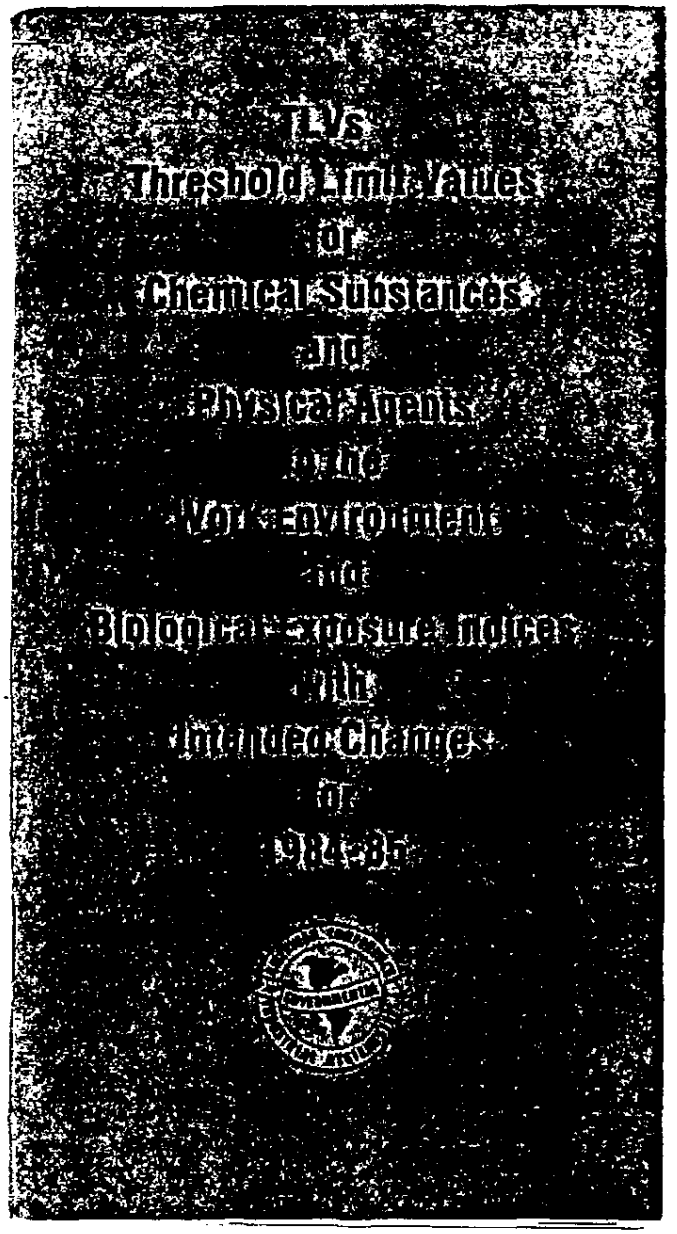
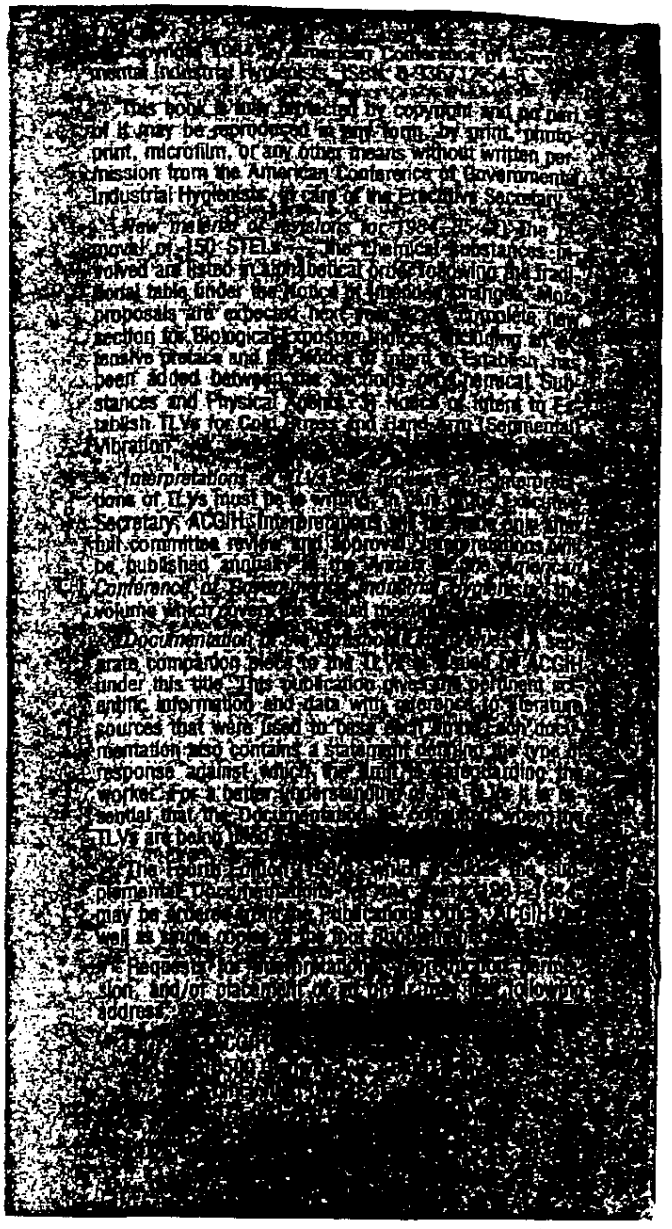

TLVs
Threshold Limit Values
for
Chemical Substances
and
Physical Agents
in the
Work Environment
with
Biological Exposure Indices
with
Intended Changes
for
1984-85



TLVs®
Threshold Limit Values
for
Chemical Substances
in the
Work Environment
Adopted by
ACGIH
for 1984-85

AP00055725

1983-84 CHEMICAL SUBSTANCES TLV COMMITTEE

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PREFACE

CHEMICAL SUBSTANCES

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.

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.

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.

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.

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.

Legal Status. The Threshold Limit Values, as issued by ACGIH, are recommendations and should be used as guidelines for good practices. Wherever these values (of whatever year) have been used or included by reference in Federal and/or State statutes and registers, the TLVs do have the force and effects of law.

"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. Values listed in parenthesis in the "Adopted" list are to be used during the period in which a proposed change for that Value is listed in the Notice of Intended Changes.

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

a) The Threshold Limit Value-Time Weighted Average (TLV-TWA) — the time-weighted average concentration for a normal 8-hour workday and a 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 concentration to which workers can be exposed continuously for a short period of time without suffering from 1) irritation, 2) chronic or irreversible tissue damage, or 3) narcosis of sufficient degree to increase the likelihood of accidental injury, impair self-rescue or materially reduce work efficiency, and provided that the daily TLV-TWA is not exceeded. It is not a separate independent exposure limit, rather it supplements the time-weighted average (TWA) limit where there are recognized acute effects from a substance whose toxic effects are primarily of a chronic nature. STELs are recommended only where toxic effects have been reported from high short-term exposures in either humans or animals.

A STEL is defined as a 15-minute time-weighted average exposure which should not be exceeded at any time during a work day even if the eight-hour time-weighted average is within the TLV. Exposures at the STEL should not be longer than 15 minutes and should not be repeated more than four times per day. There should be at least 60 minutes between successive exposures at the STEL. An averaging period other than 15 minutes may be recommended when this is warranted by observed biological effects.

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 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.

Time-Weighted Average vs Ceiling Limits. 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 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.

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. 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.

Excursion Limits. For the vast majority of substances with a TLV, there is not enough toxicological data available to warrent a STEL. Nevertheless, excursions above the TWA-TLV should be controlled even where the eight-hour TWA is within recommended limits. Earlier editions of the TLV list included such limits whose values depended on the TWA-TLVs of the substance in question.

While no rigorous rationale was provided for these particular values, the basic concept was intuitive: in a well controlled process exposure, excursions should be held within some reasonable limits. Unfortunately, neither toxicology nor collective industrial hygiene experience provide a solid basis for quantifying what those limits should be. The approach here is that the maximum recommended excursion should be related to the variability generally observed in actual industrial processes. Leidel, Busch and Crouse,* in reviewing large numbers of industrial hygiene surveys conducted by NIOSH, found that short-term exposure measurements were generally log normally distributed with geometric standard deviations mostly in the range of 1.5 to 2.0.

While a complete discussion of the theory and properties of the log normal distribution is beyond the scope of this section, a brief description of some important terms is presented. The measure of central tendency in a log normal distribution is the antilog of the mean logarithm of the sample values. The distribution is skewed and the geometric mean is always smaller than the arithmetic mean by an amount which depends on the geometric standard deviation. In the log normal distribution, the geometric standard deviation (sd_g) is the antilog of the standard deviation of the sample value logarithms and 68.26% of all values lie between m_g/sd_g and $m_g \times sd_g$.

If the short-term exposure values in a given situation have a geometric standard deviation of 2.0, 5% of all values exceed 3.13 times the geometric mean. If a process displays a variability greater than this, it is not under good control and efforts should be made to restore con-

*Leidel, N.A., K.A. Busch and W.E. Crouse: *Exposure Measurement, Action Level and Occupational Environmental Variability*, NIOSH Pub. No. 76-131 (December 1975).

trol. This concept is the basis for the new excursion limit recommendations which are as follows:

> *Short-term exposures should exceed three times the TLV-TWA for no more than a total of 30 minutes during a work day and under no circumstances should they exceed five times the TLV, provided that the TLV-TWA is not exceeded.*

The approach is a considerable simplification of the idea of the log normal concentration distribution but is considered more convenient to use by the practicing industrial hygienist. If exposure excursions are maintained within the recommended limits, the geometric standard deviation of the concentration measurements will be near two and the goal of the recommendation will be accomplished.

When the toxicologic data for a specific substance are available to establish a STEL, this value takes precedence over the excursion limit regardless of whether it is more or less stringent.

"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 air borne, or more particularly, by direct contact with the substance. Vehicles can alter skin absorption.

Little quantitative data are available describing absorption of vapors and gases through the skin. The rate of absorption is a function of the concentration to which the skin is exposed.

Substances having a skin notation and a low TLV may present a problem at high airborne concentrations, particularly if a significant area of the skin is exposed for a long period of time. Protection of the respiratory tract, while the rest of the body surface is exposed to a high concentration, may present such a situation.

Biological monitoring should be considered to determine the relative contribution of dermal exposure to the total dose.

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, or, 5 mg/m^3 respirable dust 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 D.

Simple Asphyxiants — "Inert" Gases or Vapors. A number of gases and vapors, when present in high concentrations in air, act primarily as simple asphyxiants without other significant physiologic effects. A TLV may not be recommended for each simple asphyxiant because the limiting factor is the available oxygen. The minimal 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 E.

Physical Factors. It is recognized that such physical factors as heat, ultraviolet and ionizing radiation, humidity, abnormal pressure (altitude) and 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.

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 D pertaining to nuisance particulates. This list (as well as Appendix E) is not meant to be all inclusive; the substances serve only as examples.

In addition there are some substances of not in considerable 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.

Trade Names. Because many chemical substances are marketed under several trade names, the trade names have been replaced with their generic equivalent in the alphabetical listing. Appendix H was created to ease this transition and the CAS number appears with the generic name to aid identification.

Operational Guidelines: The ACGIH Board of Directors has adopted operational guidelines for the Chemical Substances TLV Committee. These guidelines prescribe: charge, authority, policies, membership, organization, and operating procedures. The policies include the appeals procedures. Copies of the guidelines document are available from the Publications Office at a cost of $5 per copy.

NOTE: In the interest of keeping this book as small as possible, the footnotes for adopted values appear on right hand pages only.

