PLAINTIFF'S EXHIBIT
CON-55

ASBESTOS FIBERS IN THE AMBIENT AIR IN THE GREATER SAN FRANCISCO AREA

3/83 STUDY

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The ambient asbestos fiber levels in Vallejo, Oakland, and San Francisco, Califoria during 3 days in February 1983 averaged .02 asbestos fibers/ cubic centimeter of air, greater than 5 micrometers in diameter on an eight hour time weighted average as determined by phase contrast microscopy at 400X.

This data compares to previous findings of .02 asbestos fibers/cc in Seattle and Bremerton, Washington, and Portland, Oregon in July and August 1982.

Previous studies (11,12) show that GARLOCK INC asbestos gasket materials and spiral wound gaskets produce less than .02 asbestos fibers/cc during processing.This is in the same range as the eight hour daily exposure to city dwellers for which there is no significant impact on their health.

DISCLAIMER

The author is solely responsible for the contents and conclusions in this report which may not necessarily reflect the official opinion of contributors, or Federal and State agencies.

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BACKGROUND

Asbestos is one of the most plentiful, useful, and cheap industrial minerals. Consequently because of its high thermal stability and resistance to corrosion it appears in more than 3000 manufactured goods in the United States. Estimates are that at least 30 million tons have been used in construction and manufacturing since the year 1900. This common use of asbestos has led to the exposure of millions of Americans that may have a significant impact on their health. Large numbers of Americans are still exposed to asbestos fibers in industry, and non-occupationally in cities and their nearby industrial complexes, from the drinking water, and from soil high in asbestos content (1,2, 3,4,5,6,7).

Most Americans receive some regular low-level exposure to asbestos in their lifetimes from these sources. The wide spread past and continued use of asbestos is likely to continue such exposures. From 1958 to 1973 about 500,000 tons of asbestos was used in the United States to spray the inside of buildings for fireproofing. The practice was largely confined to high rise buildings in cities. This concentrated use increases the asbestos exposures to occupants and to the general population during refurbishment or razing (7). This is an important source of exposure to city dwellers. Automobile brakes and clutches are a source of continuous emission in populated cities (1,8,9). The intermittent peak exposures from these and manufacturing sources in cities may at times approach the current Federal occupational health standard of 2 asbestos fibers per cubic centimeter, greater than 5 micrometers in diameter averaged over an eight hour work day (10). Also the ambient asbestos fiber levels may exceed the known actual release of asbestos fibers from some industrial asbestos products. Therefore the the ambient as well as other sources of contamination must be determined when such asbestos gasket materials are evaluated (11,12).

There appears to be little clear evidence that these continuing ambient asbestos fiber exposures to the general population gives rise to significant identified asbestos-related disease (13,14,15).

Few studies attempt to relate the non-occupational ambient asbestos exposure of city dwellers to the Federal occupational health standard for comparison (4,6,16). The Federal standard is the only regulation in effect for which there is sound epidemiological evidence of disease from exposure to asbestos (1). Most of the environmental studies have not been conducted in the breathing zone, are reported by weight in nanograms per cubic meter of air(1×10^{-9}) which does not related to current epidemiology. The environmental studies are most often based on 24 hour samples which obscures the intermittent peak values during the normal eight hour work period in the city.

The confounding variables of environmental conditions and the actual asbestos exposure from products exists. Therefore a clear relationship between the occupational exposure from products producing few airborne asbestos fibers and the known ambient asbestos fiber exposure must be established. The daily peak asbestos exposures of city dwellers is in the same range ofasbestos gasket products being processed. However, the general population does not display a clear and significant response to these lower asbestos exposure levels according to disease incidence. Therefore, specific asbestos gasket products like those produced by GARLOCK INC that do not exceed these levels are no more likely to cause any greater risk.

Some researchers (17) have attempted to draw a relationship between the concentrations of asbestos fibers in air determined by weight as nanograms per cubic meter to asbestos fibers in air collected and counted as required by the Federal occupational health standard. The most commonly accepted value is;

1000 ng/M^3 = .03 asbestos fibers/cc, greater than 5 micrometers in diameter as counted by phase contrast microscopy.

However, the environmental data reported by weight (ng/M^3) is little more than an index and is not related to breathing zone exposure standards.

II

INTRODUCTION

In order to determine the actual contribution of airborne asbestos fibers released from GARLOCK INC gasket materials, and spiral wound or encapsulated gaskets studies (11,12) were conducted to accurately and precisely measure such exposures to workers in the absence of asbestos contamination from other sources. It was shown that 1) general atmospheric pollution in cities, 2) redispersion of fallen fibers in work areas, 3) source production of asbestos fibers from adjacent work areas, and 4) contaminated work clothing all can contribute to the total exposure and obscure the actual exposure from the gasket products. The actual exposure to a worker from the GARLOCK INC gaskets averaged less than .02 asbestos fibers per cubic centimeter(cc), greater than 5 micrometers in diameter for an 8 hour time weighted average work day(TWA).

However, ambient asbestos fiber concentrations in the cities of Seattle, Bremerton, and Portland averaged .02 fibers/cc during dry summer days in July and August 1982. These are significant exposure levels to the general population in cities and shows by direct comparison that asbestos gasket materials, and specifically encapsulated gasket materials contribute about 1/100th of the allowable occupational exposure of 2 asbestos fibers/cc, greater than 5 micrometers in diameter for any 8 hour TWA work period.

The total daily exposure of city dwellers to these ambient asbestos fiber levels may be even more elevated if they are employed in asbestos contaminated buildings (6,7,18,19,20). Le Moine (9) found relatively high levels of asbestos fibers in the ambient air in the industrial areas of Seattle (.03 f/cc) in March and April 1980 which is the rainy season in the Pacific Northwest. The fiber counts were at 300X by phase contrast microscopy instead of 400 to 430X required by the Federal occupational health standard which would give rise to fewer fibers counted. None-the-less .03 asbestos fibers/cc is a significant exposure to the general population who spend their 8 hour work day in these asbestos contaminated industrial environments.

Because there is little concrete evidence of asbestos-related disease in the general population at these levels, this data becomesimportant(20). There is clear evidence that city dwellers not occupationally exposed to asbestos fibers do breathe and retain substantial quantities of asbestos fibers in their lungs from the ambient air(13). Additionally they drink water which in many parts of the United States is highly contaminated with asbestos fibers(3,5) and through asbestos cement pipes used in city water mains(5).

City dwellers spending their 8 hour work day outside, or in asbestos contaminated buildings may receive exposure levels in the same range as those workers processing GARLOCK INC asbestos gasket materials. Also it is not scientifically correct to assume that all asbestos reaching the breathing zone of a worker handling asbestos gaskets comes from the gaskets because of the high level sources of contamination from the work environment, and ambient air.

The Environmental Protection Agency(EPA) reported in 1978(7), that razing of a structure can result not only in high local contamination, but to the surrounding community as well; and the fallen asbestos fibers become redispersed over and over again. Since 1958 to 1973, the spray application of asbestos to buildings was about 500,000 tons in the United States - a most significant source of exposure to the city dweller. Automobile brakes and clutches are another significant contribution(1,8).

Nicholson (18) determined in 1976 that buildings with deteriorating asbestos materials release significantly higher levels than outdoor ambient asbestos concentrations during quiet periods. However, when routine activity or maintenance occurred inside the buildings the exposure rose from .02 fibers/cc to .2 fibers/cc. Mangold (21) found similar conditions in a hospital facility where maintenance personnel were routinely exposed to .2 fibers/cc.

The Federal occupational health standard, 29 CFR 1910.1001 - Asbestos, and its intrepretations requires a medical examination and surviellance program for employees when 8 hour TWA exposures exceed .1 fibers/cc(10).

Selikoff (1) reported a study of industrial plants using asbestos in manufacturing that were causing relatively high levels of fugative emissions of asbestos fibers some exceeding the Federal standard of 2 fibers/cc. Such a source is capable of polluting the surrounding environment on a continuing basis, which accounts for higher concentrations of asbestos fibers in the ambient air in industrial areas. Prevailing winds and street activities redisperse and spread the contamination.

The fibers that are released from these processes are tiny fibrils that may remain airborne indefinitely (1,7,8), and are of the size found in the lungs of city dwellers not occupationally exposed according to the research of Churg and Warnock (13). The fibrils found in the streets of cities are generally smaller than those found at industrial work sites (1).

The most recent review by Selikoff and others (1,20) reports that there are no data at present that would tell approximately how many workers were exposed to fugative asbestos dusts between 1940 and 1979, nor the intensity of those exposures. The same 4 year study (1) discusses more recent findings that suggest that lower levels of exposure to asbestos fibers in air do not give rise to classical asbestosis, and center on the etiology of the asbestos-related cancers that have some risk of development. However, the risks due to ambient asbestos fiber contamination are less likely to produce significant rates of asbestos-related cancers, except adjacent to asbestos processing facilities where exposures are elevated. Regardless, current trends are to lower the allowable exposure levels in existing Federal standards (22,23,24).

Rationale was developed for a study of the Greater San Francisco Bay Area to determine the 8 hour work day exposures to city dwellers, and compare that data with that found in Seattle, Bremerton, and Portland to corroborate previous studies (11,12). A study of 187 quarterly composite samples collected in 48 cities from 1969 through 1970 showed chrysotile asbestos to be present in virtually all of those metropolitan cities in the United States, as determined by electron microscopy analysis (16,17).

III

METHODS OF INVESTIGATION

Previous studies (11,12) established that the actual contribution of GARLOCK INC gasket materials averaged less than .02 fibers/cc, greater than 5 micrometers in diameter for an 8 hour TWA, while encapsulated gasket materials averaged .004 fibers/cc. These values were compared to the exposures of city dwellers to an average of .02 fibers/cc from the ambient air. The concentrations of airborne asbestos fibers were collected in the breathing zone levels during February 15th through the 19th, 1983 in the Greater San Francisco Bay Area to determine the 8 hour work day exposures to city dwellers. The data could then be directly comparable.

