds (as Se)	—	0.2
Selenium hexafluoride	0.05	0.4
* Sevin® (see Carbaryl)	—	—
* Silane (see Silicon tetrahydride)	—	—
Silicon	—	E
Silicon carbide	—	E

Capital letters refer to Appendices.
*1974 Addition.

Substance	ppm[a]	mg/m³[b]
* Silicon tetrahydride (Silane)	0.5	0.7
Silver, metal and soluble compounds	—	0.01
Sodium fluoroacetate (1080) — Skin	—	0.05
**C Sodium hydroxide	—	—
Starch	—	E
Stibine	0.1	0.5
** Stoddard solvent	—	—
Strychnine	—	0.15
Styrene (Monomer) (Phenyl ethylene)	100	420
Sucrose	—	E
Sulfur dioxide	5	13
Sulfur hexafluoride	1,000	6,000
Sulfuric acid	—	1
Sulfur monochloride	1	6
Sulfur pentafluoride	0.025	0.25
Sulfur tetrafluoride	0.1	0.4
Sulfuryl fluoride	5	20
Systox, see Demeton®	—	—
2, 4, 5-T	—	10
Tantalum	—	5
TEDP — Skin	—	0.2
Teflon® decomposition products	—	B[1]
Tellurium	—	0.1
Tellurium hexafluoride	0.02	0.2
TEPP — Skin	0.004	0.05
C Terphenyls	1	9
1, 1, 1, 2-Tetrachloro-2, 2-difluoroethane	500	4,170

Capital letters refer to Appendices.
Footnotes (a thru h) see Pages 32 and 33.
*1974 Addition.
**See Notice of Intended Changes.

Substance	ppm[a]	mg/m³[b]
1, 1, 2, 2-Tetrachloro-1, 2-difluoroethane	500	4,170
1, 1, 2, 2-Tetrachloroethane — Skin	5	35
Tetrachloroethylene, see Perchloroethylene	—	—
Tetrachloromethane, see Carbon tetrachloride	—	—
Tetrachloronaphthalene — Skin	—	2
Tetraethyl lead (as Pb) — Skin	—	0.100[h]
Tetrahydrofuran	200	590
Tetramethyl lead (as Pb) — Skin	—	0.150[h]
Tetramethyl succinonitrile — Skin	0.5	3
Tetranitromethane	1	8
Tetryl (2, 4, 6-trinitrophenylmethylnitramine) — Skin	—	1.5
Thallium (soluble compounds) — Skin (as Tl)	—	0.1
Thiram®	—	5
Tin (inorganic compounds, except SnH_4 and SnO_2) as Sn	—	2
Tin (organic compounds) — Skin (as Sn)	—	0.1
Tin oxide	—	E
Titanium dioxide	—	E
Toluene (toluol) — Skin	100	375
C Toluene-2, 4-diisocyanate	0.02	0.12

Capital letters refer to Appendices.
Footnotes (a thru h) see Pages 32 and 33.

Substance	ppm[a]	mg/m³[b]
o-Toluidine	5	22
Toxaphene, see Chlorinated camphene	—	—
Tributyl phosphate	—	5
1, 1, 1-Trichloroethane, see Methyl chloroform.	—	—
1, 1, 2-Trichloroethane — Skin	10	45
Trichloroethylene	100	535
Trichloromethane, see Chloroform	—	—
Trichloronaphthalene — Skin	—	5
1, 2, 3-Trichloropropane	50	300
1, 1, 2-Trichloro 1, 2, 2-trifluoroethane	1,000	7,600
Triethylamine	25	100
Trifluoromonobromomethane	1,000	6,100
Trimethyl benzene	25	120
2, 4, 6-Trinitrophenol, see Picric acid	—	—
2, 4, 6 — Trinitrophenylmethylnitramine, see Tetryl	—	—
Trinitrotoluene — Skin	0.2	1.5
Triorthocresyl phosphate	—	0.1
Triphenyl phosphate	—	3
Tungsten & compounds, as W		
Soluble	—	1
Insoluble	—	5
Turpentine	100	560
Uranium (natural) soluble & insoluble compounds, as U	—	0.2