		ADOPTED VALUES			
		TWA		STEL	
Substance	[CAS #]	ppm[a]	mg/m³[b]	ppm[a]	mg/m³[b]
Acetaldehyde	[75-07-0]	100	180	150	270
Acetic acid	[64-19-7]	10	25	15	37
Acetic anhydride	[108-24-7]	C 5	C 20	—	—
Acetone	[67-64-1]	750	1,780	1,000	2,375
Acetonitrile	[75-05-8] — Skin	40	70	60	105
Acetylene	[74-86-2]	E	—	—	—
Acetylene dichloride, see 1, 2-Dichloroethylene					
‡Acetylene tetrabromide	[79-27-6]	1	15	(1.5)	(20)
Acetylsalicylic acid (Aspirin)	[50-78-2]	—	5	—	—
Acrolein	[107-02-8]	0.1	0.25	0.3	0.8
Acrylamide	[79-06-1] — Skin	—	0.3	—	0.6
Acrylic acid	[79-10-7]	10	30	—	—
*Acrylonitrile	[107-13-1] — Skin	2, A2	4.5, A2	—	—
‡Aldrin	[309-00-2] — Skin	—	0.25	—	(0.75)
Allyl alcohol	[107-18-6] — Skin	2	5	4	10
Allyl chloride	[107-05-1]	1	3	2	6
Allyl glycidyl ether (AGE)	[106-92-3] — Skin	5	22	10	44
Allyl propyl disulfide	[2179-59-1]	2	12	3	18
‡α-Alumina	[1344-28-1]	—	D	—	(20)
Aluminum	[7429-90-5]				
‡ Metal & oxide		—	10	—	(20)
Pyro powders		—	5	—	—
Welding fumes		—	5	—	—
Soluble salts		—	2	—	—
Alkyls (NOC†)		—	2	—	—
4-Aminodiphenyl	[92-67-1] — Skin	—	A1b	—	—
2-Aminoethanol, see Ethanolamine					
‡2-Aminopyridine	[504-29-0]	0.5	2	(2)	(4)

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.
‡ See Notice of Intended Changes.
* 1984–1985 Addition.
†NOC = Not otherwise classified.
Capital letters A, B, D & E refer to Appendices; C denotes ceiling limit.

Substance [CAS #]	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
3-Amino 1, 2, 4-triazole, see Amitrole				
‡Amitrole [61-82-5]	(A2)	(A2)	—	—
Ammonia [7664-41-7]	25	18	35	27
Ammonium chloride fume [12125-02-9]	—	10	—	20
‡Ammonium sulfamate [7773-06-0]	—	10	—	(20)
n-Amyl acetate [628-63-7], sec-Amyl acetate [626-38-0]	100	530	150	800
‡Aniline [62-53-3] & homologues — Skin	125	670	150	800
Anisidine [29191-52-4] (o-, p-isomers) — Skin	2	10	(5)	(20)
Antimony [7440-36-0] & compounds, as Sb	0.1	0.5	—	—
Antimony trioxide [1309-64-4]	—	0.5	—	—
Handling and use, as Sb	—	0.5	—	—
Production	—	A2	—	—
‡ANTU [86-88-4]	—	0.3	—	(0.9)
Argon [7440-37-1]	E	—	—	—
Arsenic [7440-38-2] & soluble compounds, as As	—	0.2	—	—
Arsenic trioxide production [1327-53-3]	—	A2	—	—
Arsine [7784-42-1]	0.05	0.2	—	—
Asbestos [1332-21-4], see DUSTS	—	A1a	—	—
Asphalt (petroleum) fumes [8052-42-4]	—	5	—	10
Atrazine [1912-24-9]	—	5	—	—
‡Azinphos-methyl [86-50-0] — Skin	—	0.2	—	(0.6)
Barium [7440-39-3], soluble compounds, as Ba	—	0.5	—	—
‡Benomyl [17804-35-2]	0.8	10	(1.3)	(15)
Benzene [71-43-2]	10, A2	30, A2	25, A2	75, A2
Benzidine [92-87-5] — Skin	—	A1b	—	—
p-Benzoquinone, see Quinone				
Benzoyl peroxide [94-36-0]	—	5	—	—
Benzo(a)pyrene [50-32-8]	—	A2	—	—
Benzyl chloride [100-44-7]	1	5	—	—
Beryllium [7440-41-7]	—	0.002, A2	—	—

Substance [CAS #]	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
Biphenyl [92-52-4]	0.2	1.5	0.6	4
‡Bismuth telluride [1304-82-1]	—	10	—	(20)
‡ Se-doped	—	5	—	(10)
Borates, tetra, sodium salts [1303-96-4], Anhydrous	—	1	—	—
Decahydrate	—	5	—	—
Pentahydrate	—	1	—	—
‡Boron oxide [1303-86-2]	—	10	—	(20)
‡Boron tribromide [10294-33-4]	(1)	(10)	(3)	(30)
Boron trifluoride [7637-07-2]	C 1	C 3	—	—
‡Bromacil [314-40-9]	1	10	(2)	(20)
Bromine [7726-95-6]	0.1	0.7	0.3	2
‡Bromine pentafluoride [7789-30-2]	0.1	0.7	(0.3)	(2)
Bromochloromethane, see Chlorobromomethane				
Bromoform [75-25-2] — Skin	0.5	5	—	—
‡1, 3-Butadiene [106-99-0]	(1,000)	(2,200)	(1,250)	(2,750)
Butane [106-97-8]	800	1,900	—	—
Butanethiol, see Butyl mercaptan				
2-Butanone, see Methyl ethyl ketone (MEK)				
2-Butoxyethanol [111-76-2] — Skin	25	120	75	360
n-Butyl acetate [123-86-4]	150	710	200	950
sec-Butyl acetate [105-46-4]	200	950	250	1,190
tert-Butyl acetate [540-88-5]	200	950	250	1,190
Butyl acrylate [141-32-2]	10	55	—	—
n-Butyl alcohol [71-36-3] — Skin	C 50	C 150	—	—
sec-Butyl alcohol [78-92-2]	100	305	150	455
tert-Butyl alcohol [75-65-0]	100	300	150	450
Butylamine [109-73-9] — Skin	C 5	C 15	—	—
tert-Butyl chromate, as CrO_3 [1189-85-1] — Skin	—	C 0.1	—	—
n-Butyl glycidyl ether (BGE) [2426-08-6]	25	135	—	—

Capital letters A, B, D & E refer to Appendices; C denotes ceiling limit
‡See Notice of Intended Changes.

Substance [CAS #]	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
n-Butyl lactate [138-22-7]	5	25	—	—
Butyl mercaptan [109-79-5]	0.5	1.5	—	—
o-sec-Butylphenol [89-72-5] — Skin	5	30	—	—
p-tert-Butyltoluene [98-51-1]	10	60	20	120
‡Cadmium [7440-43-9]				
Dust & salts, as Cd	—	0.05	—	(0.2)
Cadmium oxide [1306-19-0]				
Fume, as Cd	—	C 0.05	—	—
Production	—	0.05	—	—
‡Calcium carbonate/ marble [1317-65-3]	—	D	—	(20)
‡Calcium cyanamide [156-62-7]	—	0.5	—	(1)
Calcium hydroxide [1305-62-0]	—	5	—	—
Calcium oxide [1305-78-8]	—	2	—	—
Calcium silicate [1344-95-2]	—	D	—	—
Camphor, synthetic [76-22-2]	2	12	3	18
Caprolactam [105-60-2]				
Dust	—	1	—	3
Vapor	5	20	10	40
Captafol [2425-06-1] — Skin	—	0.1	—	—
‡Captan [133-06-2]	—	5	—	(15)
‡Carbaryl [63-25-2]	—	5	—	(10)
Carbofuran [1563-66-2]	—	0.1	—	—
‡Carbon black [1333-86-4]	—	3.5	—	(7)
‡Carbon dioxide [124-38-9]	5,000	9,000	(15,000)	(27,000)
Carbon disulfide [75-15-0] — Skin	10	30	—	—
Carbon monoxide [630-08-0]	50	55	400	440
Carbon tetrabromide [558-13-4]	0.1	1.4	0.3	4
‡Carbon tetrachloride [56-23-5] — Skin	5, A2	30, A2	(20, A2)	(125, A2)
Carbonyl chloride, see Phosgene				
Carbonyl fluoride [353-50-4]	2	5	5	15
Catechol (Pyrocatechol) [120-80-9]	5	20	—	—

Substance [CAS #]	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
‡Cellulose (paper fiber) [9004-34-6]	—	D	—	(20)
Cesium hydroxide [21351-79-1]	—	2	—	—
Chlordane [57-74-9] — Skin	—	0.5	—	2
Chlorinated camphene [8001-35-2] — Skin	—	0.5	—	1
Chlorinated diphenyl oxide [55720-99-5]	—	0.5	—	2
Chlorine [7782-50-5]	1	3	3	9
Chlorine dioxide [10049-04-4]	0.1	0.3	0.3	0.9
Chlorine trifluoride [7790-91-2]	C 0.1	C 0.4	—	—
Chloroacetaldehyde [107-20-0]	C 1	C 3	—	—
α-Chloroacetophenone [532-27-4] (Phenacyl chloride)	0.05	0.3	—	—
Chloroacetyl chloride [79-04-9]	0.05	0.2	—	—
Chlorobenzene [108-90-7] (Monochlorobenzene)	75	350	—	—
o-Chlorobenzylidene malononitrile [2698-41-1] — Skin	C 0.05	C 0.4	—	—
Chlorobromomethane [74-97-5]	200	1,050	250	1,300
2-Chloro-1, 3-butadiene, see β Chloroprene				
Chlorodifluoromethane [75-45-6]	1,000	3,500	1,250	4,375
Chlorodiphenyl (42% Chlorine) [53469-21-9] — Skin	—	1	—	2
Chlorodiphenyl (54% Chlorine) [11097-69-1] — Skin	—	0.5	—	1
1-Chloro, 2, 3-epoxy-propane, see Epichlorohydrin				
2-Chloroethanol, see Ethylene chlorohydrin				
Chloroethylene, see Vinyl chloride				
‡Chloroform [67-66-3]	10, A2	50, A2	(50, A2)	(225, A2)
bis-Chloromethyl ether [542-88-1]	0.001, A1a	0.005, A1a	—	—

Capital letters A, B, D & E refer to Appendices; C denotes ceiling limit.
‡See Notice of Intended Changes.

Substance	[CAS #]	ADOPTED VALUES TWA ppm[c]	TWA mg/m³[b]	STEL ppm[c]	STEL mg/m³[b]
Chloromethyl methyl ether	[107-30-2]	A2	A2	—	—
1-Chloro-1-nitropropane	[600-25-9]	2	10	—	—
Chloropentafluoroethane	[76-15-3]	1,000	6,320	—	—
Chloropicrin	[76-06-2]	0.1	0.7	0.3	2
β-Chloroprene	[126-99-8] — Skin	10	45	—	—
o-Chlorostyrene	[1331-28-8]	50	285	75	430
o-Chlorotoluene	[95-49-8]	50	250	75	375
2-Chloro- 6-(trichloromethyl) pyridine, see Nitrapyrin					
Chlorpyrifos	[2921-88-2] — Skin	—	0.2	—	0.6
Chromite ore processing	(Chromate), as Cr	—	0.05, A1a	—	—
Chromium	[7440-47-3] Metal	—	0.5	—	—
Chromium (II) compounds,	as Cr	—	0.5	—	—
Chromium (III)	compounds, as Cr	—	0.5	—	—
Chromium (VI)	compounds, as Cr				
	Water soluble	—	0.05	—	—
	Certain water insoluble	—	0.05, A1a	—	—
Chromyl chloride	[14977-61-8]	0.025	0.15	—	—
Chrysene	[218-01-9]	A2	A2	—	—
Clopidol	[2971-90-6]	—	10	—	20
Coal tar pitch volatiles	[8007-45-2], as benzene solubles	—	0.2, A1a	—	—
‡Cobalt	[7440-48-4], as Co metal, dust & fume	—	(0.1)	—	—
Cobalt carbonyl	[00000-00-0], as Co	—	0.1	—	—
Cobalt hydrocarbonyl	[16842-03-8], as Co	—	0.1	—	—
Copper	[7440-50-8] Fume	—	0.2	—	—
‡	Dusts & mists, as Cu	—	1	—	(2)
‡Cotton dust, raw		—	0.2[d]	—	(0.5)
Cresol	[1319-77-3], all isomers — Skin	5	22	—	—
Crotonaldehyde	[123-73-9]	2	6	6	18

Substance	[CAS #]	ADOPTED VALUES TWA ppm[c]	TWA mg/m³[b]	STEL ppm[c]	STEL mg/m³[b]
Crufomate	[299-86-5]	—	5	—	20
Cumene	[98-82-8] — Skin	50	245	75	365
Cyanamide	[420-04-2]	—	2	—	—
Cyanides	[151-50-8; 143-33-9], as CN — Skin	—	5	—	—
Cyanogen	[460-19-5]	10	20	—	—
Cyanogen chloride	[506-77-4]	C 0.3	C 0.6	—	—
Cyclohexane	[110-82-7]	300	1,050	375	1,300
Cyclohexanol	[108-93-0]	50	200	—	—
Cyclohexanone	[108-94-1]	25	100	100	400
Cyclohexene	[110-83-8]	300	1,015	—	—
Cyclohexylamine	[108-91-8] — Skin	10	40	—	—
Cyclonite	[121-82-4] — Skin	—	1.5	—	3
Cyclopentadiene	[542-92-7]	75	200	150	400
Cyclopentane	[287-92-3]	600	1,720	900	2,580
‡Cyhexatin	[13121-70-5]	—	5	—	(10)
‡2, 4-D	[94-75-7]	—	10	—	(20)
‡DDT (Dichlorodiphenyl-trichloroethane)	[50-29-3]	—	1	—	(3)
Decaborane	[17702-41-9] — Skin	0.05	0.3	0.15	0.9
‡Demeton	[8065-48-3] — Skin	0.01	0.1	(0.03)	(0.3)
Diacetone alcohol	[123-42-2]	50	240	75	360
1, 2-Diaminoethane, see Ethylenediamine					
‡Diazinon	[333-41-5] — Skin	—	0.1	—	(0.3)
Diazomethane	[334-88-3]	0.2	0.4	—	—
Diborane	[19287-45-7]	0.1	0.1	—	—
1, 2-Dibromoethane, see Ethylene dibromide					
‡2-N-Dibutylaminoethanol	[102-81-8] — Skin	2	14	(4)	(28)
Dibutyl phosphate		1	5	2	10
Dibutyl phthalate	[84-74-2]	—	5	—	10

Capital letters A, B, D & E refer to Appendices; C denotes ceiling limit.
‡See Notice of Intended Changes.
d) Lint-free dust as measured by the vertical elutriator cotton-dust sampler described in the *Transactions of the National Conference on Cotton Dust*, p. 33 by J. R. Lynch, (May 2, 1970).