Three locations were selected to represent typical urban exposure in Vallejo, Oakland, and San Francisco proper. The weather was partly cloudy, calm to light winds, a visible smog envelope, and a temperature range of 45 to 52°F. The data reflects full 8 hour samples collected at 2 liters per minute required by standard sampling methods that relate to the Federal standard, 29 CFR 1910.1001-Asbestos (10,25,26). Aerosol type Millipore filters MAW P037AO, .8 micron pore size, in an open-faced cassette were used to collect the asbestos fibers (27). The samples were then prepared and counted by phase contrast microscopy at 400X according to requirements in the Federal standard (10,28,29,30).

This technique of measuring the peak exposures of city dwellers during their 8 hour work period at the street level relates to the methodology that is used to evaluate exposures to asbestos gasket materials in any workplace. Therefore, a direct comparison may be made to the known actual release of asbestos fibers from GARLOCK INC gasket materials to similar exposures experienced by the public in cities for which there is no significant impact on their health.

Curb-side street dust from each of the cities of Vallejo, Oakland, and San Francisco was examined to positively identify the existance of fallen asbestos fibers available for redispersion. One eight hour sample was collected in the Second Lower Level, Union Square Parking Garage, San Francisco to determine the ambient levels from accumulation mainly from brakes and clutches. Floor samples were also collected to verify the presence of fallen asbestos fibers.

IV

FINDINGS

Table I shows the ambient asbestos fiber concentrations in Vallejo, Oakland, and San Francisco at the locations listed during February 15th through the 19th, 1983. The ambient asbestos fiber concentrations average less than .02 fibers/cc, as previously reported for the cities of Seattle, Bremerton, and Portland, even though it was the winter season in the San Francisco area. The weather was dry and sunny except for rain on the morning of the18th which is reflected as lower ambient asbestos fiber levels. The smoggy conditions, the light winds, dry streets, heavy automobile traffic, and the concentration of industrial areas contributed to the consistantly high levels of airborne asbestos fibers collected from the ambient air. Tiny asbestos fibers once airborne are not easily scrubbed from the atmosphere by rain.

A map of the sample locations follows Table I.

V

CONCLUSIONS

Ambient air samples collected in the breathing zone at street level in three locations in each of the cities of Vallejo, Oakland, and San Francisco, California during the 8 hour daytime work period revealed that;

a. City dwellers are exposed to an average of .02 asbestos fibers/cc, greater than 5 micrometers in diameter as determined by phase contrast microscopy at 400X.

b. The ambient asbestos fiber levels of .02 fibers/cc compare to the average concentration of less than .02 asbestos fibers/cc released by GARLOCK INC gasket materials, and is 5 times greater than the concentrations of .004 fibers/cc released by spiral wound or encapsulated gaskets. This 1/100th and 1/500th respectively of the allowable occupational exposure of 2 fibers/cc, greater than 5 micrometers in diameter for an 8 hour time weighted average work day.

c. The data in Table I shows a relatively consistant elevated asbestos fiber exposure to city dwellers in the Greater San Francisco Bay Area during their 8 hour stay in the city.

d. Since there is no solid evidence of significant risk to the public at these levels based on asbestos disease incidence, then GARLOCK INC gasket materials that release asbestos fibers on processing at or below the ambient exposure levels present a negligible occupational risk to users.

GREATER SAN FRANCISCO BAY AREA

AMBIENT ASBESTOS FIBER CONCENTRATIONS, FEBRUARY 15-19,1983

Concentrations are expressed in asbestos fibers per cubic centimeter, greater than 5 micrometers in diameter for an eight hour time weighted average daytime period

San Francisco, California

LOCATION	CONSECUTIVE 8 HOUR WORK DAYS						ROUNDED
	1	2	3	4	5	AVE	AVE
Downtown San Francisco at Union Square	.012	.008*	.006	.004	.010	.008	.01
Union Square Parking Garage, 2d Lower Level					(.030)		
Central Basin Industrial Area, S.F.	.020	.022	.028*	.010	.024	.021	.02
Embarcadero Avenue Industrial Area	.031	.025	.033*	.021	.033	.029	.03
					AVERAGE		.02

Vallejo, California

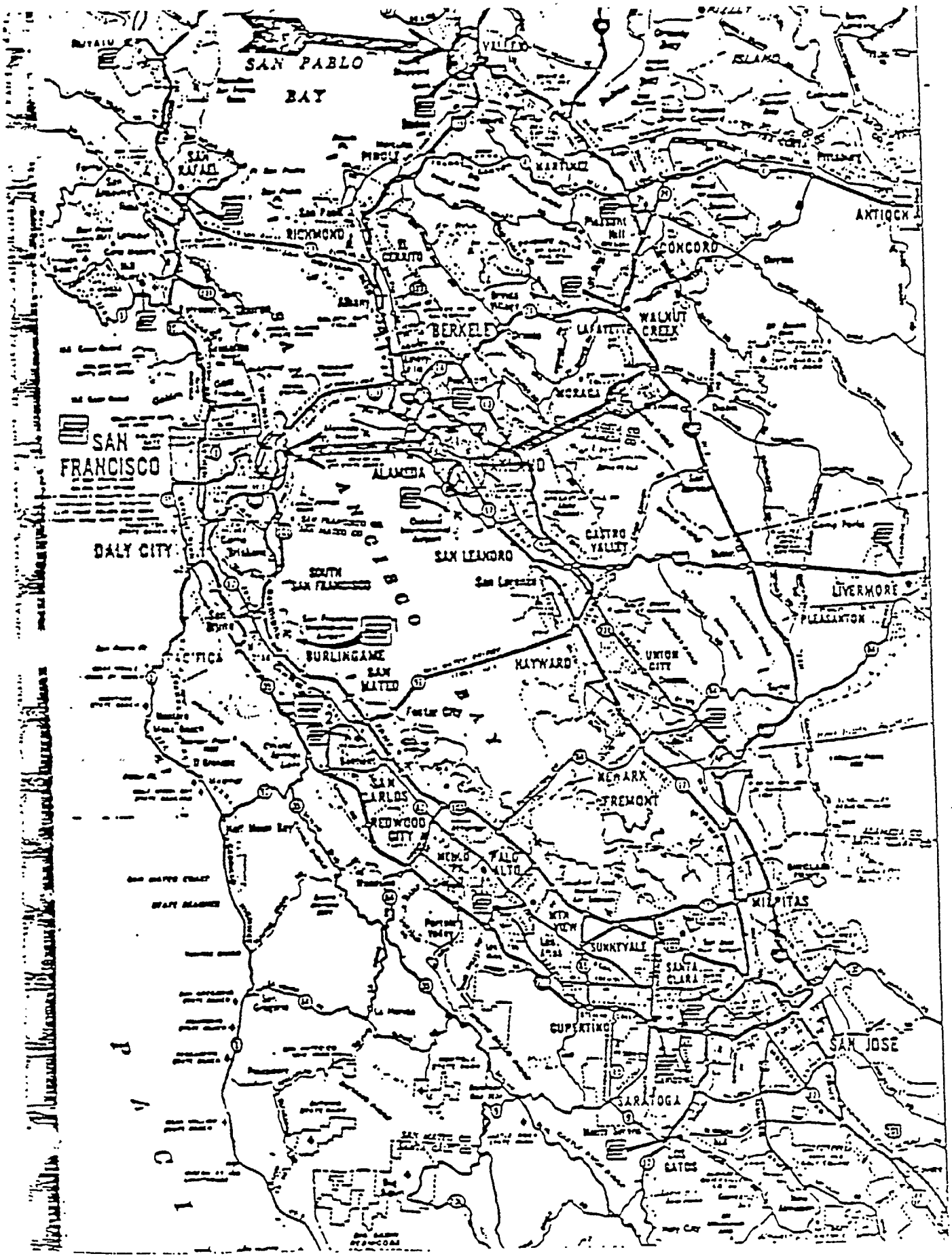
Santa Clara Avenue West Vallejo, CA	.014	.008	.018	.010	.018	.014	.01
Sears Road, North End Mare Island Naval Shipyard	.023	.020*	.031	.015	.025	.023	.02
Mare Island Way Across Bay From Mare Island Naval Shipyard	.024	.029	.035	.011	.028	.025	.03
					AVERAGE		.03

TABLE I (Cont'd)

LOCATION	1	2	3	4	5	AVE	ROU A
Downtown Oakland at 13th Avenue, near Court House	.018	.012	.008	.006	.010	.011	
Alameda Industrial Complex at 3d Ave.	.022	.028*	.030	.021	.034	.027	
Nimitz Highway Industrial Area, 2 blks from BART Elevated Railway	.031	.021	.028	.015	.025	.024	
					AVERAGE		

NOTE: The lower limit of detection for 100 microscope fields counted per sample is equal to .002 fibers/cc, greater than 5 micrometers in diameter for an eight hour period, and based on the effective filter area, and the microscope counting area.

* denotes street dirt collected and examined at that location and day while samples of the ambient air were being collected. The dirt was examined for proof of fallen asbestos fibers by phase contrast microscopy. All samples showed evidence of asbestos fibers.