Substance	ppm[a]	mg/m³[b]
Vanadium (V_2O_5), as V		
Dust	—	0.5
C Fume	—	0.05
Vinyl acetate	10	30
Vinyl benzene, see Styrene	—	—
Vinyl bromide	250	1,100
** Vinyl chloride	—	—
Vinylcyanide, see Acrylonitrile	—	—
Vinyl toluene	100	480
Warfarin	—	0.1
Wood dust (nonallergenic)	—	5
Xylene (xylol) — Skin	100	435
Xylidine — Skin	5	25
Yttrium	—	1
Zinc chloride fume	—	1
Zinc oxide fume	—	5
* Zinc stearate	—	E
Zirconium compounds (as Zr)	—	5

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.

e) <7 μm in diameter.

f) As sampled by method that does not collect vapor.

Capital letters refer to Appendices.
*1974 Addition.
**See Notice of Intended Changes.

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 4867, Washington, D.C. 20008.

MINERAL DUSTS

Substance

SILICA, SiO_2

Crystalline

Quartz — TLV in mppcf:

$$\frac{300^{j}}{\%\ \text{quartz} + 10}$$

TLV for respirable dust in mg/m³:

$$\frac{10\ \text{mg/m}^3\ [k]}{\%\ \text{Respirable quartz} + 2}$$

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.

Amorphous — 20 mppcf[l]

SILICATES (< 1% quartz)

*Asbestos, all forms†	5 fibers/cc > 5μm in length[m]; A[n]
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.	
*Tripoli, use respirable[p]	mass quartz formula

COAL DUST

(bituminous) — 2 mg/m³ (respirable dust fraction < 5% quartz). If > 5% quartz use respirable mass formula.

*1974 Addition.
†A more stringent TLV for crocidolite may be required.

NUISANCE PARTICULATES

(see Appendix E)

30 m.p.p.c.f. or 10 mg/m³[b]
of-total dust < 1% quartz

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:

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 400–450 X 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 1974)

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]
+Arsenic, inorganic compounds (as As)	—	0.25
+Benzene—Skin	10	30
+Butane	600	1,450
+n-Butyl alcohol	50	150
+n-Butyl lactate	5	25
+Cadmium dusts & salts	—	0.05
C Cadmium oxide fume	—	0.05
+Calcium cyanamide	—	0.5
+Calcium hydroxide	—	2
+Captan	—	5
+Carbofuran	—	0.10
Carbon tetrabromide	0.1	1.4
Catechol (Pyrocatechol)	1	4.5
Cesium hydroxide	—	2
Chlorodifluoromethane	1000	3500
Chlorpyrifos (Dursban®)—Skin	—	0.2
o-Chlorostyrene	50	285

Capital letters refer to Appendices.
+1974 Revision or Addition.

Substance	ppm[a]	mg/m³[b]
2-Chloro-6-(trichloromethyl) pyridine (N-Serve®)	—	10
Clopidol (Coyden®)	—	10
Copper fume	—	0.2
Crufomate (Ruelene)®	—	5
+Dicyclopentadiene	5	30
Dicyclopentadienyliron	—	10
Diethylphthalate	—	5
+Dimethyl sulfate—Skin	—	A²
3,5-Dinitro-o-toluamide (Zoalene®)	—	5
+Disulfuram	—	2
2,6-Ditert. butyl-p-cresol	-	10
+Dyfonate	—	0.1
+C Ethylene chlorohydrin — Skin	1	3
+Fensulfothion (Dasanit)	—	0.1
Formamide	20	30
+C Glutaraldehyde	2	8
+C Glutaraldehyde (Alkaline activated)	—	0.25
+Heptane	400	1,600
+Hexane	100	360
+Hexylene glycol	25	125
+Hydrogenated terphenyls	0.4	4.4
+Iodoform	0.2	3.0
Iron oxide fume	B⁴	5
+Isobutyl alcohol	50	150
+Isophorone	5	25
+Methylcyclohexane	400	1,600
+Methylene chloride (Dichloromethane)	100	360
+Nickel, soluble salts (as Ni)	—	0.1

Capital letters refer to Appendices.
+1974 Addition or Revision.