Substance [CAS #]	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
Dichloroacetylene [7572-29-4]	C 0.1	C 0.4	—	—
o-Dichlorobenzene [95-50-1]	C 50	C 300	—	—
p-Dichlorobenzene [106-46-7]	75	450	110	675
3,3'-Dichlorobenzidine [91-94-1] — Skin	—	A2	—	A2
‡Dichlorodifluoromethane [75-71-8]	1,000	4,950	(1,250)	(6,200)
1, 3-Dichloro-5, 5-dimethyl hydantoin [118-52-5]	—	0.2	—	0.4
1, 1-Dichloroethane [75-34-3]	200	810	250	1,010
1, 2-Dichloroethane, see Ethylene dichloride				
1, 1-Dichloroethylene, see Vinylidene chloride				
1, 2-Dichloroethylene [540-59-0]	200	790	250	1,000
Dichloroethyl ether [111-44-4] — Skin	5	30	10	60
Dichlorofluoromethane [75-43-4]	10	40	—	—
Dichloromethane, see Methylene chloride				
‡1, 1-Dichloro-1-nitroethane [594-72-9]	2	10	(10)	(60)
1, 2-Dichloropropane, see Propylene dichloride				
‡Dichloropropene [542-75-6] — Skin	1	5	(10)	(50)
2, 2-Dichloropropionic acid [75-99-0]	1	6	—	—
‡Dichlorotetrafluoroethane [76-14-2]	1,000	7,000	(1,250)	(8,750)
‡Dichlorvos [62-73-7] — Skin	0.1	1	(0.3)	(3)
Dicrotophos [141-66-2] — Skin	—	0.25	—	—
Dicyclopentadiene [77-73-6]	5	30	—	—
‡Dicyclopentadienyl iron [102-54-5]	—	10	—	(20)
‡Dieldrin [60-57-1] — Skin	—	0.25	—	(0.75)
Diethanolamine [111-42-2]	3	15	—	—
Diethylamine [109-89-7]	10	30	25	75
Diethylaminoethanol [100-37-8] — Skin	10	50	—	—
Diethylene triamine [111-40-0] — Skin	1	4	—	—

Substance [CAS #]	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
Diethyl ether, see Ethyl ether				
Diethyl ketone [96-22-0]	200	705	—	—
Diethyl phthalate [84-66-2]	—	5	—	10
‡Difluorodibromomethane [75-61-6]	100	860	(150)	(1,290)
Diglycidyl ether (DGE) [2238-07-5]	0.1	0.5	—	—
Dihydroxybenzene, see Hydroquinone				
Diisobutyl ketone [108-83-8]	25	150	—	—
Diisopropylamine [108-18-9] — Skin	5	20	—	—
Dimethoxymethane, see Methylal				
‡Dimethyl acetamide [127-19-5] — Skin	10	35	(15)	(50)
Dimethylamine [124-40-3]	10	18	—	—
Dimethylaminobenzene, see Xylidene				
Dimethylaniline [121-69-7] (N, N-Dimethylaniline) — Skin	5	25	10	50
Dimethylbenzene, see Xylene				
Dimethyl carbamyl chloride [79-44-7]	A2	A2	—	—
Dimethyl-1, 2-dibromo-2-dichloroethyl phosphate, see Naled				
‡Dimethylformamide [68-12-2] — Skin	10	30	(20)	(60)
2, 6-Dimethyl-4-heptanone, see Diisobutyl ketone				
‡1, 1-Dimethylhydrazine [57-14-7] — Skin	0.5, A2	1, A2	(1, A2)	(2, A2)
‡Dimethylphthalate [131-11-3]	—	5	—	(10)
Dimethyl sulfate [77-78-1] — Skin	0.1, A2	0.5, A2	—	—
Dinitolmide [148-01-6]	—	5	—	10
‡Dinitrobenzene [528-29-0; 99-65-0; 100-25-4] (all isomers) — Skin	0.15	1	(0.5)	(3)
‡Dinitro-o-cresol [534-52-1] — Skin	—	0.2	—	(0.6)
3, 5-Dinitro-o-toluamide, see Dinitolmide				
‡Dinitrotoluene [121-14-2] — Skin	—	1.5	—	(5)
‡Dioxane, tech. grade [123-91-1] — Skin	25	90	(100)	(360)

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‡ See Notice of Intended Changes.

Substance (CAS #)	ADOPTED VALUES TWA ppm[1]	TWA mg/m³[2]	STEL ppm[1]	STEL mg/m³[2]
Dioxathion [78-34-2] — Skin	—	0.2	—	—
Diphenyl, see Biphenyl				
‡Diphenylamine [122-39-4]	—	10	—	(20)
Diphenylmethane diisocyanate, see Methylene bisphenyl isocyanate				
Dipropylene glycol methyl ether [34590-94-8]	100	600	150	900
Dipropyl ketone [123-19-3]	50	235	—	—
‡Diquat [85-00-7]	—	0.5	—	(1)
Di-sec, octyl phthalate [117-81-7] (Di-2-ethylhexylphthalate)	—	5	—	10
‡Disulfiram [97-77-8]	—	2	—	(5)
‡Disulfoton [298-04-4]	—	0.1	—	(0.3)
2, 6-Ditert. butyl-p-cresol [128-37-0]	—	10	—	20
Diuron [330-54-1]	—	10	—	—
Divinyl benzene [108-57-6]	10	50	—	—
‡Emery [112-62-9]	—	D	—	(20)
‡Endosulfan [115-29-7] — Skin	—	0.1	—	(0.3)
‡Endrin [72-20-8] — Skin	—	0.1	—	(0.3)
‡Epichlorohydrin [106-89-8] — Skin	2	10	(5)	(20)
‡EPN [2104-64-5] — Skin	—	0.5	—	(2)
1, 2-Epoxypropane, see Propylene oxide				
2, 3-Epoxy-1-propanol, see Glycidol				
Ethane [74-84-0]	E	—	—	—
Ethanethiol, see Ethyl mercaptan				
Ethanolamine [141-43-5]	3	8	6	15
Ethion [563-12-2] — Skin	—	0.4	—	—
*2-Ethoxyethanol [110-80-5] — Skin	5	9	—	—
*2-Ethoxyethyl acetate [111-15-9] — Skin	5	27	—	—
Ethyl acetate [141-78-6]	400	1,400	—	—
Ethyl acrylate [140-88-5] — Skin	5	20	25	100
Ethyl alcohol (Ethanol) [64-17-5]	1,000	1,900	—	—
Ethylamine [75-04-7]	10	18	—	—
Ethyl amyl ketone [541-85-5]	25	130	—	—
Ethyl benzene [100-41-4]	100	435	125	545
Ethyl bromide [74-96-4]	200	890	250	1,110
Ethyl butyl ketone [106-35-4]	50	230	75	345

Substance (CAS #)	ADOPTED VALUES TWA ppm[1]	TWA mg/m³[2]	STEL ppm[1]	STEL mg/m³[2]
‡Ethyl chloride [75-00-3]	1,000	2,600	(1,250)	(3,250)
Ethylene [74-85-1]	E	—	—	—
Ethylene chlorohydrin [107-07-3] — Skin	C 1	C 3	—	—
Ethylenediamine [107-15-3]	10	25	—	—
Ethylene dibromide [106-93-4] — Skin	A2	A2	—	—
‡Ethylene dichloride [107-06-2]	10	40	(15)	(60)
Ethylene glycol [107-21-1] Vapor	C 50	C 125	—	—
‡Ethylene glycol dinitrate [628-96-6] — Skin	0.05	0.3	(0.1)	(0.6)
Ethylene glycol methyl ether acetate, see 2-Methoxyethyl acetate				
* Ethylene oxide [75-21-8]	1,A2	2,A2	—	—
Ethyleneimine [151-56-4] — Skin	0.5	1	—	—
Ethyl ether [60-29-7]	400	1,200	500	1,500
Ethyl formate [109-94-4]	100	300	150	450
Ethylidene chloride, see 1, 1-Dichloroethane				
Ethylidene norbornene [16219-75-3]	C 5	C 25	—	—
‡Ethyl mercaptan [75-08-1]	0.5	1	(2)	(3)
‡N-Ethylmorpholine [100-74-3] — Skin	5	23	(20)	(95)
‡Ethyl silicate [78-10-4]	10	85	(30)	(255)
*Fenamiphos [22224-92-6] — Skin	—	0.1	—	—
Fensulfothion [115-90-2]	—	0.1	—	—
Fenthion [55-38-9] — Skin	—	0.2	—	—
‡Ferbam [14484-64-1]	—	10	—	(20)
Ferrovanadium dust [12604-58-9]	—	1	—	3
Fibrous glass dust	—	10	—	—
Fluorides, as F	—	2.5	—	—
Fluorine [7782-41-4]	1	2	2	4
Fluorotrichloromethane, see Trichlorofluoromethane				
Fonofos [944-22-9] — Skin	—	0.1	—	—
‡Formaldehyde [50-00-0]	(C 2)	(C 3)	—	—
‡Formamide [75-12-7]	20	30	(30)	(45)
Formic acid [64-18-6]	5	9	—	—

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*1984–1985 Addition
‡See Notice of Intended Changes.