SAN PABLO
BAY
SAN RAFAEL
RICHMOND
EL CERRITO
MARTINEZ
CONCORD
ANTIOCH
BERKELEY
WALNUT CREEK
MORAGA
SAN FRANCISCO
ALAMEDA
DALY CITY
SOUTH SAN FRANCISCO
SAN LEANDRO
CASTRO VALLEY
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BURLINGAME
SAN MATEO
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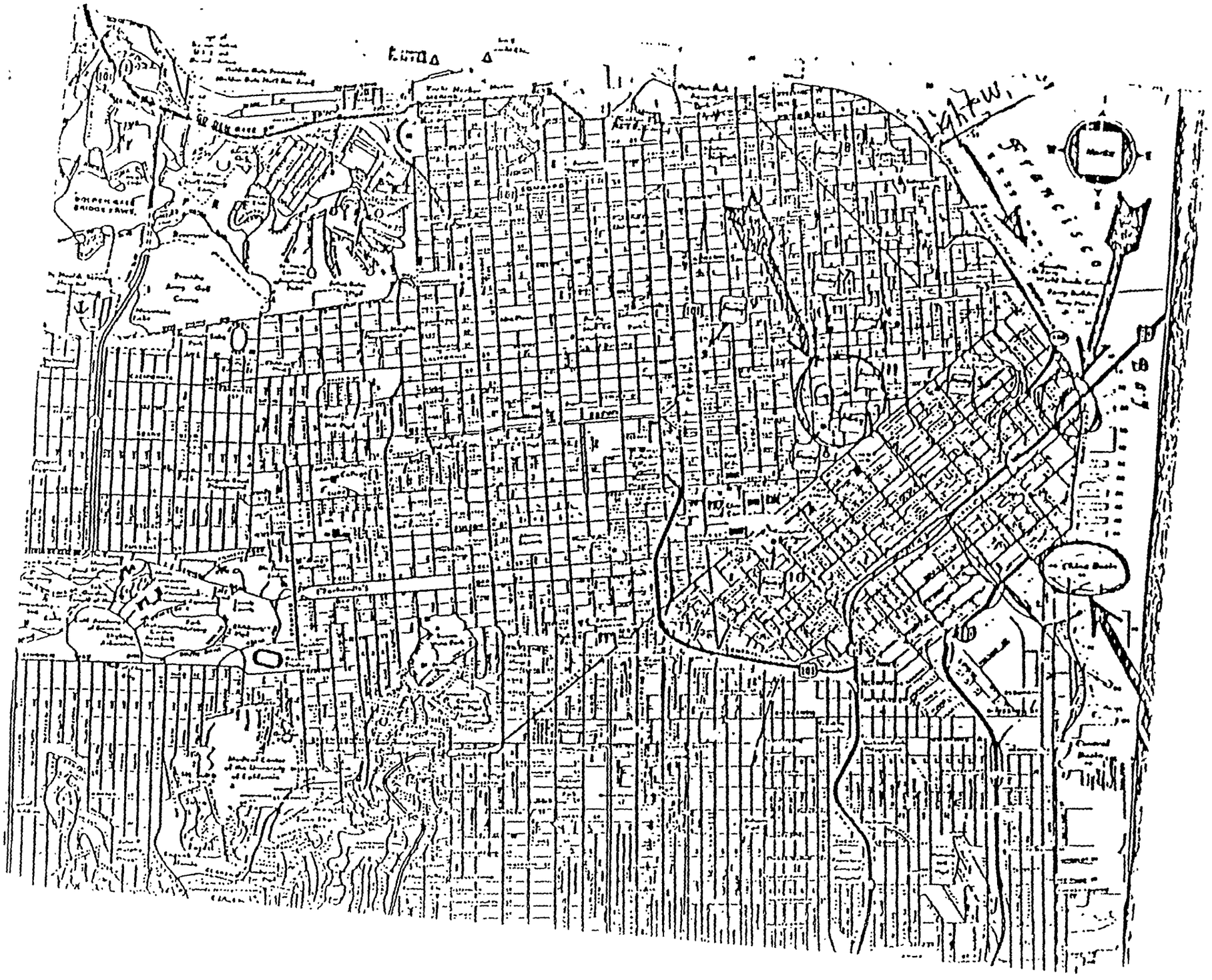

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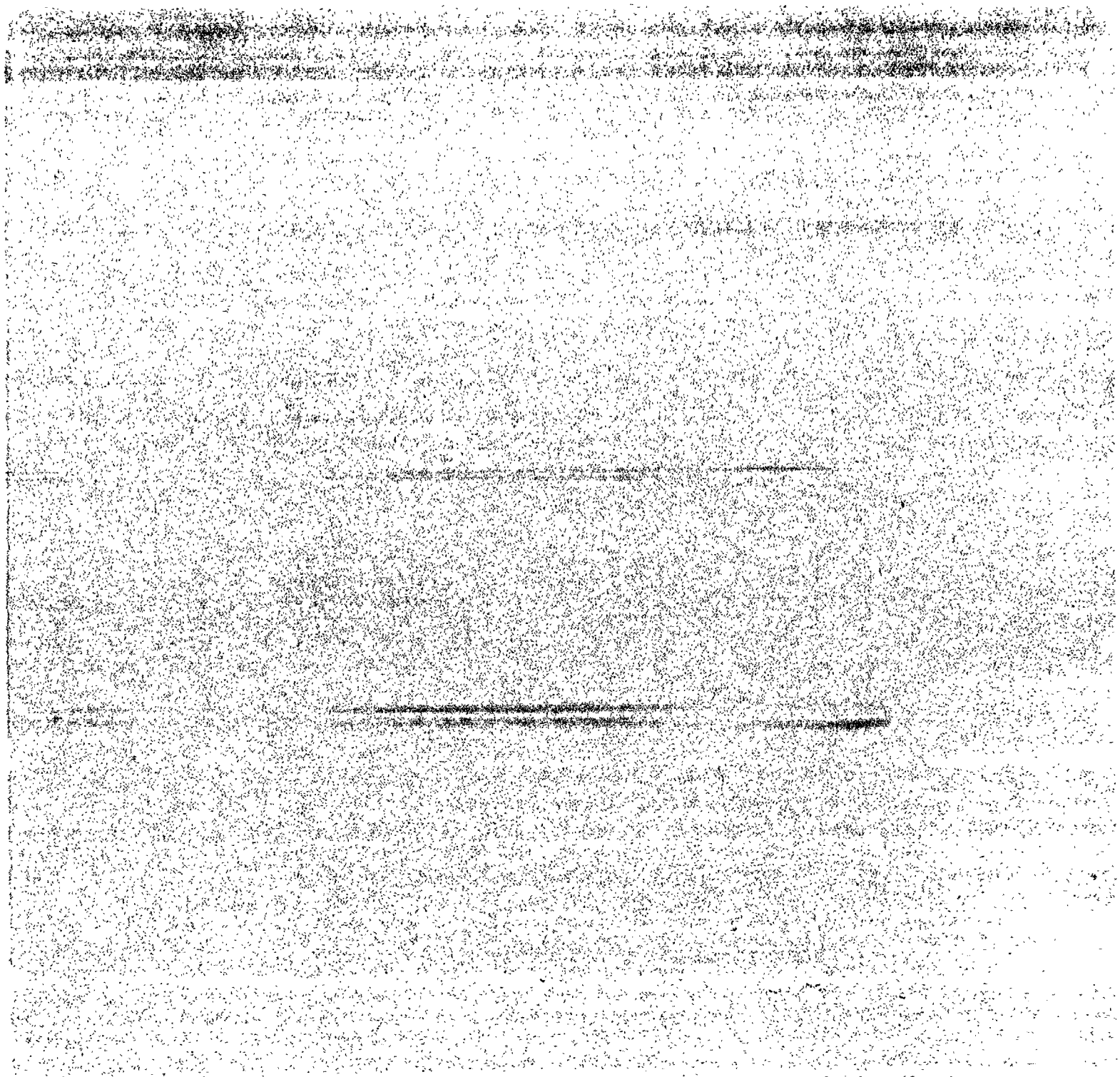

TLVs®
Threshold Limit Values for Chemical Substances in the Work Environment Adopted by ACGIH



with Intended Changes for 1987-88

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INTRODUCTION TO THE 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. Smoking of tobacco may act synergistically with airborne chemicals encountered in the workplace, e.g., asbestos.

Individuals may also be hypersusceptible or otherwise unusually responsive to some industrial chemicals because of genetic factors, age, personal habits (smoking, other drugs), medication, or previous exposures. Such workers may not be adequately protected from adverse health effects from certain chemicals at concentrations at or below the threshold limits. An occupational physician should evaluate the extent to which such workers require additional protection.

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 as guidelines or recommendations in the control of potential health hazards and for no other use, e.g., in the evaluation or control of community air pollution nuisances, in estimating the toxic potential of continuous, uninterrupted exposures or other extended work periods, as proof or disproof of an existing disease or physical condition, or adoption by countries whose working conditions differ from those in the United States of America and where substances and processes differ. These limits are *not* fine lines between safe and dangerous concentration nor are they a relative index of toxicity, and *should not* be used by anyone untrained in the discipline of industrial hygiene.

The Threshold Limit Values, as issued by ACGIH, are recommendations and should be used as guidelines for good practices.

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.

The ACGIH disclaims liability with respect to the use of TLVs.

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 *during* any part of the working exposure.

In conventional industrial hygiene practice if instantaneous monitoring is not feasible, then the TLV-C can be assessed by sampling over a 15-minute period except for those substances which

may cause immediate irritation with exceedingly short exposures.

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. Sustances 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-TWA, there is not enough toxicological data available to

warrant a STEL. Nevertheless, excursions above the TLV-TWA 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 TLV-TWAs 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 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 deviation 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 description 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 control. 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-TWA, 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 2.0 and the goal of the recommendations will be accomplished.

When the toxicological 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 airborne, 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.

Respirable and Total Dust. For solid substances and liquified mists, TLVs are expressed in terms of total dust except where the term "respirable dust" is used. See Appendix F, Particle Size-Selective Sampling Criteria for Airborne Particulate Matter, for the definition of respirable dust.

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; and 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.

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* 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)

A threshold limit of 10 mg/m³ of total dust < 1% quartz is recommended for substances in these categories and for which no specific threshold limits have been assigned. This limit, for a normal workday, does not apply to brief exposures at higher concentrations. Neither does it apply to those substances which may cause physiologic impairment at lower concentrations but for which a threshold limit has not yet been adopted. Some nuisance particulates are given in Appendix D. This list is not meant to be all inclusive; the substances serve only as examples.

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. This list is not meant to be all inclusive; the substances serve only as examples.

Physical Factors. It is recognized that such physical factors as heat, ultraviolet and ionizing radiation, humidity, abnormal pressure (altitude), and the like may place added stress on the body so that the effects from exposure at a threshold limit may be altered. Most of these stresses act adversely to increase the toxic response of a substance. *Although most threshold limits have built-in safety factors to guard against adverse effects to moderate deviations* from normal environments, the safety factors of most substances are not of such a magnitude as to take care of gross deviations. For example, continuous work at temperatures above 90°F, or overtime extending the workweek more than 25%, might be considered gross deviations. In such instances judgment must be exercised in the proper adjustments of the Threshold Limit Values.