Substance	ppm[a]	mg/m³[b]
+Nonane	200	1,050
+Octane	300	1,450
+Pentane	600	1,800
+C Phosgene	0.05	0.2
Picloram (Tordon®)	—	10
+Resorcinol	10	45
+C Sodium azide	0.1	0.3
C Sodium hydroxide	—	2.0
+Stoddard Solvent	100	575
C Subtilisins (Proteolytic enzymes as 100% pure crystalline enzyme)	—	0.00006[c]
+Succindialdehyde (see Glutaraldehyde)	—	—
+4,4'-Thiobis (6-tert butyl-m-cresol)	—	10
Tricyclohexyltin hydroxide (Plictran®)	—	5
+Triphenylamine	—	5
+Vinyl chloride	Pending	A¹[c]
Vinylidene chloride	10	40
+Welding fumes (Total Particulate)	—	5&B⁴
+m-Xylene,α,α'-Diamine	—	0.1

a) Parts of vapor or gas per million parts of contaiminated air by volume at 25°C and 760 mm. Hg. pressure.
b) Approximate milligrams of particulate per cubic meter of air.

NOTICE OF INTENDED CHANGES (Cont'd) MINERAL DUSTS

Substance	TLV
+Diatomaceous earth (Natural, uncalcined)	1 mg/m³

Capital letters refer to Appendices.
+1974 Addition.
For explanations of o) and p), see pg. 36.

Silica flour	Use respirable[p] mass formula for quartz.	

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.

1a. *Human Carcinogens* — Substances recognized as occupational carcinogens with an assigned TLV:
Asbestos, all forms, 5 fibers/cc > 5μm in length.
bis (Chloromethyl) ether, 1ppb.
Chromates, certain insoluble forms, (Pb, Zn, and chromate-chromite ore, 100μg/m³, as Cr)
Coal tar pitch volatiles 200μg/m³
Nickel carbonyl, 1ppb

1b. *Human Carcinogens* — Substances known to be potent occupational carcinogens without an assigned TLV:
4-Aminodiphenyl (p-Xenylamine)
Benzidine & its salts
beta-Naphthylamine
4-Nitrodiphenyl

1c. *Human Carcinogens*—Substances awaiting reassignment of TLV because of recently discovered carcinogenicity.
Vinyl chloride, TLV pending.

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.

2. *Experimental Carcinogens* — Industrial substances found to be capable of inducing tumors under experimental conditions in animals:

	TLV
Beryllium	0.002 mg/m³
3, 3'-Dichlorobenzidine	
Dimethyl sulfate	
Ethylenimine	
4, 4'-Methylene bis (2-chloroaniline)	
N-Nitrosodimethylamine	
beta-Propiolactone	

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

APPENDIX B

B¹ *Polytetrafluoroethylene* decomposition products.* Thermal decomposition of the fluorocarbon chain in air leads to the formation of oxidized products containing carbon, fluorine and oxygen. Because these products decompose in part by hydrolysis in alkaline solution, they can

*Trade Names: Algoflon, Fluon, Halon, Teflon, Tetran

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 kept below the limit of sensitivity of the analytic method.

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).

B³ *Petroleum Distillates.* For petroleum distillates for which no specific TLV's are listed, approximate values can be obtained by use of the following equation:

$$TLV = \frac{100}{\frac{\%\ Al}{3.6(200 - B.P.°C.) + 20} + \frac{\%\ Ar}{1.3(200 - B.P.°C.) + 10}}\ ppm$$

where Al = aliphatic component
Ar = aromatic component
B.P. = mean boiling point in degrees centigrade (normally the 50% distillation temperature).

The equation cannot be used if the benzene content of the fraction exceeds 1%, nor if the mean boiling point is above 200°C.

It may also lead to error if there are large amounts of hexane or cyclohexane in the distillate.

If the molecular weight (average) is not known for the mixture, it can be approximated by the following equation:

M.W. = %Al + 0.88%Ar + 0.5(B.P.°C.) − 100)

B[q] *Welding Fumes* — Total Particulate 5 mg/m³ (N.O.C.)[q]

In electric or oxy-gas welding of iron or steel, galvanized iron or aluminum, the chief components of the fume are ordinarily oxides of iron, zinc or aluminum. Other fumes, as well as toxic gases may be present in significant amounts, however. Manganese, silicate and organic binders are commonly present in the coatings of welding rods for ferrous metals; fluoride in those for aluminum. And elements such as arsenic, copper, are sometimes found. Many aluminum rods contain appreciable quantities of silicon, and some have traces of beryllium. In shielded arc welding, ozone is often formed, and carbon monoxide has been reported when CO_2 was utilized as shield gas. Oxides of nitrogen are more likely to be associated with oxy-gas than with electric arc welding.