Substance	[CAS #]	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
Furfural	[98-01-1] — Skin	2	8	10	40
Furfuryl alcohol	[98-00-0] — Skin	10	40	15	60
Gasoline	[8006-61-9]	300	900	500	1,500
‡Germanium tetrahydride	[7782-65-2]	0.2	0.6	(0.6)	(1.8)
Glass, fibrous or dust, see Fibrous glass dust					
Glutaraldehyde	[111-30-8]	C 0.2	C 0.7	—	—
Glycerin mist	[56-81-5]	—	D	—	—
Glycidol	[556-52-5]	25	75	100	300
Glycol monoethyl ether, see 2-Ethoxyethanol					
Graphite (Natural)	[7782-42-5], see DUSTS				
‡Graphite (Synthetic)		—	(D)	—	—
‡Gypsum	[10101-41-4]	—	D	—	(20)
‡Hafnium	[7440-58-6]	—	0.5	—	(1.5)
Helium	[7440-59-7]	E	—	—	—
‡Heptachlor	[76-44-8] — Skin	—	0.5	—	(2)
Heptane (n-Heptane)	[142-82-5]	400	1,600	500	2,000
2-Heptanone, see Methyl n-amyl ketone					
3-Heptanone, see Ethyl butyl ketone					
Hexachlorobutadiene	[87-68-3] — Skin	0.02, A2	0.24, A2	—	—
‡Hexachlorocyclopentadiene	[77-47-4]	0.01	0.1	(0.03)	(0.3)
Hexachloroethane	[67-72-1]	10	100	—	—
‡Hexachloronaphthalene	[1335-87-1] — Skin	—	0.2	—	(0.6)
‡Hexafluoroacetone	[684-16-2] — Skin	0.1	0.7	(0.3)	(2)
Hexamethyl phosphoramide	[680-31-9] — Skin	A2	A2	—	—
Hexane (n-Hexane)	[110-54-3]	50	180	—	—
Other isomers		500	1,800	1,000	3,600
2-Hexanone, see Methyl n-butyl ketone					
Hexone, see Methyl isobutyl ketone					
sec-Hexyl acetate	[142-92-7]	50	300	—	—
Hexylene glycol	[107-41-5]	C 25	C 125	—	—
Hydrazine	[302-01-2] — Skin	0.1, A2	0.1, A2	—	—
Hydrogen	[1333-74-0]	E	—	—	—
Hydrogenated terphenyls	[92-94-4]	0.5	5	—	—

Substance	[CAS #]	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
‡Hydrogen bromide	[10035-10-6]	(3)	(10)	—	—
Hydrogen chloride	[7647-01-0]	C 5	C 7	—	—
Hydrogen cyanide	[74-90-8] — Skin	C 10	C 10	—	—
‡Hydrogen fluoride	[7664-39-3], as F	(3)	(2.5)	(6)	(5)
‡Hydrogen peroxide	[7722-84-1]	1	1.5	(2)	(3)
Hydrogen selenide	[7783-07-5], as Se	0.05	0.2	—	—
Hydrogen sulfide	[7783-06-4]	10	14	15	21
Hydroquinone	[123-31-9]	—	2	—	4
4-Hydroxy-4-methyl-2-pentanone, see Diacetone alcohol					
2-Hydroxypropyl acrylate	[999-61-1] — Skin	0.5	3	—	—
Indene	[95-13-6]	10	45	15	70
‡Indium	[7440-74-6] & compounds, as In	—	0.1	—	(0.3)
Iodine	[7553-56-2]	C 0.1	C 1	—	—
‡Iodoform	[75-47-8]	0.6	10	(1)	(20)
‡Iron oxide fume (Fe_2O_3)	[1309-37-1], as Fe	B2	5	—	(10)
Iron pentacarbonyl	[13463-40-6], as Fe	0.1	0.8	0.2	1.6
‡Iron salts, soluble, as Fe		—	1	—	(2)
Isoamyl acetate	[123-92-2]	100	525	125	655
Isoamyl alcohol	[123-51-3]	100	360	125	450
Isobutyl acetate	[110-19-0]	150	700	187	875
Isobutyl alcohol	[78-83-1]	50	150	75	225
Isooctyl alcohol	[26952-21-6]	50	270	—	—
Isophorone	[78-59-1]	C 5	C 25	—	—
Isophorone diisocyanate — Skin		0.01	0.09	—	—
Isopropoxyethanol	[109-59-1]	25	105	75	320
Isopropyl acetate	[108-21-4]	250	950	310	1,185
Isopropyl alcohol	[67-63-0]	400	980	500	1,225
Isopropylamine	[75-31-0]	5	12	10	24

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‡Notice of Intended Changes.

Substance [CAS #]	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
‡N-Isopropylaniline [643-28-7] — Skin	2	10	(5)	(20)
Isopropyl ether [108-20-3]	250	1,050	310	1,320
Isopropyl glycidyl ether [4016-14-2] (IGE)	50	240	75	360
‡Kaolin	—	D	—	(20)
Ketene [463-51-4]	0.5	0.9	1.5	3
‡Lead [7439-92-1], inorg., dusts & fumes, as Pb	—	0.15	—	(0.45)
‡Lead arsenate [10102-48-4], as $Pb_3(AsO_4)_2$	—	0.15	—	(0.45)
Lead chromate [18454-12-1], as Cr	—	0.05, A2	—	—
‡Limestone [1317-65-3]	—	D	—	(20)
‡Lindane [58-89-9] — Skin	—	0.5	—	(1.5)
Lithium hydride [7580-67-8]	—	0.025	—	—
L.P.G. (Liquified petroleum gas)	1,000	1,800	1,250	2,250
‡Magnesite [546-93-0]	—	D	—	(20)
Magnesium oxide fume [1309-48-4]	—	10	—	—
Malathion [121-75-5] — Skin	—	10	—	—
Maleic anhydride [108-31-6]	0.25	1	—	—
Manganese [7439-96-5], as Mn				
Dust & compounds	—	C 5	—	—
Fume	—	1	—	3
‡Maganese cyclopentadienyl tricarbonyl [12079-65-1], as Mn — Skin	—	0.1	—	(0.3)
Manganese tetroxide	—	1	—	—
‡Marble/calcium carbonate [1317-65-3]	—	D	—	(20)
Mercury [7439-97-6], as Hg — Skin				
Alkyl compounds	—	0.01	—	0.03
All forms except alkyl Vapor	—	0.05	—	—
Aryl & inorganic compounds	—	0.1	—	—
Mesityl oxide [141-79-7]	15	60	25	100
Methacrylic acid [79-41-4]	20	70	—	—
Methane [74-82-8]	E	—	—	—

Substance [CAS #]	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
Methanethiol, see Methyl mercaptan				
Methomyl [16752-77-5] — Skin	—	2.5	—	—
Methoxychlor [72-43-5]	—	10	—	—
*2-Methoxyethanol [109-86-4] — Skin	5	16	—	—
*2-Methoxyethyl acetate [110-49-6] — Skin	5	24	—	—
4-Methoxyphenol [150-76-5]	—	5	—	—
Methyl acetate [79-20-9]	200	610	250	760
Methyl acetylene [74-99-7]	1,000	1,650	1,250	2,040
Methyl acetylene-propadiene mixture (MAPP)	1,000	1,800	1,250	2,250
Methyl acrylate [96-33-3] — Skin	10	35	—	—
‡Methylacrylonitrile [126-98-7] — Skin	1	3	(2)	(6)
Methylal [109-87-5]	1,000	3,100	1,250	3,875
Methyl alcohol [67-56-1] (methanol) — Skin	200	260	250	310
Methylamine [74-89-5]	10	12	—	—
Methyl amyl alcohol, see Methyl isobutyl carbinol				
Methyl n-amyl ketone [110-43-0]	50	235	100	465
‡N-Methyl aniline [100-61-8] — Skin	0.5	2	(1)	(5)
‡Methyl bromide [74-83-9] — Skin	5	20	(15)	(60)
Methyl n-butyl ketone [591-78-6]	5	20	—	—
Methyl chloride [74-87-3]	50	105	100	205
Methyl chloroform [71-55-6]	350	1,900	450	2,450
Methyl 2-cyanoacrylate [137-05-3]	2	8	4	16
Methylcyclohexane [108-87-2]	400	1,600	500	2,000
Methylcyclohexanol [25639-42-3]	50	235	75	350
o-Methylcyclohexanone [583-60-8] — Skin	50	230	75	345

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‡See Notice of Intended Changes.
*1984–1985 Addition.

Substance (CAS #)	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
‡Methylcyclopentadienyl manganese tricarbonyl, [12108-13-3] — Skin, as Mn	—	0.2	—	(0.6)
‡Methyl demeton [8022-00-2] — Skin	—	0.5	—	(1.5)
Methylene bisphenyl isocyanate (MDI) [101-68-8]	C 0.02	C 0.2	—	—
‡Methylene chloride [75-09-2]	100	350	(500)	(1,740)
4, 4'-Methylene bis (2-chloroaniline) [101-14-4] — Skin	0.02, A2	0.22, A2	—	—
Methylene bis(4-cyclohexylisocyanate) [5124-30-1]	C 0.01	C 0.11	—	—
‡4, 4-Methylene dianiline [101-77-9] — Skin	(0.1)	(0.8)	(0.5)	(4)
Methyl ethyl ketone (MEK) [78-93-3]	200	590	300	885
Methyl ethyl ketone peroxide [1338-23-4]	C 0.2	C 1.5	—	—
Methyl formate [107-31-3]	100	250	150	375
5-Methyl-3-heptanone, see Ethyl amyl ketone				
Methyl hydrazine [60-34-4] — Skin	C 0.2, A2	C 0.35, A2	—	—
‡Methyl iodide [74-88-4] — Skin	2, A2	10, A2	(5, A2)	(30, A2)
Methyl isoamyl ketone [110-12-3]	50	240	—	—
Methyl isobutyl carbinol [108-11-2] — Skin	25	100	40	165
Methyl isobutyl ketone [108-10-1]	50	205	75	300
Methyl isocyanate [624-83-9]	0.02	0.05	—	—
Methyl isopropyl ketone [563-80-4]	200	705	—	—
Methyl mercaptan [74-93-1]	0.5	1	—	—
Methyl methacrylate [80-62-6]	100	410	125	510
‡Methyl parathion [298-00-0] — Skin	—	0.2	—	(0.6)

Substance (CAS #)	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
Methyl propyl ketone [107-87-9]	200	700	250	875
‡Methyl silicate [681-84-5]	1	6	(5)	(30)
α-Methyl styrene [98-83-9]	50	240	100	485
* Metribuzin [21087-64-9]	—	5	—	—
Mevinphos [7786-34-7] — Skin	0.01	0.1	0.03	0.3
Molybdenum [7439-98-7], as Mo				
‡ Soluble compounds	—	5	—	(10)
‡ Insoluble compounds	—	10	—	(20)
Monocrotophos [6923-22-4]	—	0.25	—	—
Morpholine [110-91-8] — Skin	20	70	30	105
‡Naled [300-76-5]	—	3	—	(6)
Naphthalene [91-20-3]	10	50	15	75
β-Naphthylamine [91-59-8]	—	A1b	—	—
Neon [7440-01-9]	E	—	—	—
Nickel carbonyl, as Ni	0.05	0.35	—	—
Nickel [7440-02-0] Metal	—	1	—	—
‡ Soluble compounds, as Ni	—	0.1	—	(0.3)
Nickel carbonyl [13463-39-3], as Ni	0.05	0.35	—	—
Nickel sulfide roasting, fume & dust, as Ni	—	1, A1a	—	—
‡Nicotine [54-11-5] — Skin	—	0.5	—	(1.5)
Nitrapyrin [1929-82-4]	—	10	—	20
Nitric acid [7697-37-2]	2	5	4	10
‡Nitric oxide [10102-43-9]	25	30	(35)	(45)
p-Nitroaniline [100-01-6] — Skin	—	3	—	—
‡Nitrobenzene — Skin	1	5	(2)	(10)
‡p-Nitrochlorobenzene [100-00-5] — Skin	—	(1)	—	(2)
4-Nitrodiphenyl [92-93-3]	—	A1b	—	—
‡Nitroethane [79-24-3]	100	310	(150)	(465)
Nitrogen dioxide [10102-44-0]	3	6	5	10

Capital letters A, B, D & E refer to Appendices; C denotes ceiling limit.
‡See Notices of Intended Changes.
*1984–1985 Addition.