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 inconsiderable toxicity, which have been omitted primarily because only a limited number of workers (e.g., employees of a single plant) are known to have potential exposure to possibly harmful concentrations

Operational Guidelines. The ACGIH Board of Directors has adopted operational guidelines for 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 the adopted values appear on right hand pages only.

Substance (CAS #)	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL 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	—	—
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 03,A2	—	—
‡Acrylic acid [79-10-7] ...	(10)	(30)	—	—
Acrylonitrile [107-13-1] — Skin	2,A2	4.5,A2	—	—
Aldrin [309-00-2] — Skin .	—	0.25	—	—
Allyl alcohol [107-18-6] — Skin	2	5	4	10
Allyl chloride [107-5-1] ...	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] ...	—	0	—	—
Aluminum [7429-90-5]				
Metal & oxide	—	10	—	—
Pyro powders	—	5	—	—
Welding fumes.....	—	5	—	—
Soluble salts.....	—	2	—	—
Alkyls (NOC†).....	—	2	—	—
4-Aminodiphenyl [92-67-1] — Skin	—	A1	—	—
2-Aminoethanol, see Ethanolamine				
2-Aminopyridine [504-29-0]	0 5	2	—	—
3-Amino 1,2,4-triazole, see Amitrole				
Amitrole [61-82-5]	—	0.2	—	—

(a) Parts of vapor or gas per million parts of contaminated air by volume at 25°C and 760 torr.

(b) Milligrams of substance per cubic meter of air. When entry is in this column only, the value is exact; when listed with a ppm entry, it is approximate.

‡ See Notice of Intended Changes

* 1987-1988 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]
Ammonia [7664-41-7]	25	18	35	27
Ammonium chloride fume [12125-02-9]	—	10	—	20
Ammonium sulfamate [7773-06-0]	—	10	—	—
Amosite, see Asbestos				
•n-Amyl acetate [628-63-7]	100	530	—	—
•sec-Amyl acetate [626-38-0]	125	665	—	—
Aniline [62-53-3] & homologues—Skin	2	10	—	—
Anisidine [29191-52-4] (o-, p-isomers)—Skin	0.1	0.5	—	—
Antimony [7440-36-0] & compounds, as Sb	—	0.5	—	—
Antimony trioxide [1309-64-4]				
Handling and use, as Sb	—	0.5	—	—
Production	—	A2	—	—
ANTU [86-88-4]	—	0.3	—	—
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[c,d]				
Amosite [12172-73-5]		0.5 fiber/cc, A1		
Chrysotile [12001-29-5]		2 fibers/cc, A1		
Crocidolite [12001-28-4]		0.2 fiber/cc, A1		
Other forms		2 fibers/cc, A1		
•Asphalt (petroleum) fumes [8052-42-4]	—	5	—	—
Atrazine [1912-24-9]	—	5	—	—
Azinphos-methyl [86-50-0]—Skin	—	0.2	—	—
Barium [7440-39-3], soluble compounds, as Ba	—	0.5	—	—
Barium sulfate [7727-43-7]	—	10[e]	—	—
Benomyl [17804-35-2]	0.8	10	—	—
•Benzene [71-43-2]	10,A2	30,A2	—	—
Benzidine [92-87-5]—Skin	—	A1	—	—
p-Benzoquinone, see Quinone				
Benzoyl peroxide [94-36-0]	—	5	—	—
Benzo(a)pyrene [50-32-8]	—	A2	—	—
Benzyl chloride [100-44-7]	1	5	—	—

Substance [CAS #]	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
Beryllium and compounds [7440-41-7]	—	0.002,A2	—	—
•Biphenyl [92-52-4]	0.2	1.5	—	—
Bismuth telluride [1304-82-1]	—	10	—	—
Se-doped	—	5	—	—
Borates, tetra, sodium salts [1303-96-4]				
Anhydrous	—	1	—	—
Decahydrate	—	5	—	—
Pentahydrate	—	1	—	—
Boron oxide [1303-86-2]	—	10	—	—
Boron tribromide [10294-33-4]	C 1	C 10	—	—
Boron trifluoride [7637-07-2]	C 1	C 3	—	—
Bromacil [314-40-9]	1	10	—	—
Bromine [7726-95-6]	0.1	0.7	0.3	2
Bromine pentafluoride [7789-30-2]	0.1	0.7	—	—
Bromochloromethane, see Chlorobromomethane				
Bromoform [75-25-2]—Skin	0.5	5	—	—
1,3-Butadiene [106-99-0]	10,A2	22,A2	—	—
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	—	—
n-Butyl acetate [123-86-4]	150	710	200	950
•sec-Butyl acetate [105-46-4]	200	950	—	—
•tert-Butyl acetate [540-88-5]	200	950	—	—
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	—	—
n-Butyl lactate [138-22-7]	5	25	—	—

Capital letters A, B, D & E refer to Appendices; C denotes ceiling limit.

• STEL deleted, TWA retained

(d) Fibers longer than 5 μm and with an aspect ratio equal to or greater than 3:1 as determined by the membrane filter method at 400-450X magnification (4 mm objective) phase contrast illumination

(e) The value is for total dust containing no asbestos and <1% free silica.

Substance [CAS #]	ADOPTED VALUES TWA ppm[4]	TWA mg/m³[3&4]	STEL ppm[4]	STEL mg/m³[3&4]
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] Dusts & salts, as Cd	—	(0.05)	—	—
‡Cadmium oxide [1306-19-0] Fume, as Cd	—	(C 0.05)	—	—
Production	—	(0.05)	—	—
Calcium carbonate [1317-65-3]	—	10[1]	—	—
Calcium cyanamide [156-62-7]	—	0.5	—	—
Calcium hydroxide [1305-62-0]	—	5	—	—
Calcium oxide [1305-78-8]	—	2	—	—
Calcium silicate [1344-95-2]	—	D	—	—
Calcium sulfate [7778-18-9]	—	10[1]	—	—
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	—	—
Carbaryl [63-25-2]	—	5	—	—
Carbofuran [1563-66-2]	—	0.1	—	—
Carbon black [1333-86-4]	—	3.5	—	—
Carbon dioxide [124-38-9]	5,000	9,000	30,000	54,000
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	—	—
Carbonyl chloride, see Phosgene				
Carbonyl fluoride [353-50-4]	2	5	5	15
Catechol [120-80-9]	5	20	—	—
Cellulose (paper fiber) [9004-34-6]	—	D	—	—
Cesium hydroxide [21351-79-1]	—	2	—	—
Chlordane [57-74-9]—Skin	—	0.5	—	2
Chlorinated camphene [8001-35-2]—Skin	—	0.5	—	1

Substance [CAS #]	ADOPTED VALUES TWA ppm[4]	TWA mg/m³[3&4]	STEL ppm[4]	STEL mg/m³[3&4]
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]	0.05	0.3	—	—
Chloroacetyl chloride [79-04-9]	0.05	0.2	—	—
Chlorobenzene [108-90-7]	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	—	—
bis(Chloromethyl) ether [542-88-1]	0.001, A1	0.005, A1	—	—
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

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]
β-Chloroprene [126-99-8]—Skin	10	35	—	—
o-Chlorostyrene [2039-87-4]	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,A1	—	—
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,A1	—	—
Chromyl chloride [14977-61-8]	0.025	0.15	—	—
Chrysene [218-01-9]	A2	A2	—	—
Chrysotile, see Asbestos				
Clopidol [2971-90-6]	—	10	—	20
*Coal dust	—	2,[m] Respirable fraction		
Coal tar pitch volatiles [65996-93-2], as benzene solubles	—	0.2,A1	—	—
*Cobalt [7440-48-4], as Co Metal dust & fume	—	0.05	—	—
Cobalt carbonyl [10210-68-1], 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	—	—
Cotton dust, raw	—	0.2[n]	—	—
Cresol [1319-77-3], all isomers—Skin	5	22	—	—
Cristobalite, see Silica—Crystalline				
Crocidolite, see Asbestos				
•Crotonaldehyde [4170-30-3]	2	8	—	—

Substance [CAS #]	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
Cruformate [299-86-5]	—	5	—	20
•Cumene [98-82-8]—Skin	50	245	—	—
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	—	—
Cyclohexanol [108-93-0]—Skin	50	200	—	—
•Cyclohexanone [108-94-1]—Skin	25	100	—	—
Cyclohexene [110-83-8]	300	1,015	—	—
Cyclohexylamine [108-91-8]	10	40	—	—
Cyclonite [121-82-4]—Skin	—	1.5	—	3
•Cyclopentadiene [542-92-7]	75	200	—	—
•Cyclopentane [287-92-3]	600	1,720	—	—
Cyhexatin [13121-70-5]	—	5	—	—
2,4-D [94-75-7]	—	10	—	—
DDT (Dichlorodiphenyl-trichloroethane) [50-29-3]	—	1	—	—
Decaborane [17702-41-9]—Skin	0.05	0.3	0.15	0.9
Demeton [8065-48-3]—Skin	0.01	0.1	—	—
•Diacetone alcohol [123-42-2]	50	240	—	—
1,2-Diaminoethane, see Ethylenediamine				
Diatomaceous earth, see Silica—Amorphous				
Diazinon [333-41-5]—Skin	—	0.1	—	—
Diazomethane [334-88-3]	0.2	0.4	—	—

Capital letters A, B, D & E refer to Appendices; C denotes ceiling limit.

* 1987-1988 Addition.

• STEL deleted, TWA retained.

(f) The value is for dust containing <5% free silica. For dust containing more than this percentage of free silica, the environment should be evaluated against the TLV-TWA of 0.1 mg/m³ for respirable quartz. The concentration of respirable dust for the application of this limit is to be determined from the fraction passing a size-selector with the characteristics defined in the "c." paragraphs of Appendix F.