Because of the additional hazard created by toxic gases and traces to small amounts of fumes of more toxic elements, the total fume concentration, when welding iron, mild steel or aluminum, should not exceed 5 mg/m³ in the

q) Not otherwise classified.

breathing zone of the welder or others in the area.

The fumes from stainless steel, cadmium- or lead-coated steel, and other metals such as copper and nickel are considerably more toxic and concentrations should generally be kept at a lower level, depending on the TLV's of the metals involved. In addition, in the shielded arc welding of aluminum, relatively large amounts of ozone may be generated, and the concentration of this gas may largely determine the health hazard.

APPENDIX C

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,

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

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

Exceptions to the above rule may be made when there is good reason to believe that the chief effects of the different harmful substances are not in fact additive, but

independent as when purely local effects on different organs of the body are produced by the various components of the mixture. In such cases the threshold limit ordinarily is exceeded only when at least one member of the series $\left(\frac{C_1}{T_1} + \text{ or } + \frac{C_2}{T_2} \text{ etc.}\right)$ itself has a value exceeding unit (See Example 1A. c.).

Antagonistic action or potentiation may occur with some combinations of atmospheric contaminants. Such cases at present must be determined individually. Potentiating or antagonistic agents are not necessarily harmful by themselves. Potentiating effects of exposure to such agents by routes other than that of inhalation is also possible, e.g. imbibed alcohol and inhaled narcotic (trichloroethylene). Potentiation is characteristically exhibited at high concentrations, less probably at low.

When a given operation or process characteristically emits a number of harmful dusts, fumes, vapors or gases, it will frequently be only feasible to attempt to evaluate the hazard by measurement of a single substance. In such cases, the threshold limit used for this substance should be reduced by a suitable factor, the magnitude of which will depend on the number, toxicity and relative quantity of the other contaminants ordinarily present.

Examples of processes which are typically associated with two or more harmful atmospheric contaminants are welding, automobile repair, blasting, painting, lacquering, certain foundry operations, diesel exhausts, etc. (Example 2 in 1A.a.).

THRESHOLD LIMIT VALUES FOR MIXTURES

EXAMPLES

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.*)

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

Example No. 1A.a: Air contains 5 ppm of carbon tetrachloride (TLV = 10 ppm) 20 ppm of ethylene dichloride (TLV = 50 ppm) and 10 ppm of ethylene dibromide (TLV = 20 ppm)

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

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

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

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

1A.b. Special case when the source of contaminant is a liquid mixture and the

atmospheric composition is *assumed* to be similar to that of the original material; e.g. on a time weighted average exposure basis, all of the liquid (solvent) mixture eventually evaporates.

Additive effects (approximate solution)

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

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

TLV of mixture =

$$\frac{1}{\frac{f_a}{TLV_a} + \frac{f_b}{TLV_b} + \frac{f_c}{TLV_c} + \cdots \frac{f_n}{TLV_n}}$$

Example No. 1: Liquid solvent contains (by weight) 50% heptane (TLV = 2000 mg/m³) 30% methylene chloride (TLV = 1740 mg/m³) 20% perchlorethylene (TLV = 670 mg/m³)

$$\text{TLV of mixture} = \frac{1}{\frac{0.5}{1600} + \frac{0.3}{360} + \frac{0.2}{670}}$$

$$= \frac{1}{0.00031 + 0.00083 + 0.0003} = \frac{1}{0.00144}$$

$= 692 \text{ mg/m}^3$

To convert to ppm, consult TLV list:

50% heptane = 200 ppm
30% methylene chloride = 33 ppm
20% perchloroethylene = 20 ppm