Substance [CAS #]	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
‡Nitrogen trifluoride [7783-54-2]	10	30	(15)	(45)
‡Nitroglycerin (NG) [55-63-0] — Skin	0.05	0.5	(0.1)	(1)
‡Nitromethane [75-52-5]	100	250	(150)	(375)
‡1-Nitropropane [108-03-2]	25	90	(35)	(135)
‡2-Nitropropane [79-46-9]	(C 25, A2)	(C 90, A2)	—	—
N-Nitrosodimethylamine [62-75-9] (dimethylnitrosoamine) — Skin	—	A2	—	—
Nitrotoluene [99-08-1] — Skin	2	11	—	—
Nitrotrichloromethane, see Chloropicrin				
Nonane [111-84-2]	200	1,050	250	1,300
Octachloronaphthalene [2234-13-1] — Skin	—	0.1	—	0.3
Octane [111-65-9]	300	1,450	375	1,800
Oil mist, mineral [8012-95-1]	—	5[e]	—	10
Osmium tetroxide [20816-12-0], as Os	0.0002	0.002	0.0006	0.006
Oxalic acid [144-62-7]	—	1	—	2
‡Oxygen difluoride [7783-41-7]	(0.05)	(0.1)	(0.15)	(0.3)
Ozone [10028-15-6]	0.1	0.2	0.3	0.6
Paraffin wax fume [8002-74-2]	—	2	—	6
Paraquat [1910-42-5], respirable sizes	—	0.1	—	—
‡Parathion [56-38-2] — Skin	—	0.1	—	(0.3)
Particulate polycyclic aromatic hydrocarbons (PPAH), see Coal tar pitch volatiles				
Pentaborane [19624-22-7]	0.005	0.01	0.015	0.03
‡Pentachloronaphthalene [1321-64-8]	—	0.5	—	(2)
‡Pentachlorophenol [87-86-5] — Skin	—	0.5	—	(1.5)
‡Pentaerythritol [115-77-5]	—	D	—	(20)
Pentane [109-66-0]	600	1,800	750	2,250
2-Pentanone, see Methyl propyl ketone				
*Perchloroethylene [127-18-4]	50	335	200	1,340
Perchloromethyl mercaptan [594-42-3]	0.1	0.8	—	—

Substance [CAS #]	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
Perchloryl fluoride [7616-94-6]	3	14	6	28
Phenol [108-95-2] — Skin	5	19	10	38
‡Phenothiazine [92-84-2] — Skin	—	5	—	(10)
N-Phenyl-beta-naphthylamine [135-88-6]	A2	A2	—	—
p-Phenylene diamine [106-50-3] — Skin	—	0.1	—	—
Phenyl ether [101-84-8], vapor	1	7	2	14
Phenylethylene, see Styrene, monomer				
Phenyl glycidyl ether (PGE) [122-60-1]	1	6	—	—
‡Phenylhydrazine [100-63-0] — Skin	(5)	(20)	(10)	(45)
Phenyl mercaptan [108-98-5]	0.5	2	—	—
Phenylphosphine [638-21-1]	C 0.05	C 0.25	—	—
Phorate [298-02-2] — Skin	—	0.05	—	0.2
Phosdrin, see Mevinphos				
Phosgene [75-44-5]	0.1	0.4	—	—
Phosphine [7803-51-2]	0.3	0.4	1	1
Phosphoric acid [7664-38-2]	—	1	—	3
‡Phosphorus [7723-14-0] (yellow)	—	0.1	—	(0.3)
Phosphorus oxychloride [10026-13-8]	0.1	0.6	0.5	3
Phosphorus pentachloride [10026-13-8]	0.1	1	—	—
Phosphorus pentasulfide [1314-80-3]	—	1	—	3
Phosphorus trichloride [7719-12-2]	0.2	1.5	0.5	3
Phthalic anhydride [85-44-9]	1	6	4	24
m-Phthalodinitrile [626-17-5]	—	5	—	—
Picloram [1918-02-1]	—	10	—	20

Capital letters A, B, D & E refer to Appendices; C denotes ceiling limit.
‡See Notice of Intended Changes.
*1984–1985 Addition.
e) As sampled by method that does not collect vapor.

Substance (CAS #)	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
Picric acid (88-89-1] — Skin	—	0.1	—	0.3
Pindone (83-26-1]	—	0.1	—	0.3
Piperazine dihydrochloride (142-64-3]	—	5	—	—
2-Pivalyl-1, 3-indandione, see Pindone				
‡Plaster of Paris	—	D	—	(20)
Platinum (7440-06-4]				
Metal	—	1	—	—
Soluble salts, as Pt	—	0.002	—	—
Polychlorobiphenyls, see Chlorodiphenyls				
Polytetrafluoroethylene decomposition products	—	B1	—	—
Portland cement	—	D	—	—
Potassium hydroxide (1310-58-3]	—	C 2	—	—
Propane (74-98-6]	E	—	—	—
Propane sultone (1120-71-4]	A2	A2	—	—
Propargyl alcohol (107-19-7] — Skin	1	2	3	6
β-Propiolactone (57-57-8].	0.5, A2	1.5, A2	1, A2	3, A2
Propionic acid (79-09-4]	10	30	15	45
Propoxur (114-26-1]	—	0.5	—	2
n-Propyl acetate (109-60-4]	200	840	250	1,050
Propyl alcohol (71-23-8] — Skin	200	500	250	625
n-Propyl nitrate (627-13-4]	25	105	40	170
Propylene (115-07-1]	E	—	—	—
Propylene dichloride (78-87-5]	75	350	110	510
‡Propylene glycol dinitrate (6423-43-4] — Skin	0.05	0.3	(0.1)	(0.6)
Propylene glycol monomethyl ether (107-98-2].	100	360	150	540
Propyleneimine (75-55-8] — Skin	2, A2	5, A2	—	—
Propylene oxide (75-56-9].	20	50	—	—
Propyne, see Methyl acetylene				
Pyrethrum (8003-34-7]	—	5	—	10
Pyridine (110-86-1]	5	15	10	30
Quinone (106-51-4]	0.1	0.4	0.3	1
RDX, see Cyclonite				
Resorcinol (108-46-3]	10	45	20	90
Rhodium (7440-16-6]				
Metal	—	1	—	—

Substance (CAS #)	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
* Insoluble compounds, as Rh	—	1	—	—
* Soluble compounds, as Rh	—	0.01	—	—
Ronnel (299-84-3]	—	10	—	—
Rosin core solder pyrolysis products, as formaldehyde	—	0.1	—	0.3
Rotenone (commercial) (83-79-4]	—	5	—	10
‡Rouge	—	D	—	(20)
Rubber solvent (Naphtha)	400	1,600	—	—
Selenium compounds (7782-49-2], as Se	—	0.2	—	—
Selenium hexafluoride (7783-79-1], as Se	0.05	0.2	—	—
‡Sesone (136-78-7]	—	10	—	(20)
Silane, see Silicon tetrahydride				
‡Silicon (7440-21-3]	—	D	—	(20)
‡Silicon carbide (409-21-2].	—	D	—	(20)
Silicon tetrahydride (Silane) (7803-62-5]	5	7	—	—
Silver (7440-22-4], as Ag				
Metal	—	0.1	—	—
Soluble compounds	—	0.01	—	—
Sodium azide (26628-22-8]	C 0.1	C 0.3	—	—
Sodium bisulfite (7631-90-5]	—	5	—	—
Sodium 2, 4-dichloro-phenoxyethyl sulfate, see Sesone				
Sodium fluoroacetate (62-74-8] — Skin	—	0.05	—	0.15
Sodium hydroxide (1310-73-2]	—	C 2	—	—
Sodium metabisulfite (7681-57-4]	—	5	—	—
‡Starch (9005-25-8]	—	D	—	(20)
‡Stibine (7803-52-3]	0.1	0.5	(0.3)	(1.5)
Stoddard solvent (8052-41-3]	100	525	200	1,050
‡Strychnine (57-24-9]	—	0.15	—	(0.45)
Styrene, monomer (100-42-5]	50	215	100	425

Capital letters A, B, D & E refer to Appendices; C denotes ceiling limit.
*1984–1985 Addition
‡See Notice of Intended Changes.

Substance [CAS #]	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
Subtilisins [1395-21-7] (Proteolytic enzymes as 100% pure crystaline enzyme)	—	C0.00006[f]	—	—
Sucrose [57-50-1]	—	D	—	20
‡Sulfotep [3689-24-5] — Skin	—	0.2	—	(0.6)
‡Sulfur dioxide [7446-09-5]	2	5	(5)	(10)
‡Sulfur hexafluoride [2551-62-4]	1,000	6,000	(1,250)	(7,500)
Sulfuric acid [7664-93-9]	—	1	—	—
‡Sulfur monochloride [10025-67-9]	(1)	(6)	(3)	(18)
‡Sulfur pentafluoride [5714-22-7]	(0.025)	(0.25)	(0.075)	(0.75)
‡Sulfur tetrafluoride [7783-60-0]	(0.1)	(0.4)	(0.3)	(1)
Sulfuryl fluoride [2699-79-8]	5	20	10	40
*Sulprofos [35400-43-2]	—	1	—	—
Systox, see Demeton				
‡2, 4, 5-T [93-76-5]	—	10	—	(20)
‡Tantalum [7440-25-7]	—	5	—	(10)
TEDP, see Sulfotep				
Tellurium & compounds [13494-80-9], as Te	—	0.1	—	—
Tellurium hexafluoride [7783-80-4], as Te	0.02	0.2	—	—
‡Temephos [3383-96-8]	—	10	—	(20)
‡TEPP [107-49-3] — Skin	0.004	0.05	(0.01)	(0.2)
Terphenyls [92-94-4]	C 0.5	C 5	—	—
‡1, 1, 1, 2-Tetrachloro-2, 2-difluoroethane [76-11-9]	500	4,170	(625)	(5,210)
‡1, 1, 2, 2-Tetrachloro-1, 2-difluoroethane [76-12-0]	500	4,170	(625)	(5,210)
‡1, 1, 2, 2-Tetrachloroethane [79-34-5] — Skin	1	7	(5)	(35)
Tetrachloroethylene, see Perchloroethylene				
Tetrachloromethane, see Carbon tetrachloride				
‡Tetrachloronaphthalene [1335-88-2]	—	2	—	(4)
‡Tetraethyl lead [78-00-2], as Pb — Skin	—	0.1[g]	—	(0.3)
Tetrahydrofuran [109-99-9]	200	590	250	735
‡Tetramethyl lead [75-74-1], as Pb — Skin	—	0.15[g]	—	(0.5)

Substance [CAS #]	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
‡Tetramethyl succinonitrile [3333-52-6] — Skin	0.5	3	(2)	(9)
Tetranitromethane [509-14-8]	1	8	—	—
Tetrasodium pyrophosphate [7722-88-5]	—	5	—	—
‡Tetryl [479-45-8] (2, 4, 6-trinitrophenyl-methylnitramine) — Skin	—	1.5	—	(3.0)
Thallium [7440-28-0] Soluble compounds, as Tl — Skin	—	0.1	—	—
‡4, 4'-Thiobis(6-tert. butyl-m-cresol) [96-69-5]	—	10	—	(20)
Thioglycolic acid [68-11-1]	1	5	—	—
‡Thiram [137-26-8]	—	5	—	(10)
Tin [7440-31-5]				
‡ Metal	—	2	—	(4)
‡ Oxide & inorganic compounds, except SnH_4, as Sn	—	2	—	(4)
‡ Organic compounds, as Sn — Skin	—	0.1	—	(0.2)
‡Titanium dioxide [13463-67-7], as Ti	—	D	—	(20)
o-Tolidine [119-93-7] — Skin	A2	A2	—	—
Toluene [108-88-3] (toluol)	100	375	150	560
Toluene-2, 4-diisocyanate (TDI) [584-84-9]	0.005	0.04	0.02	0.15
*o-Toluidine [95-53-4] — Skin	2, A2	9, A2	—	—
Toxaphene, see Chlorinated camphene				
‡Tributyl phosphate [126-73-8]	0.2	2.5	(0.4)	(5)
Trichloroacetic acid [76-03-9]	1	5	—	—
1, 2, 4-Trichlorobenzene [120-82-1]	C 5	C 40	—	—

Capital letters A, B, D & E refer to Appendices: C denotes ceiling limit.
‡See Notice of Intended Changes.
*1984–1985 Addition.
f) Based on "high volume" sampling.
g) For control of general room air, biologic monitoring is essential for personnel control.