(g) 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]
Diborane [19287-45-7]	0.1	0.1	—	—
1,2-Dibromoethane, see Ethylene dibromide				
2-N-Dibutylaminoethanol [102-81-8]—Skin	2	14	—	—
Dibutyl phosphate [107-66-4]	1	5	2	10
•Dibutyl phthalate [84-74-2]	—	5	—	—
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	—	—
Dichlorodifluoromethane [75-71-8]	1,000	4,950	—	—
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	—	—
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	—	—
1,2-Dichloropropane, see Propylene dichloride				
Dichloropropene [542-75-6]—Skin	1	5	—	—
2,2-Dichloropropionic acid [75-99-0]	1	6	—	—
Dichlorotetrafluoroethane [76-14-2]	1,000	7,000	—	—
Dichlorvos [62-73-7]—Skin	0.1	1	—	—
Dicrotophos [141-66-2]—Skin	—	0.25	—	—
Dicyclopentadiene [77-73-6]	5	30	—	—
Dicyclopentadienyl iron [102-54-5]	—	10	—	—
Dieldrin [60-57-1]—Skin	—	0.25	—	—
Diethanolamine [111-42-2]	3	15	—	—
Diethylamine [109-89-7]	10	30	25	75

Substance [CAS #]	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
2-Diethylaminoethanol [100-37-8]—Skin	10	50	—	—
Diethylene triamine [111-40-0]—Skin	1	4	—	—
Diethyl ether, see Ethyl ether				
Di(2-ethylhexyl)phthalate, see Di-sec-octyl phthalate				
Diethyl ketone [96-22-0]	200	705	—	—
•Diethyl phthalate [84-66-2]	—	5	—	—
Difluorodibromomethane [75-61-6]	100	860	—	—
Diglycidyl ether (DGE) [2238-07-5]	0.1	0.5	—	—
Dihydroxybenzene, see Hydroquinone				
Diisobutyl ketone [108-83-8]	25	250	—	—
Diisopropylamine [108-18-9]—Skin	5	20	—	—
Dimethoxymethane, see Methylal				
Dimethyl acetamide [127-19-5]—Skin	10	35	—	—
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 carbamoyl chloride [79-44-7]	A2	A2	—	—
Dimethyl-1,2-dibromo-2-dichloroethyl phospate, see Naled				
Dimethylformamide [68-12-2]—Skin	10	30	—	—
2,6-Dimethyl-4-heptanone, see Diisobutyl ketone				
1,1-Dimethylhydrazine [57-14-7]—Skin	0.5,A2	1,A2	—	—
Dimethylnitrosoamine, see N-Nitrosodimethylamine				
Dimethylphthalate [131-11-3]	—	5	—	—
Dimethyl sulfate [77-78-1]—Skin	0.1,A2	0.5,A2	—	—
Dinitolmide [148-01-6]	—	5	—	—

Capital letters A, B, D & E refer to Appendices; C denotes ceiling limit.
• STEL deleted, TWA retained

Substance [CAS #]	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
Dinitrobenzene [528-29-0; 99-65-0, 100-25-4] (all isomers)—Skin	0.15	1	—	—
Dinitro-o-cresol [534-52-1]—Skin	—	0.2	—	—
3,5-Dinitro-o-toluamide, see Dinitolmide				
Dinitrotoluene [121-14-2]—Skin	—	1.5	—	—
Dioxane [123-91-1]—Skin	25	90	—	—
Oxathion [78-34-2]—Skin	—	0.2	—	—
Diphenyl, see Biphenyl				
Diphenylamine [122-39-4]	—	10	—	—
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	—	—
Di-sec-octyl phthalate [117-81-7]	—	5	—	10
Disulfiram [97-77-8]	—	2	—	—
Disulfoton [298-04-4]	—	0.1	—	—
•2,6-Di-tert-butyl-p-cresol [128-37-0]	—	10	—	—
Diuron [330-54-1]	—	10	—	—
Divinyl benzene [1321-74-0]	10	50	—	—
Emery [112-62-9]	—	D	—	—
Endosulfan [115-29-7]—Skin	—	0.1	—	—
Endrin [72-20-8]—Skin	—	0.1	—	—
Enzymes, see Subtilisins				
Epichlorohydrin [106-89-8]—Skin	2	10	—	—
EPN [2104-64-5]—Skin	—	0.5	—	—
1,2-Epoxypropane, see Propylene oxide				
2,3-Epoxy-1-propanol, see Glycidol				
Ethane [74-84-0]	E	—	—	—
Ethanethiol, see Ethyl mercaptan				
Ethanol, see Ethyl alcohol				
Ethanolamine [141-43-5]	3	8	6	15
Ethion [563-12-2]—Skin	—	0.4	—	—
2-Ethoxyethanol [110-80-5]—Skin	5	19	—	—
2-Ethoxyethyl acetate [111-15-9]—Skin	5	27	—	—

Substance [CAS #]	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
Ethyl acetate [141-78-6]	400	1,400	—	—
‡Ethyl acrylate [140-88-5]—Skin	5	20	(25)	(100)
Ethyl alcohol [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	—	—
Ethyl chloride [75-00-3]	1,000	2,600	—	—
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	—	—
Ethylene glycol [107-21-1] Vapor	C 50	C 125	—	—
Ethylene glycol dinitrate [628-96-6]—Skin	0.05	0.3	—	—
Ethylene glycol methyl ether acetate, see 2-Methoxyethyl acetate				
Ethylene oxide [75-21-8]	1,A2	2,A2	—	—
Ethylenimine [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	—	—
Ethylidene chloride, see 1,1-Dichloroethane				
Ethylidene norbornene [16219-75-3]	C 5	C 25	—	—
Ethyl mercaptan [75-08-1]	0.5	1	—	—
N-Ethylmorpholine [100-74-3]—Skin	5	23	—	—
Ethyl silicate [78-10-4]	10	85	—	—
Fenamiphos [22224-92-6]—Skin	—	0.1	—	—
Fensulfothion [115-90-2]	—	0.1	—	—

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‡ See Notice of Intended Changes
• STEL deleted, TWA retained

Substance [CAS #]	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
Fenthion [55-38-9] — Skin	—	0.2	—	—
Ferbam [14484-64-1]	—	10	—	—
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]	1,A2	1.5,A2	2,A2	3,A2
‡Formamide [75-12-7]	(20)	(30)	(30)	(45)
‡Formic acid [64-18-6]	5	9	(—)	(—)
•Furfural [98-01-1] — Skin	2	8	—	—
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	—	—
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	—	—
Glycol monoethyl ether, see 2-Ethoxyethanol				
Grain dust (oat, wheat, barley)	—	4[m]	—	—
‡*Graphite (natural) [7782-42-5]	—	(2.5[n], Respirable dust)		
‡Graphite (synthetic)	—	(10[m])	—	—
Gypsum, see Calcium sulfate				
Hafnium [7440-58-6]	—	0.5	—	—
Helium [7440-59-7]	E	—	—	—
Heptachlor [76-44-8] — Skin	—	0.5	—	—
Heptane [142-82-5] (n-Heptane)	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	—	—
‡Hexachloroethane [67-72-1]	(10)	(100)	—	—
Hexachloronaphthalene [1335-87-1] — Skin	—	0.2	—	—

Substance [CAS #]	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
Hexafluoroacetone [684-16-2] — Skin	0.1	0.7	—	—
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 [108-84-9]	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 [61788-32-7]	0.5	5	—	—
Hydrogen bromide [10035-10-6]	C 3	C 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	C 3	C 2.5	—	—
Hydrogen peroxide [7722-84-1]	1	1.5	—	—
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-Hydroxy-4-methyl-2-pentanone, see Diacetone alcohol				
2-Hydroxypropyl acrylate [999-61-1] — Skin	0.5	3	—	—
•Indene [95-13-6]	10	45	—	—

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‡ See Notice of Intended Changes.

* 1987-1988 Addition

• STEL deleted, TWA retained

(e) The value is for total dust containing no asbestos and < 1% free silica.

(h) Total particulate

(i) The concentration of respirable dust for the application of this limit is to be determined from the fraction passing a size-selector with the characteristics defined in the "c" paragraphs of Appendix F.

Substance [CAS #]	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
Indium [7440-74-6] & compounds, as In	—	0.1	—	—
Iodine [7553-56-2]	C 0.1	C 1	—	—
Iodoform [75-47-8]	0.6	10	—	—
Iron oxide fume (Fe_2O_3) [1309-37-1], as Fe	5	5	—	—
Iron pentacarbonyl [13463-40-6], as Fe	0.1	0.8	0.2	1.6
Iron salts, soluble, as Fe	—	1	—	—
•Isoamyl acetate [123-92-2]	100	525	—	—
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	—	—
Isooctyl alcohol [26952-21-6]—Skin	50	270	—	—
Isophorone [78-59-1]	C 5	C 25	—	—
‡Isophorone diisocyanate [4098-71-9]—Skin	(0.01)	(0.09)	—	—
•Isopropoxyethanol [109-59-1]	25	105	—	—
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
N-Isopropylaniline [768-52-5]—Skin	2	10	—	—
Isopropyl ether [108-20-3]	250	1,050	310	1,320
Isopropyl glycidyl ether (IGE) [4016-14-2]	50	240	75	360
Kaolin	—	D	—	—
Ketene [463-51-4]	0.5	0.9	1.5	3
Lead [7439-92-1], inorg. dusts & fumes; as Pb	—	0.15	—	—
Lead arsenate [10102-48-4], as $Pb_3(AsO_4)_2$	—	0.15	—	—
Lead chromate [7758-97-6], as Cr	—	0.05,A2	—	—
Limestone, see Calcium carbonate				
Lindane [58-89-9]—Skin	—	0.5	—	—
Lithium hydride [7580-67-8]	—	0.025	—	—
•L.P.G. (Liquified petroleum gas) [68476-85-7]	1,000	1,800	—	—
Magnesite [546-93-0]	—	D	—	—
Magnesium oxide fume [1309-48-4]	—	10	—	—