TLV of mixture: 200 + 33 + 20 = 253 ppm

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

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

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

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

(3) $C_1 = ap_1.$
and by Raoult's Law,

(4) $p_1 = F_1 p_1°.$
Combine (3) and (4) to obtain

(5) $C_1 = aF_1 p_1°.$
Combining (1), (2,1) and (5), we obtain

(6) $$\frac{F_1p_1^\circ}{T} + \frac{F_2p_2^\circ}{T} + \cdots + \frac{F_np_n^\circ}{T} =$$

$$\frac{F_1p_1^\circ}{T_1} + \frac{F_2p_2^\circ}{T_2} + \cdots + \frac{F_np_n^\circ}{T_n}$$

and solving for T,

(6.1) $$T = \frac{F_1p_1^\circ + F_2p_2^\circ + \cdots + F_np_n^\circ}{\frac{F_1p_1^\circ}{T_1} + \frac{F_2p_2^\circ}{T_2} + \cdots + \frac{F_np_n^\circ}{T_n}}$$

or $$\sum_{i=1}^{i=n} = n\,F_1p_1^\circ$$

(6.2) $$T = \frac{i = 1}{\sum_{i=n}}$$

$$i = \frac{F_1p_1^\circ}{T_1}$$

T — Threshold Limit Value in ppm.
C — Vapor concentration in ppm.
p — Vapor pressure of component in solution.
p°— Vapor pressure of pure component.
F — Mol fraction of component in solution.
a — A constant of proportionality.

Subscripts 1, 2, . . . n relate the above quantities to components 1, 2, . . . n, respectively.

Subscript i refers to an arbitrary component from 1 to n.

Absence of subscript relates the quantity to the mixture.

1B.b. Solution to be applied when there is a reservoir of the solvent mixture whose composition does not change appreciably by evaporation.

Exact Arithmetic Solution of Specific Mixture

Solvent	Mol. wt.	Density	TLV	p° at 25°C	Mol fraction in half-and-half solution by volume
Trichloroethylene (1)	131.4	1.46 g/ml	100	73mm Hg	0.527
Methylchloroform (2)	133.42	1.33 g/ml	350	125mm Hg	0.473

$$F_1p_1^\circ = (0.527)\ (73) = 38.2$$

$$F_2p_2^\circ = (0.473)\ (125) = 59.2$$

$$TLV = \frac{38.2 + 59.2}{\frac{38.2}{100} + \frac{59.2}{350}} = \frac{(97.4)\ (350)}{133.8 + 59.2} =$$

$$\frac{(97.4)\ (350)}{193.0} = 177$$

TLV = 177 ppm (Note difference in TLV when account is taken of vapor pressure and mol fraction in comparison with the above example where such account is not taken.)

2. A mixture of one part of (1) parathion (TLV, 0.1) and two parts of (2) EPN (TLV, 0.5).

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

$$C_m = 3C_1$$

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

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

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

1C. TLV for Mixtures of Mineral Dusts.

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

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

$$TLV = \frac{1}{\frac{0.8}{20} + \frac{0.2}{2.9}} = 8.0\ mppcf$$

Essentially the same result will be obtained if the limit of the more (most) toxic component is used provided the effects are additive. In the above example the limit for 20% quartz is 10 mppcf.

For another mixture of 25% quartz, 25% amorphous silica and 50% talc:

$$TLV = \frac{1}{\frac{0.25}{2.9} + \frac{0.25}{20} + \frac{0.5}{20}} = 7.0\ mppcf$$

The limit for 25% quartz approximates 8 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
	ppm		ppm
Nitrobenzene	1	3	3
Carbon tetrachloride	10	2	20

Substance	TLV	Excursion Factor	Max. Conc. Permitted for short time
	ppm		ppm
o-Dichlorobenzene	50	1.5	75
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.

BASIS FOR ASSIGNING LIMITING "C" VALUES

By definition in the Preface, a listed value bearing a "C" designation refers to a "ceiling" value that should not be exceeded; all values should fluctuate below the listed value. This, in effect, makes the "C" designation a maximal allowable concentration (MAC). In general, the bases for assigning or not assigning a "C" value rest on whether excursions of concentration above a proposed limit *for periods up to 15 minutes* may result in a) intolerable irritation, b) chronic, or irreversible tissue change, or c) narcosis of sufficient degree to increase accident

proneness, impair self-rescue or materially reduce work efficiency.

APPENDIX E

Some Nuisance Particulates[q]

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[r] 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

q) When toxic impurities are not present, e.g. quartz < 1%
r) <7μm in diameter

APPENDIX F

Some Simple Asphyxiants[s]

Acetylene
Argon
Butane
Ethane
Ethylene
Helium
Hydrogen
Methane
Neon
Nitrous oxide
Propane

s) As defined on pg. 6.

*1974 Addition.