Substance	[CAS #]	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
1, 1, 1-Trichloroethane, see Methyl chloroform					
‡1, 1, 2-Trichloroethane	[79-00-5] — Skin	10	45	(20)	(90)
*Trichloroethylene	[79-01-6]	50	270	200	1,080
Trichlorofluoromethane	[75-69-4]	C 1,000	C 5,600	—	—
Trichloromethane, see Chloroform					
‡Trichloronaphthalene	[1321-65-9]	—	5	—	(10)
Trichloronitromethane, see Chloropicrin					
1, 2, 3-Trichloropropane	[96-18-4]	50	300	75	450
1, 1, 2-Trichloro-1, 2, 2-trifluoroethane	[76-13-1]	1,000	7,600	1,250	9,500
Tricyclohexyltin hydroxide, see Cyhexatin					
Triethylamine	[121-44-8]	10	40	15	60
‡Trifluorobromomethane	[75-63-8]	1,000	6,100	(1,200)	(7,300)
Trimellitic anhydride	[552-30-7]	0.005	0.04	—	—
Trimethylamine	[75-50-3]	10	24	15	36
Trimethyl benzene	[25551-13-7]	25	125	35	170
‡Trimethyl phosphite	[121-45-9]	2	10	(5)	(25)
2, 4, 6-Trinitrophenol, see Picric acid					
2, 4, 6-Trinitrophenyl-methylnitramine, see Tetryl					
‡2, 4, 6-Trinitrotoluene (TNT)	[118-96-7] — Skin	—	0.5	—	(3)
‡Triorthocresyl phosphate	[78-30-8]	—	0.1	—	(0.3)
Triphenyl amine	[603-34-9]	—	5	—	—
‡Triphenyl phosphate	[115-86-6] — Skin	—	3	—	(6)
Tungsten	[7440-33-7], as W				
Insoluble compounds		—	5	—	10
Soluble compounds		—	1	—	3
Turpentine	[8006-64-2]	100	560	150	840
Uranium (natural)	[7440-61-1], Soluble & insoluble compounds, as U	—	0.2	—	0.6
Valeraldehyde	[110-62-3]	50	175	—	—

Substance	[CAS #]	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
Vanadium, as V_2O_5	[1314-62-1], respirable dust & fume	—	0.05	—	—
Vegetable oil mists		—	D	—	—
Vinyl acetate	[108-05-4]	10	30	20	60
Vinyl benzene, see Styrene					
Vinyl bromide	[593-60-2]	5, A2	20, A2	—	—
Vinyl chloride	[75-01-4]	5, A1a	10, A1a	—	—
Vinyl cyanide, see Acrylonitrile					
Vinyl cyclohexene dioxide	[106-87-6]	10, A2	60, A2	—	—
*Vinylidene chloride	[75-35-4]	5	20	20	80
Vinyl toluene	[25013-15-4]	50	240	100	485
VM & P Naphtha	[8030-30-6]	300	1,350	400	1,800
Warfarin	[81-81-2]	—	0.1	—	0.3
Welding fumes (NOC†)		—	5, B2	—	—
Wood dust (certain hard woods as beech & oak)		—	1	—	—
Soft wood		—	5	—	10
Xylene	[1330-20-7] (o-, m-, p-isomers)	100	435	150	655
m-Xylene α, α'-diamine	[1477-55-0] - Skin	—	C 0.1	—	—
Xylidine	[1300-73-8] — Skin	2	10	—	—
Yttrium	[7440-65-5]	—	1	—	3
Zinc chloride fume	[7646-85-7]	—	1	—	2
Zinc chromate	[13530-65-9], as Cr	—	0.05, A2	—	—
Zinc oxide	[1314-13-2]				
Fume		—	5	—	10
Dust		—	D	—	—
‡Zinc stearate	[557-05-1]	—	D	—	(20)
Zirconium compounds	[7440-67-2], as Zr	—	5	—	10

Capital letters A, B, D & E refer to Appendices; C denotes ceiling limit.
‡See Notice of Intended Changes.
* 1984–1985 Addition.
† NOC = Not otherwise classified.

Radioactivity: See Physical Agents section on Ionizing Radiation.

DUSTS

Substance	TLV
SILICA, SiO_2	
Crystalline	
‡Quartz [14808-60-7]	TLV in mppcf [h]: $\frac{300^{[i]}}{\%\ \text{quartz} + 10}$ TLV for respirable dust in mg/m³: $\frac{10\ \text{mg/m}^3{}^{[j]}}{\%\ \text{Respirable quartz} + 2}$ TLV for "total dust," respirable and nonrespirable: $\frac{30\ \text{mg/m}^3}{\%\ \text{quartz} + 3}$
‡Cristobalite [14464-46-1]	Use one-half the value calculated from the count or mass formulae for quartz.
‡Tridymite [15468-32-3]	Use one-half the value calculated from formulae for quartz.
‡Tripoli [1317-95-9]	Use respirable[k] mass quartz formula
‡*Amorphous* [7631-86-9]	(20 mppcf [h])
‡Silica, fused [60676-86-0]	Use quartz formulae.
SILICATES and OTHER DUSTS (< 1% quartz)	
Asbestos [l]	
Amosite [12172-73-5]	0.5 fiber/cc > 5 μm in length, A1a
Chrysotile [12001-29-5]	2 fibers/cc > 5 μm in length, A1a
Crocidolite [12001-28-4]	0.2 fiber/cc > 5 μm in length, A1a
Other forms	2 fibers/cc > 5 μm in length, A1a
‡Graphite (natural) [7782-42-5]	15 mppcf
‡Mica [12001-26-2]	20 mppcf
Mineral wool fiber	10 mg/m³
‡Perlite	30 mppcf
‡Portland Cement	30 mppcf
‡Soapstone	20 mppcf
Talc (containing no asbestos fibers) [14807-96-6]	2 mg/m³, Respirable dust

‡Talc (fibrous), (use Asbestos limit.)	
Nuisance particles (see Appendix D)	‡(30 mppcf) or 10 mg/m³[m] of total dust < 1% quartz, or, ‡(5 mg/m³ respirable dust.)

Conversion factors:
mppcf × 35.3 = Million particles per cubic meter
= particles per cc

COAL DUST

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

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

i) 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.

j) 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

k) "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: *Pulmonary Deposition and Retention of Inhaled Aerosols*, p. 149. Academic Press, New York, (1964).

(2) AIHA Aerosol Technology Committee: Interim Guide for Respirable Mass Sampling. *Am. Ind. Hyg. Assoc. J. 31(2)*:133 (1970).

l) As determined by the membrane filter method at 400–450X magnification (4 mm objective) phase contrast illumination.

‡m) containing < 1% quartz; (if quartz content > 1%, use formulae for quartz.)

‡See Notice of Intended Changes.

NOTICE OF INTENDED CHANGES (for 1984-85)

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 [CAS #]	TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
†Amitrole [61-82-5]	—	0.2	—	—
†Ammonium persulfate [7727-54-1], as S_2O_8	—	5	—	—
†Boron tribromide [10294-33-4]	C 1	C 10	—	—
†1, 3-Butadiene [106-99-0]	10, A2	22, A2	—	—
†Carbon dioxide [124-38-9]	5,000	9,000	30,000	54,000
Cobalt metal, dust & fume [7440-48-4], as Co	—	0.05	—	0.1
Enflurane [13838-16-9]	75	575	—	—
Ethylene glycol dinitrate [628-96-6] — Skin	0.05	0.3	—	—
Formaldehyde [50-00-0]	1, A2	1.5, A2	2, A2	3, A2
Grain dust	—	4	—	—
Halothane [151-67-7]	50	400	—	—
†Hydrogen bromide [10035-10-6]	C 3	C 10	—	—
†Hydrogen fluoride [7664-39-3], as F	C3	C 2.5	—	—
Lead arsenate [10102-48-4], as $Pb_3(AsO_4)_2$	—	0.15	—	—
†4,4-Methylene dianiline [101-77-9]	0.1, A2	0.8, A2	—	—
p-Nitrochlorobenzene [100-00-5] — Skin	0.5	3	—	—
Nitroglycerin [55-63-0] — Skin	0.05	0.5	—	—
2-Nitropropane [79-46-9]	10, A2	35, A2	20, A2	70, A2
†Oxygen difluoride [7783-41-7]	C 0.05	C 0.1	—	—
†Persulfates, alkali metal, as S_2O_8	—	5	—	—

Substance [CAS #]	TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
Phyenylhydrazine [100-63-0] — Skin	5, A2	20, A2	10, A2	45, A2
†Potassium persulfate [7727-21-1], as S_2O_8	—	5	—	—
Propylene glycol dinitrate [6423-43-4] — Skin	0.05	0.3	—	—
†Sodium persulfate [7775-27-1], as S_2O_8	—	5	—	—
†Sulfur monochloride [10025-67-9]	C 1	C 6	—	—
†Sulfur pentafluoride [5714-22-7]	C 0.01	C 0.1	—	—
†Sulfur tetrafluoride [7783-60-0]	C 0.1	C 0.4	—	—
†Thionyl chloride [7719-09-7]	C 1	C 5	—	—
†m-Toluidine [108-44-1] — Skin	2	9	—	—
†p-Toluidine [108-49-0] — Skin	2, A2	9, A2	—	—

Capital letters A, B, D & E refer to Appendices; C denotes ceiling limit.
†1984–1985 Revision or Addition.

STEL VALUES DELETED FROM THE FOLLOWING:

Acetylene tetrabromide	Cellulose (paper fiber)
Aldrin	Chloroform
α-Alumina	Copper dusts & mists
Aluminum metal & oxide	Cotton dust, raw
2-Aminopyridine	Cyhexatin
Ammonium sulfamate	2,4-D
Aniline & homologues	DDT
ANTU	Demeton
Azinphos-methyl	Diazinon
Benomyl	2-N-Dibutylaminoethanol
Bismuth telluride & Se-doped	Dichlorodifluoromethane
Boron oxide	1,1-Dichloro-1-nitroethane
Bromacil	Dichloropropene
Bromine pentafluoride	Dichlorotetrafluorethane
Cadmium dusts & salts	Dichlorvos
Calcium carbonate/marble	Dicyclopentadienyl iron
Calcium cyanamide	Dieldrin
Captan	Difluorodibromomethane
Carbaryl	Dimethyl acetamide
Carbon black	Dimethylformamide
Carbon tetrachloride	1,1-Dimethylhydrazine

Dimethylphthalate
Dinitrobenzene
Dinitro-o-cresol
Dinitrotoluene
Dioxane, tech. grade
Diphenylamine
Diquat
Disulfiram
Disulfoton
Emery
Endosulfan
Endrin
Epichlorohydrin
EPN
Ethyl chloride
Ethylene dichloride
Ethyl mercaptan
N-Ethylmorpholine
Ethyl silicate
Ferbam
Formamide
Germanium tetrahydride
Gypsum
Hafnium
Heptachlor
Hexachlorocyclopentadiene
Hexachloronaphthalene
Hexafluoroacetone
Hydrogen peroxide
Indium & compounds
Iodoform
Iron oxide fume
Iron salts, soluble
N-Isopropylaniline
Kaolin
Lead, inorganic dusts & fumes
Limestone
Lindane
Magnesite
Manganese cyclopentadienyl tricarbonyl
Marble/calcium carbonate
Methylacrylonitrile
N-Methyl aniline
Methyl bromide
Methylcyclopentadienyl manganese tricarbonyl
Methyl demeton
Methylene chloride
Methyl iodide
Methyl parathion
Methyl silicate
Molybdenum, soluble & insoluble compounds
Naled
Nickel soluble compounds
Nicotine
Nitric oxide
Nitrobenzene
Nitroethane
Nitrogen trifluoride
Nitromethane
1-Nitropropane
Parathion
Pentachloronaphthalene
Pentachlorophenol
Pentaerythritol
Phenothiazine
Phosphorus (yellow)
Plaster of Paris
Rouge
Sesone
Silicon
Silicon carbide
Starch
Stibine
Strychnine
Sulfotep
Sulfur dioxide
Sulfur hexafluoride
2,4,5-T
Tantalum
Temephos
TEPP
1,1,1,2-Tetrachloro-2,2-difluoroethane
1,1,2,2-Tetrachloro-1,2,difluoroethane
1,1,2,2-Tetrachloroethane
Tetrachloronaphthalene
Tetraethyl lead
Tetramethyl lead
Tetramethyl succinonitrile
Tetryl
4,4'-Thiobis(6-tert. butyl-m-cresol)
Thiram
Tin, metal, oxide, & insoluble compounds
Tin, organic compounds
Titanium dioxide
Tributyl phosphate
1,1,2-Trichloroethane
Trichloronaphthalene

Trifluorobromomethane
Trimethyl phosphite
2,4,6-Trinitrotoluene (TNT)
Trior*thocresyl phosphate*
Triphenyl phosphate
Zinc stearate

NOTICE OF INTENDED CHANGES

DUSTS

Substance	TLV
SILICA, SiO_2	
Crystalline	
†Quartz [14808-60-7]	0.1 mg/m³, Respirable dust
†Cristobalite [14464-46-1]	0.05 mg/m³, Respirable dust
†Tridymite [15468-32-3]	0.05 mg/m³, Respirable dust
Silica, fused [60676-86-0]	Use quartz value.
Tripoli [1317-95-9]	0.1 mg/m³ of contained quartz, respirable dust
Amorphous	
†Diatomaceous earth (uncalcined) [60676-86-0]	10 mg/m³, Total dust
Precipitated silica and silica gel	5 mg/m³, Respirable dust 10 mg/m³, Total dust
SILICATES and OTHER DUSTS (< 1% quartz)	
†Barium sulfate [7727-43-7]	10 mg/m³, Total dust
Graphite (natural) [7782-42-5]	2.5 mg/m³, Respirable dust 5 mg/m³, Total dust
†Graphite (synthetic)	10 mg/m³, Total dust
†Mica [12001-26-2]	3 mg/m³, Respirable dust
†Perlite	10 mg/m³, Total dust
†Portland Cement	10 mg/m³, Total dust
Soapstone	3 mg/m³, Respirable dust 6 mg/m³, Total dust
Talc (containing asbestos fibers)	Use asbestos TLV. However, should not exceed 2 mg/m³ respirable dust.