Substance [CAS #]	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
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
Manganese cyclopentadienyl tricarbonyl [12079-65-1], as Mn—Skin	—	0.1	—	—
Manganese tetroxide [1317-35-7]	—	1	—	—
Marble, see Calcium carbonate				
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	—	—	—
Methanethiol, see Methyl mercaptan				
Methanol, see Methyl alcohol				
Methomyl [16752-77-5]	—	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	—	—

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‡ See Notice of Intended Changes
• STEL deleted, TWA retained

Substance [CAS #]	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
•Methytal [109-87-5]	1,000	3,100	—	—
Methyl alcohol [67-56-1] — 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	—	—
N-Methyl aniline [100-61-8] — Skin	0.5	2	—	—
Methyl bromide [74-83-9] — Skin	5	20	—	—
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	—	—
•Methylcyclohexanol [25639-42-3]	50	235	—	—
o-Methylcyclohexanone [583-60-8] — Skin	50	230	75	345
2-Methylcyclopentadienyl manganese tricarbonyl [12108-13-3], as Mn — Skin	—	0.2	—	—
Methyl demeton [8022-00-2] — Skin	—	0.5	—	—
‡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)	(C0.11)	—	—
4,4'-Methylene dianiline [101-77-9] — Skin	0.1,A2	0.8,A2	—	—
Methyl ethyl ketone (MEK) [78-93-3]	200	590	300	885
Methyl ethyl ketone peroxide [1338-23-4]	C 0.2	C 1.5	—	—

Substance [CAS #]	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
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	—	—
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] — Skin	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	—	—
Methyl parathion [298-00-0] — Skin	—	0.2	—	—
Methyl propyl ketone [107-87-9]	200	700	250	875
Methyl silicate [681-84-5]	1	6	—	—
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
Mica [12001-25-2]	—	3,[n] Respirable dust		
Mineral wool fiber	—	10	—	—
Molybdenum [7439-98-7], as Mo				
Soluble compounds	—	5	—	—
Insoluble compounds	—	10	—	—
Monochlorobenzene, see Chlorobenzene				
Monocrotophos [6923-22-4]	—	0.25	—	—

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‡ See Notice of Intended Changes

• STEL deleted, TWA retained

(i) The concentration of respirable dust for the application of this limit is to be determined from the fraction passing a size-selector with the characteristics defined in the "c" paragraphs of Appendix F

Substance [CAS #]	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
Morpholine [110-91-8]—Skin	20	70	30	105
Naled [300-76-5]—Skin	—	3	—	—
Naphthalene [91-20-3]	10	50	15	75
β-Naphthylamine [91-59-8]	—	A1	—	—
Neon [7440-01-9]	E	—	—	—
Nickel [7440-02-0]				
Metal	—	1	—	—
Soluble compounds, as Ni	—	0.1	—	—
Nickel carbonyl [13463-39-3], as Ni	0.05	0.35	—	—
Nickel sulfide roasting, fume & dust, as Ni	—	1,A1	—	—
Nicotine [54-11-5]—Skin	—	0.5	—	—
Nitrapyrin [1929-82-4]	—	10	—	20
Nitric acid [7697-37-2]	2	5	4	10
Nitric oxide [10102-43-9]	25	30	—	—
p-Nitroaniline [100-01-6]—Skin	—	3	—	—
Nitrobenzene [98-95-3]—Skin	1	5	—	—
‡p-Nitrochlorobenzene [100-00-5]—Skin	(0.5)	(3)	—	—
4-Nitrodiphenyl [92-93-3]	—	A1	—	—
Nitroethane [79-24-3]	100	310	—	—
Nitrogen dioxide [10102-44-0]	3	6	5	10
Nitrogen trifluoride [7783-54-2]	10	30	—	—
Nitroglycerin (NG) [55-63-0]—Skin	0.05	0.5	—	—
Nitromethane [75-52-5]	100	250	—	—
1-Nitropropane [108-03-2]	25	90	—	—
*2-Nitropropane [79-46-9]	10, A2	35, A2	—	—
N-Nitrosodimethylamine [62-75-9]—Skin	—	A2	—	—
Nitrotoluene [99-08-1]—Skin	2	11	—	—
Nitrotrichloromethane, see Chloropicrin				
•Nonane [111-84-2]	200	1,050	—	—
Nuisance particulates	—	10[m]	—	—
Octachloronaphthalene [2234-13-1]—Skin	—	0.1	—	0.3

Substance [CAS #]	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
Octane [111-65-9]	300	1,450	375	1,800
Oil mist, mineral [8012-95-1]	—	5[p]	—	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]	C 0.05	C 0.1	—	—
‡Ozone [10028-15-6]	(0.1)	(0.2)	(0.3)	(0.6)
•Paraffin wax fume [8002-74-2]	—	2	—	—
Paraquat [4685-14-7], respirable sizes	—	0.1	—	—
Parathion [56-38-2]—Skin	—	0.1	—	—
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	—	—
Pentachlorophenol [87-86-5]—Skin	—	0.5	—	—
Pentaerythritol [115-77-5]	—	D	—	—
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	—	—
Perchloryl fluoride [7616-94-6]	3	14	6	28
Percipitated silica, see Silica—Amorphous				
Perlite	—	10[m]	—	—
Phenacyl chloride, see ω-Chloroacetophenone				
•Phenol [108-95-2]—Skin	5	19	—	—
Phenothiazine [92-84-2]—Skin	—	5	—	—

Capital letters A, B, D & E refer to Appendices; C denotes ceiling limit.
‡ See Notice of Intended Changes.
* 1987-1988 Addition
• STEL deleted, TWA retained.
(a) The value is for total dust containing no asbestos and <1% free silica.
(j) 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]
N-Phenyl-beta-naphthyl-amine [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,A2	20,A2	10,A2	45,A2
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 (yellow) [7723-14-0]	—	0.1	—	—
Phosphorus oxychloride [10025-87-3]	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	—	—
m-Phthalodinitrile [626-17-5]	—	5	—	—
Picloram [1918-02-1]	—	10	—	20
Picric acid [88-89-1] — Skin	—	0.1	—	0.3
•Pindone [83-26-1]	—	0.1	—	—
Piperazine dihydrochloride [142-64-3]	—	5	—	—
2-Pivalyl-1,3-indandione, see Pindone				
Plaster of Paris, see Calcium sulfate				
Platinum [7440-06-4]				
Metal	—	1	—	—
Soluble salts, as Pt	—	0.002	—	—
Polychlorobiphenyls, see Chlorodiphenyls				
Polytetrafluoroethylene decomposition products	—	B1	—	—
Portland cement	—	10[e]	—	—

Substance [CAS #]	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
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	—	—
•β-Propiolactone [57-57-8]	0.5,A2	1.5,A2	—	—
Propionic acid [79-09-4]	10	30	15	45
•Propoxur [114-26-1]	—	0.5	—	—
n-Propyl acetate [109-60-4]	200	840	250	1,050
Propyl alcohol [71-23-8] — Skin	200	500	250	625
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	—	—
Propylene glycol mono-methyl ether [107-98-2]	100	360	150	540
Propylene imine [75-55-8] — Skin	2,A2	5,A2	—	—
Propylene oxide [75-56-9]	20	50	—	—
n-Propyl nitrate [627-13-4]	25	105	40	170
Propyne, see Methyl acetylene				
•Pyrethrum [8003-34-7]	—	5	—	—
•Pyridine [110-86-1]	5	15	—	—
Pyrocatechol, see Catechol				
Quartz, see Silica — Crystalline				
•Quinone [106-51-4]	0.1	0.4	—	—
RDX, see Cyclonite				
Resorcinol [108-46-3]	10	45	20	90
Rhodium [7440-16-6]				
Metal	—	1	—	—
Insoluble compounds, as Rh	—	1	—	—
Soluble compounds, as Rh	—	0.01	—	—
Ronnel [299-84-3]	—	10	—	—

Capital letters A, B, D & E refer to Appendices, C denotes ceiling limit

• STEL deleted, TWA retained.

(e) The value is for total dust containing no asbestos and <1% free silica.

Substance [CAS #]	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
•Rosin core solder pyrolysis products, as formaldehyde	—	0.1	—	—
•Rotenone (commercial) [83-79-4]	—	5	—	—
Rouge	—	D	—	—
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	—	—
Silane, *see* Silicon tetrahydride				
Silica—Amorphous				
Diatomaceous earth (uncalcined) [68855-54-9]	—	10[m]	—	—
•Percipitated silica	—	10[m]	—	—
•Silica gel	—	10[m]	—	—
Silica—Crystalline				
Cristobalite [14464-46-1]	—	0.05,[n] Respirable dust		
Quartz [14808-60-7]	—	0.1,[n] Respirable dust		
Silica, fused [60676-86-0]	—	0.1,[n] Respirable dust		
Tridymite [15468-32-3]	—	0.05,[n] Respirable dust		
Tripoli [1317-95-9]	—	0.1,[n] of contained respirable quartz		
Silica, fused, *see* Silica—Crystalline				
Silica gel, *see* Silica—Amorphous				
Silicon [7440-21-3]	—	10[m]	—	—
Silicon carbide [409-21-2]	—	10[m]	—	—
Silicon tetrahydride [7803-62-5]	5	7	—	—
Silver [7440-22-4]				
Metal	—	0.1	—	—
Soluble compounds, as Ag	—	0.01	—	—
Soapstone				
Respirable	—	3[m]	—	—
Total	—	6[m]	—	—
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	—	—

Substance [CAS #]	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
Sodium metabisulfite [7681-57-4]	—	5	—	—
Starch [9005-25-8]	—	D	—	—
Stibine [7803-52-3]	0.1	0.5	—	—
•Stoddard solvent [8052-41-3]	100	525	—	—
Strychnine [57-24-9]	—	0.15	—	—
Styrene, monomer [100-42-5]	50	215	100	425
Subtilisins [1395-21-7] (Proteolytic enzymes as 100% pure crystalline enzyme)	—C 0.00006[m]		—	—
Sucrose [57-50-1]	—	D	—	—
Sulfiram [3689-24-5]—Skin	—	0.2	—	—
Sulfur dioxide [7446-09-5]	2	5	5	10
Sulfur hexafluoride [2551-62-4]	1,000	6,000	—	—
‡Sulfuric acid [7664-93-9]	—	1	—	(—)
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	—	—
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	—	—
Talc (containing no asbestos fibers) [14807-96-6]	—	2,[n] Respirable dust		
Talc (containing asbestos fibers)	Use asbestos TLV-TWA.[n]			
‡Tantalum [7440-25-7]	—	(5)	—	(10)
TEDP, *see* Sulfotep				

Capital letters A, B, D & E refer to Appendices; C denotes ceiling limit.