†1984–1985 Revision or Addition.

†*Nuisance particulates (see Appendix D)*
10 mg/m³ [m] of total dust < 1% quartz

COAL DUST

If > 5% quartz, use respirable quartz value.

Generic Listing

All mppcf values for mineral dusts will be eliminated in favor of equivalent respirable mass or total mass values, i.e., Appendix F.

Footnote:

m) Containing < 1% quartz; if quartz content > 1%, use quartz value.

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 two forms: Those for which a TLV has been assigned (1a) and those for which environmental conditions have not been sufficiently defined to assign a TLV (1b).

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

	TLV
Asbestos	
Amosite	0.5 fiber > 5μm/cc
Chrysotile	2 fibers > 5μm/cc
Crocidolite	0.2 fiber > 5μm/cc
Other forms	2 fibers > 5μm/cc
bis (Chloromethyl) ether	0.001 ppm
Chromite ore processing (chromate)	0.05 mg/m³, as Cr
Chromium (VI), certain water insoluble compounds	0.05 mg/m³, as Cr
Coal tar pitch volatiles	0.2 mg/m³, as benzene solubles
Nickel sulfide roasting. fume & dust	1.0 mg/m³, as Ni
Vinyl chloride	5 ppm

A1b. *Human Carcinogens*. Substances, or substances associated with industrial processes, recognized to have carcinogenic potential without an assigned TLV:

4-Aminodiphenyl (p-Xenylamine) — Skin
Benzidine — Skin
β-Naphthylamine
4-Nitrodiphenyl

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. 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.

‡Acrylonitrile — Skin	2 ppm
**Amitrole	—
Antimony trioxide production*	—
Arsenic trioxide production	—
Benzene	10 ppm
Benzo(a)pyrene	—
Beryllium	2.0 μg/m³
†1, 3-Butadiene	10 ppm
Carbon tetrachloride — Skin	5 ppm
Chloroform	10 ppm
Chloromethyl methyl ether	—
Chromates of lead and zinc, as Cr	0.05 mg/m³
Chrysene	—
3, 3'-Dichlorobenzidine — Skin	—
Dimethylcarbamyl chloride	—
1, 1-Dimethyl hydrazine — Skin	0.5 ppm

†1984–1985 Revision or Addition.

**See Notice of Intended Changes.
†1984–1985 Addition.
‡1984–1985 Adoption.
*Cigarette smoking can enhance the incidence of respiratory cancers from this or others of these substances or processes.

Dimethyl sulfate — Skin	0.1 ppm
Ethylene dioromide — Skin	——
‡Ethylene oxide	1 ppm
Formaldenyde	1 ppm
Hexachlorobutadiene	0.02 ppm
Hexamethyl phosphoramide — Skin	——
Hydrazine — Skin	0.1 ppm
4, 4'-Methylene bis (2-chloroaniline) — Skin	0.02 ppm
†4,4-Methylene dianiline	0.1 ppm
Methyl hydrazine — Skin	C 0.2 ppm
Methyl iodide — Skin	2 ppm
2-Nitropropane	10 ppm
N-Nitrosodimethylamine — Skin	——
N-Phenyl-beta-naphthylamine	——
Phenylhydrazine — Skin	5 ppm
Propane sultone	——
beta-Propiolactone	0.5 ppm
Propyleneimine — Skin	2 ppm
o-Tolidine	——
‡o-Toluidine — Skin	2 ppm
†p-Toluidine — Skin	2 ppm
Vinyl bromide	5 ppm
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.

* * *

THE COMMITTEE GUIDELINES FOR 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 carcino gen 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, 10 g 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

†1984 Addition.
‡1984 Adoption.

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

A. *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- to 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

Benzo(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

Benzo(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.

B. *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 A and C 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.

C. *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 = 5g 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 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 *Welding Fumes — Total Particulate (NOC)†*
TLV, 5 mg/m³

Welding fumes cannot be classified simply. The composition and quantity of both are dependent on the alloy being welded and the process and electrodes used. Reliable analysis of fumes cannot be made without considering the nature of the welding process and system being examined; reactive metals and alloys such as aluminum and titanium are arc-welded in a protective, inert atmosphere such as argon. These arcs create relatively little fume, but an intense radiation which can produce ozone. Similar processes are used to arc-weld steels, also creating a relatively low level of fumes. Ferrous alloys also are arc-welded in oxidizing environments which generate considerable fume, and can produce carbon monoxide instead of ozone. Such fumes generally are composed of discreet particles of amorphous slags containing iron, manganese, silicon and other metallic constituents depending on the alloy system involved. Chromium and nickel compounds are found in fumes when stainless steels are arc-welded. Some coated and flux-cored electrodes are formulated with fluorides and the fumes associated with them can contain significantly more fluorides than oxides. Because of the above factors, arc-welding fumes frequently must be tested for individual constituents which are likely to be present to determine whether specific TLV's are exceeded. Conclusions based on total fume concentration are generally adequate if no toxic elements are present in welding rod, metal, or metal coating and conditions are not conducive to the formation of toxic gases.

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

*Trade Names: Algoflon, Fluon, Halon, Teflon, Tetran.
†Not otherwise classified (NOC).

APPENDIX C
MIXTURES

C.1 THRESHOLD LIMIT VALUES FOR MIXTURES

When two or more hazardous substances, which act upon the same organ system, 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 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.).

Synergistic action or potentiation may occur with some combinations of atmospheric contaminants. Such cases at present must be determined individually. Potentiating or synergistic agents are not neces-

sarily harmful by themselves. Potentiating effects of exposure to such agents by routes other than that of inhalation is also possible, e.g., imbibed alcohol and inhaled narcotic (trichloroethylene). Potentiation is characteristically exhibited at high concentrations, less probably at low.

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

Examples of processes which are typically associated with two or more harmful atmospheric contaminants are welding, automobile repair, blasting, painting, lacquering, certain foundry operations, diesel exhausts, etc.

C.1A Examples of THRESHOLD LIMIT VALUES FOR MIXTURES

The following formulae apply only when the components in a mixture have similar toxicologic effects; they should not be used for mixtures with widely differing reactivities, e.g., hydrogen cyanide and 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 400 ppm of acetone (TLV = 750 ppm), 150 ppm of sec-butyl acetate (TLV = 200 ppm) and 100 ppm of methyl ethyl ketone (TLV = 200 ppm)

Atmospheric concentration of mixture = 400 + 150 + 100 = 650 ppm of mixture

$$\frac{400}{750} + \frac{150}{200} + \frac{100}{200} = 0.53 + 0.75 + 0.5 = 1.78$$

Threshold Limit is exceeded.

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 =

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

Example No. 1A.b.: Liquid contains (by weight)

50% heptane: TLV = 400 ppm or 1600 mg/m³
1 mg/m³ = 0.25 ppm

30% methyl chloroform: TLV = 350 ppm or 1900 mg/m³
1 mg/m³ = 0.18 ppm

20% perchloroethylene: TLV = 50 ppm or 335 mg/m³
1 mg/m³ = 0.15 ppm

$$\text{TLV of Mixture} = \frac{1}{\frac{0.5}{1600} + \frac{0.3}{1900} + \frac{0.2}{335}}$$

$$= \frac{1}{0.00031 + 0.00016 + 0.0006}$$

$$= \frac{1}{0.00107} = 935 \text{ mg/m}^3$$

of this mixture
50% or (935) (0.5) = 468 mg/m³ is heptane
30% or (935) (0.3) = 281 mg/m³ is methyl chloroform
20% or (935) (0.2) = 187 mg/m³ is perchloroethylene

These values can be converted to ppm as follows:

heptane: 468 mg/m³ × 0.25 = 117 ppm
methyl chloroform: 281 mg/m³ × 0.18 = 51 ppm
perchloroethylene: 187 mg/m³ × 0.15 = 29 ppm

TLV of mixture = 117 + 51 + 29 = 197 ppm, or 935 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 given in 1A.b. may be used.

APPENDIX D
Some Nuisance Particulates[n]

‡TLV, (30 mppcf or) 10 mg/m³ of total dust < 1% quartz, (or, 5 mg/m³ respirable dust)

α-Alumina (Al_2O_3)	Plaster of Paris
Calcium carbonate	Portland Cement
Calcium silicate	Rouge
Cellulose (paper fiber)	Silicon
Emery	Silicon carbide
Glycerin mist	Starch
‡Graphite (synthetic)	Sucrose
Gypsum	Titanium dioxide
Kaolin	Vegetable oil mists
Limestone	(except castor, cashew
Magnesite	nut, or similar irritant
Marble	oils)
Mineral wool fiber	Zinc stearate
Pentaerythritol	Zinc oxide dust

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

APPENDIX E
Some Simple Asphyxiants[o]

Acetylene	Helium	Propane
Argon	Hydrogen	Propylene
Ethane	Methane	
Ethylene	Neon	

o) As defined in the preface.

‡APPENDIX F
Conversion of mppcf to Mass Concentration

Calculations for Conversion of Particle Count Concentration (by Standard Light Field — Midget Impinger Techniques), in mppcf, to Respirable Mass Concentration (by Re spirable Sampler) in mg/m³.[(1)]

1. In 1967, Jacobsen and Tomb,[(1)] 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. Studies on conversion factors have been undertaken and preliminary evidence suggests that the application of any single conversion factor may not be adequate for use in risk assessments, epidemiology studies, or setting TLVs.
   The following calculation results in an equivalence of 6.37 mppcf to 1 mg/m³ of respirable dust. Thus, an approximate ratio of 6 mppcf to 1 mg/m³ of respirable dust is suggested for conversion of TLVs from a count to a mass basis when the density and mass median diameter have not been determined.
2. Basic assumptions:
   a) Average density for silica containing dusts = 2.5 g/cm³ (2500 mg/cm³). Pulmonary significant dust densities may vary from 1.2 g/cm³ for coal dust to 3.1 g/cm³ for Portland Cement. Silica densities vary from 2.2 (amorphous) to 2.3 (cristobalite and tridymite) to 2.5 (alpha-quartz.) gms per cm³.
   b) The mass median diameter (mmd) of particles collected in midget impinger samplers and counted by the standard light field technique, *and* collected in a respirable sampler is approximately 1.5 μm or 1.5×10^{-4} cm. This assumption is, of course, quite arbitrary since the mmd of all dust clouds is quite

‡ See Notice of Intended Changes.

variable, depending on many independent parameters, such as source of dust, age of dust cloud, meteorological conditions, processes and equipment changes, etc. If the density and the mass median diameter of the dust particles are known, the nomograph in Figure 1 can be used to convert dust count concentrations (mppcf) to respirable mass concentrations (mg/m³).

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. × 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 = 35.3 part./m³
(since 35.5 cu ft = 1 cu m.)

10^6 part./ft³ = mppcf = 35.3×10^6 part./m³

wt. of 1 mppcf = 35.5×10^6 part./m³ × 4.425×10^{-9} mg/part.

1 mppcf = 0.157 mg/m³
or
6.37 mppcf = 1 mg/m³
or approximately 6 mppcf = 1 mg/m³.

Reference:

1. **Jacobson, M., and T. F. Tomb:** Relationship Between Gravimetric Respirable Dust Concentration and Midget Impinger Number Concentration. *Am. Ind. Hyg. Assoc. J. 28:554* (Nov.–Dec. 1967).

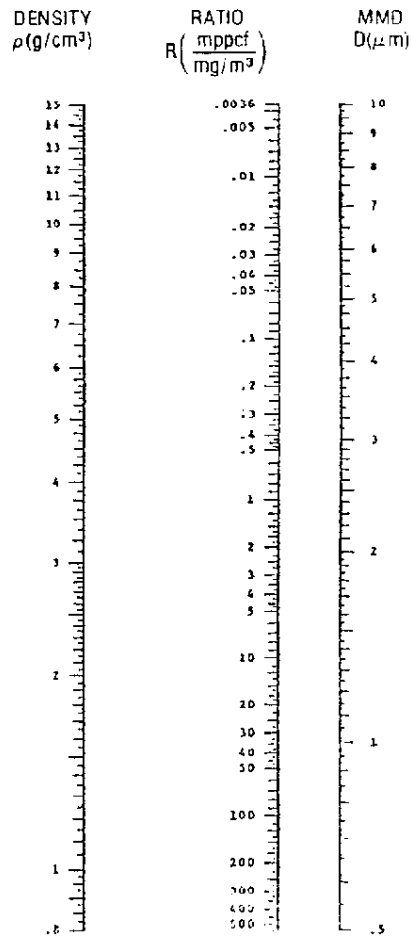

Figure 1 — Ratio of Particle Count — mppcf to Respirable Mass Concentration — mg/m³ (as function of density and mmd)†

†Prepared by P. E. Caplan and R. J. Smith

Table 1

Equivalent TLVs in mppcf and mg/m³ (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 (natural)	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)
Tripoli	(3)	0.1	(0.3)

†Assuming that the mass median diameter is 1.5 μm and density is 2.5 g/cm³.