‡ See Notice of Intended Changes.

• STEL deleted, TWA retained

(e) The value is for total dust containing no asbestos and <1% free silica.

(f) The concentration of respirable dust for the application of this limit is to be determined from the fraction passing a size-selector with the characteristics defined in the "c." paragraphs of Appendix F.

(k) Based on "high Volume" sampling

(l) However, should not exceed 2 mg/m³ respirable dust.

Substance [CAS #]	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
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	—	—
TEPP [107-49-3] — Skin	0.004	0.05	—	—
Terphenyls [26140-60-3]	C 0.5	C 5	—	—
1,1,1,2-Tetrachloro-2,2-difluoroethane [76-11-9]	500	4,170	—	—
1,1,2,2-Tetrachloro-1,2-difluoroethane [76-12-0]	500	4,170	—	—
1,1,2,2-Tetrachloroethane [79-34-5] — Skin	1	7	—	—
Tetrachloroethylene, see Perchloroethylene				
Tetrachloromethane, see Carbon tetrachloride				
Tetrachloronaphthalene [1335-88-2]	—	2	—	—
Tetraethyl lead [78-00-2], as Pb — Skin	—	0.1[m]	—	—
Tetrahydrofuran [109-99-9]	200	590	250	735
Tetramethyl lead [75-74-1], as Pb — Skin	—	0.15[m]	—	—
Tetramethyl succinonitrile [3333-52-6] — Skin	0.5	3	—	—
Tetranitromethane [509-14-8]	1	8	—	—
Tetrasodium pyrophosphate [7722-88-5]	—	5	—	—
Tetryl [479-45-8] — Skin	—	1.5	—	—
Thallium [7440-28-0] Soluble compounds, as Tl — Skin	—	0.1	—	—
4,4'-Thiobis(6-tert-butyl-m-cresol) [96-69-5]	—	10	—	—
Thioglycolic acid [68-11-1] — Skin	1	4	—	—
Thionyl chloride [7719-09-7]	C 1	C 5	—	—
‡Thiram [137-26-8]	—	(5)	—	—
Tin [7440-31-5] Metal	—	2	—	—
Oxide & inorganic compounds, except SnH_4, as Sn	—	2	—	—
Organic compounds, as Sn — Skin	—	0.1	—	—

Substance [CAS #]	ADOPTED VALUES TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
Titanium dioxide [13463-67-7]	—	10[m]	—	—
o-Tolidine [119-93-7] — Skin	A2	A2	—	—
Toluene (toluol) [108-88-3]	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	—	—
m-Toluidine [108-44-1] — Skin	2	9	—	—
p-Toluidine [106-49-0] — Skin	2,A2	9,A2	—	—
Toxaphene, see Chlorinated camphene				
Tributyl phosphate [126-73-8]	0.2	2.5	—	—
Trichloroacetic acid [76-03-9]	1	7	—	—
1,2,4-Trichlorobenzene [120-82-1]	C 5	C 40	—	—
1,1,1-Trichloroethane, see Methyl chloroform				
1,1,2-Trichloroethane [79-00-5] — Skin	10	45	—	—
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] — Skin	—	5	—	—
Trichloronitromethane, see Chloropicrin				
*1,2,3-Trichloropropane [96-18-4] — Skin	10	60	—	—
1,1,2-Trichloro-1,2,2-trifluoroethane [76-13-1]	1,000	7,600	1,250	9,500
Tricyclohexyltin hydroxide, see Cyhexatin				
Tridymite, see Silica — Crystaline				
Triethylamine [121-44-8]	10	40	15	60
Trifluorobromomethane [75-63-8]	1,000	6,100	—	—

Capital letters A, B, D & E refer to Appendices; C denotes ceiling limit.

‡ See Notice of Intended Changes

* 1987-1988 Addition

(a) The value is for total dust containing no asbestos and <1% free silica.

(m) For control of general room air, biologic monitoring is essential for personnel control.

Substance [CAS #]	ADOPTED VALUES TWA ppm[1]	TWA mg/m³[2]	STEL ppm[1]	STEL mg/m³[2]
Trimellitic anhydride [552-30-7]	0.005	0.04	—	—
Trimethylamine [75-50-3]	10	24	15	36
•Trimethyl benzene [25551-13-7]	25	125	—	—
Trimethyl phosphite [121-45-9]	2	10	—	—
2,4,6-Trinitrophenol, see Picric acid				
2,4,6-Trinitrophenylmethylnitramine, see Tetryl				
2,4,6-Trinitrotoluene (TNT) [118-96-7]—Skin	—	0.5	—	—
Triorthocresyl phosphate [78-30-8]—Skin	—	0.1	—	—
Triphenyl amine [603-34-9]	—	5	—	—
Triphenyl phosphate [115-86-6]	—	3	—	—
Tripoli, see Silica—Crystalline				
Tungsten [7440-33-7], as W				
Insoluble compounds	—	5	—	10
Soluble compounds	—	1	—	3
•Turpentine [8006-64-2]	100	560	—	—
Uranium (natural) [7440-61-1]				
Soluble & insoluble compounds, as U	—	0.2	—	0.6
n-Valeraldehyde [110-62-3]	50	175	—	—
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,A1	10,A1	—	—
Vinyl cyanide, see Acrylonitrile				
Vinyl cyclohexene dioxide [106-87-6]—Skin	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	—	—
•Warfarin [81-81-2]	—	0.1	—	—
Welding fumes (NOC‡)	—	5,B2	—	—

Substance [CAS #]	ADOPTED VALUES TWA ppm[1]	TWA mg/m³[2]	STEL ppm[1]	STEL mg/m³[2]
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.
• STEL deleted, TWA retained.

Radioactivity: See Physical Agents section on Ionizing Radiation.

DUSTS

In this edition of the TLV list, dusts are also listed in the main alphabetical listing. Starting with the 1988-1989 edition, dusts will be listed in the main alphabetical listing only.

Substance	TLV-TWA
SILICA, SiO_2	
Crystalline	
Quartz[m] [14808-60-7]	0.1 mg/m³, Respirable dust
Cristobalite[m] [14464-46-1]	0.05 mg/m³, Respirable dust
Silica, fused[m] [60676-86-0]	0.1 mg/m³, Respirable dust
Tridymite[m] [15468-32-3]	0.05 mg/m³, Respirable dust
Tripoli[m] [1317-95-9]	0.1 mg/m³ of contained respirable quartz dust.
Amorphous	
Diatomaceous earth (uncalcined)[m] [68855-54-9]	10 mg/m³, Total dust
* Precipitated silica[m]	10 mg/m³, Total dust
* Silica gel[m]	10 mg/m³, Total dust
SILICATES	
Asbestos[d]	
Amosite [12172-73-5]	0.5 fiber/cc, A1
Chrysotile [12001-29-5]	2 fibers/cc, A1
Crocidolite [12001-28-4]	0.2 fiber/cc, A1
Other forms	2 fibers/cc, A1
Mica[m] [12001-25-2]	3 mg/m³, Respirable dust
Mineral wool fiber	10 mg/m³
Perlite[m]	10 mg/m³, Total dust
Portland cement[m]	10 mg/m³, Total dust
Soapstone	3 mg/m³, Respirable dust[m] 6 mg/m³, Total dust[m]
Talc (containing no asbestos fibers)[m] [14807-96-6]	2 mg/m³, Respirable dust
Talc (containing asbestos fibers)	Use asbestos TLV-TWA. However, should not exceed 2 mg/m³ respirable dust.

OTHER DUSTS	
Barium sulfate[m] [7727-43-7]	10 mg/m³, Total dust
*Coal dust[m]	2 mg/m³, Respirable fraction
Grain dust (oats, wheat, barley)	4 mg/m³, Total particulate
‡*Graphite[m] (natural) [7782-42-5]	(2.5 mg/m³, Respirable dust)
‡Graphite, synthetic[m]	(10 mg/m³, Total dust)
Nuisance particulates[m] (see Appendix D)	10 mg/m³, Total dust

‡ See Notice of Intended Changes.

* 1987-1988 Adoption.

(d) Fibers longer than 5 μm and with an aspect ratio equal to or greater than 3:1 as determined by the membrane filter method at 400-450X magnification (4 mm objective) phase contrast illumination.

(e) The value is for total dust containing no asbestos and <1% free silica.

(f) The value is for dust containing <5% free silica. For dust containing more than this percentage of free silica, the environment should be evaluated against the TLV-TWA of 0.1 mg/m³ for respirable quartz. The concentration of respirable dust for the application of this limit is to be determined from the fraction passing a size-selector with the characteristics defined in the "c." paragraphs of Appendix F.

(l) The concentration of respirable dust for the application of this limit is to be determined from the fraction passing a size-selector with the characteristics defined in the "c." paragraphs in Appendix F.

NOTICE OF INTENDED CHANGES
(for 1987-88)

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]
†Acrylic acid [79-10-7]—Skin	2	6	—	—
Ammonium perfluorooctanoate [3825-26-1]	—	0.1	—	—
†Cadmium [7440-43-9] and compounds, as Cd	—	0.01,A2	—	—
Caprolactam [105-60-2] Vapor & aerosol	0.25	1	—	—
†Chlorine [7782-50-5]	0.5	1.5	1	3
†Chloroacetone [78-95-5]—Skin	C 1	C 4	—	—
Enflurane [13838-16-9]	75	575	—	—
†Ethyl acrylate [140-88-5]—Skin	5	20	15	61
Formamide [75-12-7]—Skin	10	15	—	—
†Formic acid [64-18-6]	5	9	10	18
†Graphite (all forms)	—	10[d]	—	—
Halothane [151-67-7]	50	400	—	—
†Hexachloroethane [67-72-1]	1	10	—	—
Hexamethylene diisocyanate [822-06-0]	0.005	0.035	—	—
Isophorone diisocyanate [4098-71-9]	0.005	0.045	—	—
Manganese dust & compounds [7439-96-5]	—	5	—	—
Methylene bisphenyl isocyanate [101-68-8]	0.005	0.055	—	—
Methylene chloride [75-09-2]	50,A2	175,A2	—	—
Methylene bis-(4-cyclohexylisocyanate [5124-30-1]	0.005	0.055	—	—

Substance [CAS #]	TWA ppm[a]	TWA mg/m³[b]	STEL ppm[a]	STEL mg/m³[b]
p-Nitrochlorobenzene [100-00-5]	0.1	0.6	—	—
†Nitrous oxide [10024-97-2]	50	91	—	—
†Ozone [10028-15-6]	C 0.1	C 0.2	—	—
Stearates	—	10[d]	—	—
†Sulfuric acid [7664-93-9]	—	1	—	3
Tantalum [7440-25-7], metal and oxide	—	10[d]	—	—
†Thiram [137-26-8]	—	1	—	—
Yttrium [7440-65-5] metal and compounds, as Y	—	1	—	—
Zinc chromates [13530-65-9; 1103-86-9; 37300-23-5], as Cr	—	0.01,A1	—	—

(a) Parts of vapor or gas per million parts of contaminated air by volume at 25°C and 760 torr.
(b) Milligrams of substance per cubic meter of air. When entry is in this column only, the value is exact; when listed with a ppm entry, it is approximate.
(c) The value is for total dust containing no asbestos and <1% free silica.
† 1987-1988 Revision or Addition.
Capital letters A, B, D & E refer to Appendices; C denotes ceiling limit.

ADOPTED APPENDICES

APPENDIX A
Carcinogens

The Chemical Substances Threshold Limit Values Committee classifies certain substances found in the occupational environment as either confirmed or suspected human carcinogens. The present listing of substances which have been identified as carcinogens takes two forms: those for which a TLV has been assigned and those for which environmental and exposure conditions have not been sufficiently defined to assign a TLV. Where a TLV has been assigned, it does not necessarily imply the existence of a biological threshold; however, if exposures are controlled to this level, we would not expect to see a measurable increase in cancer incidence or mortality.

The TLV Committee considers information from the following kinds of studies to be indicators of a substance's potential to be a carcinogen in humans: epidemiology studies, toxicology studies, and, to a lesser extent, case histories. Scientific debate over the existence of biological thresholds for carcinogens is unlikely to be resolved in the near future. Because of the long latent period for many carcinogens, and for ethical reasons, it is often impossible to base timely risk-management decisions on results from human studies.

In order to recognize the qualitative differences in research results, two categories of carcinogens are designated in this booklet:

A1—Confirmed Human Carcinogens

and

A2—Suspected Human Carcinogens

Exposures to carcinogens must be kept to a minimum. Workers exposed to A1 carcinogens without a TLV should be properly equipped to virtually eliminate all exposure to the carcinogen. For A1 carcinogens with a TLV and for A2 carcinogens, worker exposure by all routes should be carefully controlled to levels consistent with the experimental and human experience data. Please see the *Documentation of the Threshold Limit Values* for a more complete description and derivation of these designations.

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 concentration should be minimal.

B2. *Welding Fumes—Total Particulate (NOC)†*
***TLV-TWA*, 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 TLVs 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, Teflon, Tetran.
† Not otherwise classified (NOC).

APPENDIX C
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 A.1 and B.1).

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 (C_1/T_1 + or + C_2/T_2, etc.) itself has a value exceeding unity (see Example B.1).

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

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

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

Examples of TLVs for Mixtures

A. *Additive effects.* 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 (B) should be used.

1. General case, where air is analyzed for each component, the TLV of mixture =

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

Note: It is essential that the atmosphere be analyzed both qualitatively and quantitatively for each component present, in order to evaluate compliance or non-compliance with this calculated TLV.

Example A.1: Air contains 400 ppm of acetone (TLV, 750 ppm), 150 ppm of sec-butyl acetate (TLV, 200 ppm) and 100 ppm of methyl ethel 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.

2. 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. When the percent composition (by weight) of the liquid mixture is known, the TLVs of the constituents must be listed in mg/m³. TLV of mixture =

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

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)

Example A.2: 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

B. *Independent effects.* TLV for mixture =

$$\frac{C_1}{T_1} = 1; \quad \frac{C_2}{T_2} = 1 \quad \frac{C_3}{T_3} = 1; \text{ etc.}$$

Example B.1: 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.

C. *TLV for mixtures of mineral dusts.* For mixtures of biologically active mineral dusts the general formula for mixtures given in A.2 may be used.

APPENDIX D
Some Nuisance Particulates[n]

TLV-TWA, 10 mg/m³[a,n]

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

(a) The value is for total dust containing no asbestos and < 1% crystalline silica.
(n) As defined in the Introduction.
‡ See Notice of Intended Changes.

APPENDIX E
Some Simple Asphyxiants[n]

Acetylene	Ethylene	Methane	Propylene
Argon	Helium	Neon	
Ethane	Hydrogen	Propane	

(n) As defined in the Introduction.

APPENDIX F
Particle Size-Selective Sampling Criteria for Airborne Particulate Matter

For chemical substances present in inhaled air as suspensions of solid particles or droplets, the potential hazard depends on particle size as well as mass concentration because of: 1) effects of particle size on deposition site within the respiratory tract, and 2) the tendency for many occupational diseases to be associated with material deposited in particular regions of the respiratory tract.

ACGIH has recommended particle size-selective TLVs for crystalline silica for many years in recognition of the well established association between silicosis and respirable mass concentrations. It now has embarked on a re-examination of other chemical substances encountered in particulate form in occupational environments with the objective of defining: 1) the size-fraction most closely associated for each substance with the health effect of concern, and 2) the mass concentration within that size fraction which should represent the TLV.

The Particle Size-Selective TLVs (PSS-TLVs) will be expressed in three forms, e.g.,

a. *Inspirable Particulate Mass TLVs (IPM-TLVs)* for those materials which are hazardous when deposited anywhere in the respiratory tract.
b. *Thoracic Particulate Mass TLVs (TPM-TLVs)* for those materials which are hazardous when deposited anywhere within the lung airways and the gas-exchange region.
c. *Respirable Particulate Mass TLVs (RPM-TLVs)* for those materials which are hazardous when deposited in the gas-exchange region.

The three particulate mass fractions described above are defined in quantitative terms as follows:

a. Inspirable Particulate Mass consists of those particles that are captured according to the following collection efficiency regardless of sampler orientation with respect to wind direction:

$$E = 50(1 + \exp[-0.06\, d_a]) \pm 10;$$

for $0 < d_a \leq E$ 100 μm

Collection characteristics for $d_a > 100$ μm are presently unknown. E is collection efficiency in percent and d_a is aerodynamic diameter in μm.

b. Thoracic Particulate Mass consists of those particles that penetrate a separator whose size collection efficiency is described by a cumulative lognormal function with a median aerodynamic diameter of 10 μm ± 1.0 μm and with a geometric standard deviation of 1.5 (± 0.1).
c. Respirable Particulate Mass consists of those particles that penetrate a separator whose size collection efficiency is

described by a cumulative lognormal function with a median aerodynamic diameter of 3.5 μm ± 0.3 μm and with a geometric standard deviation of 1.5 (± 0.1). This incorporates and clarifies the previous ACGIH Respirable Dust Sampling Criteria.

These definitions provide a range of acceptable performance for each type of size-selective sampler. Further information is available on the background and performance criteria for these particle size-selective sampling recommendations.[1]

References

1. ACGIH: *Particle Size-Selective Sampling in the Workplace*, 80 pp. Cincinnati, Ohio (1984).

APPENDIX G
Chemical Substances and Other Issues Under Study

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

Chemical Substances

Acetomethylchloride
Acetophenone
Acids and bases
Adiponitrile
Allyl chloride
Bentonite
Benzyl acetate
Borax and boron compounds
Bromochloromethane
Bromodichloromethane
Bromoform
2-t-Butylazo-2-hydroxy-5-methylhexane
Carbon monoxide
Ceramic fibers
Chromium
Dibutyl phenyl phosphate
Dichlorodiphenyl sulfone
Dichlorocyclopentadiene
2,4-D (2,4-Dichlorophenoxy acetic acid)
1,3-Dichloropropene
Dichlorvos
Diglycidyl resorcinol ether
Dinitrotoluene
Diphenyl carbonate
Epichlorohydrin
2-Ethyl hexanoic acid
Formaldehyde
Gasoline (unleaded)
Graphite fibers
Hexachlorocyclopentadiene
Hexamethylene diamine
Hydrazines
Jet, petroleum and diesel fuels
Inorganic acids
Inorganic gases
Inorganic lead
Malathion
Methyl bromide
Methylene diamine
4,4'-Methylene dianiline
Methyl hydrazines
Mineral wool fibers
Naled
Nitromethane
Pentachlorophenol
Perchloroethylene
Persulfates
Petroleum solvents
o-Phenylenediamine
Propylene dichloride
Terephthalic acid
1,1,1,2-Tetrachloro-2,2-difluoroethane
1,1,2,2-Tetrachloro-1,2-difluoroethane
1,1,2,2-Tetrachloroethane
Tobacco smoke
Trichloroethylene
Vinyl cyclohexene

Other Issues

1. Solubility.
2. Dusts and fumes.
3. Should the TLVs currently expressed as "total dust" be changed to "inspirable particulate mass," as defined in Appendix F without changing the numerical value?
4. Application of TLVs to altered work schedules.