*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.

APPENDIX G
Chemical Substances and Other Issues Under Study*

Chemical Substances

Acetonitrile
Acrolein
Acrylic acid
Allyl chloride
Asbestos
Atrazine
Carbon black
Chlorine
bis-Chloromethyl ether
Chloromethyl methyl ether
o-Chlorotoluene
Chrysene
Copper dust & fume
Cyclohexanone
Diethylenetriamine
Epichlorohydrin
Ethyl benzene
Ethyl chloride
Ethylene dichloride
Ethyl methacrylate
Gasoline (unleaded)
Glycidol
Glycol ethers
Graphite
Hexachlorocyclopentadiene
Isocyanates
Isoamyl alcohol
Jet fuels
Nickel, metal & soluble compounds
Osmium tetroxide
Perfluorinated chemicals
Petroleum fuels
Petroleum solvents
Piperizine
Propylene chloride
Propylene oxide
1,2,3-Trichloropropane
m-Xylene 2,2'-diamine (MXDA; meta-meta-xylenediamine)
Zinc chromates

Other Issues

1. Is the current aspect ratio better than other ratios for health protection and/or differentiation of asbestos fibers.
2. *Ceiling Limits* — In light of today's instrumentation (quick response) and STELS, are ceiling limits needed and, if so, what criteria would determine their appropriateness.
3. *Soluble Inorganic Compounds* — What quantitative criteria should be used in differentiating between soluble and insoluble for TLV use.
4. Should welding fume value (not otherwise classified, NOC) be retained or should specific analytical determinations be made for metals and other compounds and these values be compared to specific TLVs?

*Information, data especially, and comments are solicited to assist the committee in its deliberations and in the development of draft documents. Draft documentations are used by the committee to decide what action, if any, to recommend on a given substance or question.

APPENDIX H
Registered* Trade Names

Trade Name	Generic Name	CAS No.
Abate	Temephos	3383-96-8
Ammate	Ammonium sulfamate	7773-06-0
Azodrin	Monocrotophos	6923-22-4
Baygon	Propoxur	114-26-1
Baytex	Fenthion	55-38-9
Bidrin	Dicrotophos	141-66-2
Bolstar	Sulprofos	35400-43-2
Butyl Cellosolve	2-Butoxyethanol	111-76-2
Cellosolve acetate	2-Ethoxyethyl acetate	111-15-9
Coyden	Clopidol	2971-90-6
Crag herbicide	Sesone	136-78-7
Dasanit	Fensulfothion	115-90-2
Delnav	Dioxathion	78-34-2
Dibrom	Naled	300-76-5
Difolatan	Captafol	2425-06-1
Disyston	Disulfoton	298-04-4
Dursban	Chlorpyrifos	2921-88-2
Dyfonate	Fonofos	944-22-9
Furadan	Carbofuran	1563-66-2
Guthion	Azinphos-methyl	86-50-0
Lannate	Methomyl	16752-77-5
Methyl Cellosolve	2-Methoxyethanol	109-84-4
Methyl Cellosolve acetate	2-Methoxyethyl acetate	110-49-6
Nemacur	Fenamiphos	22224-92-6
Nialate	Ethion	563-12-2
N-Serve	Nitrapyrin	1929-82-4
Pival	Pindone	83-26-1
Plictran	Cyhexatin	13121-70-5
Sencor	Metribuzin	21087-64-9
Sevin	Carbaryl	63-25-2
Teflon	Polytetrafluoro-ethylene	9002-84-0
Thimet	Phorate	298-02-2
Thiodan	Endosulfan	115-29-7
Tordon	Picloram	1918-02-1
Zoalene	Dinitolmide	148-01-6

Biological Exposure Indices

Proposed by ACGIH for 1984-85

1983-84 BIOLOGICAL EXPOSURE INDICES COMMITTEE

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PREFACE

BIOLOGICAL EXPOSURE INDICES

Biological Exposure Indices (BEIs) represent warning levels of biological response to the chemical, or warning levels of the chemical or its metabolic product(s) in tissues, fluids, or exhaled air of exposed workers, regardless of whether the chemical was inhaled, ingested, or absorbed via skin. Introduction of the BEI is a step in the evolution of the concept of TLVs. The BEI provides health personnel with an additional tool to provide protection for the worker. Use of body fluids and appendages such as hair or nails for measuring the absorbed amount of a substance has long been a standard practice for certain substances. Lead is a classical example of a substance for which blood concentrations have long been considered the critical value in determining "safe" versus "unsafe" exposures. Two problems hindered the wider use of biological measurements as indicators of "safe" environmental exposures: 1) the relatively wide range in individual response to a substance and the wide range of "normal" that has to be considered; and 2) The lack of simple specific analytical methods of sufficient sensitivity. Both problems are capable of solution, and we believe that sufficient progress has been made to begin utilizing selected BEIs which can be used as a guide to "safe" exposures to toxic chemicals. The BEI is considered supplementary to an airborne TLV.

TLVs are intended to provide the industrial hygienist with an additional measure to aid in the design of engineering controls or for temporary use of personal protective equipment which will protect almost all exposed workers from untoward effects of chemical exposure. In principle, TWA-TLVs are designed to prevent exposures which may cause acute or chronic adverse effects. They are also intended to avoid attendant deterioration of normal physiological function. This approach is based on the assumption that for nearly all workers there is a tolerable exposure limit and a tolerable body burden of airborne material. If this assumption is valid, there should be a range of safe biologically insignificant changes of various measures of body function.

The TLVs are a measure of the composition of the external environment surrounding the worker. BEIs are a measure of the amount of chemical *absorbed* into the body. The concept of the BEI is particularly useful in evaluating exposures to substances with significant absorption through the skin.

The biological determinant on which the BEIs are based can furnish two kinds of information useful in the control of worker exposure: 1) measure of the worker's individual response, and 2) measure of the worker's individual overall exposure. Measurements of response furnish an estimate of the physiological status of the worker and can be made by, *a)* determining changes in the amount of a critical biochemical constituent, *b)* determining changes in activity of a critical enzyme, and *c)* determining changes in a physiological function. Measurements of exposure can be made by, *a)* determining the chemical in exhaled air, urine, blood, hair, nails, body tissues and fluids, *b)* determining the metabolite(s) of the chemical in tissues and fluids, and *c)* determining the extent of specific biochemical and physiological changes induced by the chemical.

Recommended values of BEIs are based on data obtained in epidemiological and field studies or determined as bioequivalent to a TLV by means of pharmacokinetic analysis of data from controlled human studies. Most chemicals (including organic solvents) are initially absorbed and eliminated fairly rapidly — usually with initial half-life values measured in a few hours or even minutes. Rapidly changing concentrations in body fluids complicate the interpretation of data and the average body burden of a chemical attained during a work shift can easily be over-predicted or under-predicted. Furthermore, biological measurements fail in most instances to detect transient periods of over-exposure during the work shift. Because elimination of chemicals and their metabolic products, as well as biological changes induced by exposure to the chemical, are kinetic events, the listed BEIs are strictly related to 8-hour exposures and to the specified timing for the collection of biological samples.

There are other factors to be considered when the BEI is applied. Among the factors which must be considered in using BEIs are: *a)* changes induced by strenuous physical activity; *b)* changes induced by environmental conditions (altitude, heat, diet, etc.); *c)* changes induced by water intake; *d)* changes in physiological functions induced by preexisting disease or congenital variation; *e)* changes in metabolism induced by congenital variation of metabolic pathways; and *f)* changes in metabolic pathway induced by simultaneous administration of another chemical (induction or inhibition of activity of a critical enzyme by medication or by preexposure or coexposure to another chemical).

For BEIs based on urine analysis, simple measurements of concentrations can provide sufficient information on exposure, but in many instances, measurements of elimination rates provide more precise information.

Urinary concentrations related to creatinine represent a reasonable compromise between the accuracy of the information and the technical means of obtaining the data.

Some BEIs are not protective of an identified population, or are nonspecific, or the correlation between the exposure and biological determinant is weakened by variables introduced by large interindividual variation in response to the chemical or by timing and fluctuation of exposure concentration. In such cases the BEIs carry the following notations:

"R" Notation. Indicates that an identifiable population group might have an increased susceptibility to the effect of the chemical which leaves it unprotected by the recommended BEI. The specific documentation should be consulted for detailed information.

"" Notation.* Some determinants are nonspecific, since different chemicals may bear the same biological response. Such BEIs carry "*" notation. These nonspecific tests are preferred because they are easy to use and, in many instances, offer a better correlation between exposure and response than specific tests. In such instances, a BEI for a specific less quantitative biological determinant is recommended as a confirmatory test. The documentation should be consulted for information on factors affecting interpretation of such a BEI.

*"**" Notation.* Indicates that the biological determinant is a specific indicator of exposure to the chemical, but the quantitative interpretation of the measurements is very ambiguous, and that the relationship between the TLV and BEI is markedly weakened by variables in timing, fluctuation of exposure concentrations, and by other circumstantial variables. Such biological determinants should be used as confirmatory tests; and their BEIs should be applied cautiously, mainly for confirmation of exposures indicated by nonspecific BEIs.

"G" Notation. Because of the wide interindividual variation in response to some chemicals, the BEI is, in some instances, recommended as a mean value of a group test for workers subjected to a similar level of occupational exposure, rather than as an index for an individual. Such BEIs carry "G" notation.

The table includes BEIs for which a sufficient data base is available and on which the committee took action. Some BEIs are more suitable for correlation with TLV-TWAs than others. Other BEIs are preferable for evaluating recent exposure or for confirmation of exposure. For specific instances the documentation should be consulted.

Workers are not expected to suffer any ill effects as long as the described measurements of the determinants

are maintained within limits of the recommended BEIs. Measurements outside these limits are not necessarily indicators of a disease process. However, if these deviate measurements persist, it is an indication that the individual should be examined by a physician to determine whether there is any health effect. The workplace and work practices should be investigated further.

NOTICE OF INTENT TO ESTABLISH BIOLOGICAL EXPOSURE INDICES†

Airborne Chemical [CAS #] / *Indices*	*Timing*	*BEI*	
CARBON MONOXIDE [630-08-0]			R
* Carboxyhemoglobin in blood	End of shift	less than 8%	
* CO in end-exhaled air	End of shift	less than 40 ppm	
ETHEYL BENZENE [100-41-4]			
* Mandelic acid in urine	End of shift and End of workweek	2 g/L 1.5 g/g creat.	G G
** Ethyl benzene in end-exhaleo air	Prior to shift	2 ppm	
STYRENE, monomer [100-42-5]			
* Mandelic acid in urine	End of shift	1.0 g/L 0.8 g/g creat.	G G
Styrene in mixed-exhaled air	Prior to shift	40 ppb	
* Phenylglyoxylic acid in urine	End of shift	250 mg/L 240 mg/g creat.	G G
** Styrene in mixed-exhaled air	During shift	18 ppm	
** Styrene in venous blood	End of shift Prior to shift	0.55 mg/L 0.02 mg/L	
TOLUENE [108-88-3]			
* Hippuric acid in urine	End of shift Last 4 hrs of shift	2.5 g/g creat. 3 mg/min	G G
** Toluene in venous blood	End of shift	1.0 mg/L	
** Toluene in end-exhaled air	During shift	20 ppm	
TRICHLOROETHYLENE [79-01-6]			
* Trichloroacetic acid in urine	End of workweek	100 mg/L	G
* Trichloroacetic acid and trichloroethanol in urine	End of shift and End of workweek	320 mg/g creat. 300 mg/L	G G
* Free trichloroethanol in blood	End of shift and End of workweek	4 mg/L	
** Trichloroethylene in end-exhaled air	Prior to shift and End of workweek	0.5 ppm	
XYLENES [1330-20-7]			
Methylhippuric acids in urine	End of shift Last 4 hrs of shift	1.5 g/g creat. 2 mg/min	

† It is strongly advisable to consult the specific documentation before invoking BEI.