2005

TLVs® and BEIs®

Threshold Limit Values for Chemical Substances and Biological Exposure Indices

Welcome . . . . to the *2005 TLVs® and BEIs®*. The TLV®/BEI® diskette contains ten individual MS Word® 6.0/95 files. Files are in Arial or Arial and Helvetica Narrow type faces; page numbers run consecutively between files. File names and their contents are as follows:

File name: 01-Title-etc.doc
Contents

File name: 02-CS_Intro.doc

File name: 03-2005-TLVs.doc
Contents: ADOPTED TLVs FOR CHEMICAL SUBSTANCES

File name: 04-2005-NIC.doc

Contents

File name: 05—Definitions_&_UnderStudy.doc

File name: 06-Adopted Appendices.doc

Contents

File name: 07-2005-BEIs.doc

Contents: BIOLOGICAL EXPOSURE INDICES

File name: 08-Bioaerosols.doc

Contents:

File name: 09-CAS Number Index.doc

File name: 10-Endnote.doc

POLICY STATEMENT ON THE USES OF TLVs® AND BEIs®

The Threshold Limit Values (TLVs®) and Biological Exposure Indices (BEIs®) are developed as guidelines to assist in the control of health hazards. These recommendations or guidelines are intended for use in the practice of industrial hygiene, to be interpreted and applied only by a person trained in this discipline. They are not developed for use as legal standards, and ACGIH® does not advocate their use as such. However, it is recognized that in certain circumstances individuals or organizations may wish to make use of these recommendations or guidelines as a supplement to their occupational safety and health program. The ACGIH® will not oppose their use in this

manner, if the use of TLVs® and BEIs® in these instances will contribute to the overall improvement in worker protection. However, the user must recognize the constraints and limitations subject to their proper use and bear the responsibility for such use.

The Introductions to the TLV®/BEI® Book and the TLV®/BEI® *Documentation* provide the philosophical and practical bases for the uses and limitations of the TLVs® and BEIs®. To extend those uses of the TLVs® and BEIs® to include other applications, such as use without the judgment of an industrial hygienist, application to a different population, development of new exposure/recovery time models, or new effect endpoints, stretches the reliability and even viability of the database for the TLV® or BEI® as evidenced by the individual *Documentations*.

It is not appropriate for individuals or organizations to impose on the TLVs® or the BEIs® their concepts of what the TLVs® or BEIs® should be or how they should be applied or to transfer regulatory standards requirements to the TLVs® or BEIs®.

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Approved by the ACGIH® Board of Directors on March 1, 1988.

2005

TLVs® and BEIs®

Based on the Documentations of the

Threshold Limit Values

for Chemical Substances

and Physical Agents

&

Biological Exposure Indices

ISBN: 1-882417-58-5

ACGIH® is an organization devoted to the administrative and technical aspects of occupational and environmental health. The organization has contributed substantially to the development and improvement of worker health protection. The organization is a professional society, not a government agency.

The *Documentation of the Threshold Limit Values and Biological Exposure Indices* is the source publication for the TLVs® and BEIs® issued by ACGIH®. That publication gives the pertinent scientific information and data with reference to literature sources which were used to base each TLV® or BEI®. For better understanding of the TLVs® and BEIs®, it is essential that the *Documentation* be consulted when the TLVs® or BEIs® are being used. For further information, contact The Science Group, ACGIH®. The most up-to-date list of substances and agents under study by the Committees is available at www.acgih.org/TLV/

Comments, suggestions, and requests for interpretations or technical information should be directed to the The Science Group at the address below or to the following E-mail address: **science@acgih.org**. To place of an order, contact Customer Service at the address below or use the following E-mail address: **customerservice@acgih.org**

ACGIH®
1330 Kemper Meadow Drive
Cincinnati, OH 45240-4148
Telephone: 513-742-2020; Fax: 513-742-3355
http://www.acgih.org

POLICY STATEMENT ON THE USES OF TLVs® AND BEIs®

The Threshold Limit Values (TLVs®) and Biological Exposure Indices (BEIs®) are developed as guidelines to assist in the control of health hazards. These recommendations or guidelines are intended for use in the practice of industrial hygiene, to be interpreted and applied only by a person trained in this discipline. They are not developed for use as legal standards, and ACGIH® does not advocate their use as such. However, it is recognized that in certain circumstances individuals or organizations may wish to make use of these recommendations or guidelines as a supplement to their occupational safety and health program. The ACGIH® will not oppose their use in this manner, if the use of TLVs® and BEIs® in these instances will contribute to the overall improvement in worker protection. However, the user must recognize the constraints and limitations subject to their proper use and bear the responsibility for such use.

The Introductions to the TLV®/BEI® Book and the TLV®/BEI® Documentation provide the philosophical and practical bases for the uses and limitations of the TLVs® and BEIs®. To extend those uses of the TLVs® and BEIs® to include other applications, such as use without the judgment of an industrial hygienist, application to a different population, development of new exposure/recovery time models, or new effect endpoints, stretches the reliability and even viability of the database for the TLV® or BEI® as evidenced by the individual *Documentation*.

It is not appropriate for individuals or organizations to impose on the TLVs® or the BEIs® their concepts of what the TLVs® or BEIs® should be or how they should be applied or to transfer regulatory standards requirements to the TLVs® or BEIs®.

Approved by the ACGIH® Board of Directors on March 1, 1988.

Special Note to User

The values listed in this publication are intended for use in the practice of industrial hygiene as guidelines or recommendations to assist in the control of potential workplace health hazards and for no other use. These values are *not* fine lines between safe and dangerous concentrations and *should not* be used by anyone untrained in the discipline of industrial hygiene. It is imperative that the user of this publication read the Introduction to each section and be familiar with the *Documentation* of the TLVs® and BEIs® before applying the recommendations contained herein. ACGIH® disclaims liability with respect to the use of the TLVs® and BEIs®.

CONTENTS

STATEMENT OF POSITION REGARDING THE TLVs® AND BEIs®

The American Conference of Governmental Industrial Hygienists (ACGIH®) is a private, not-for-profit, nongovernmental corporation whose members are industrial hygienists or other occupa-tional health and safety professionals dedicated to promoting health and safety within the workplace. ACGIH® is a scientific association. ACGIH® is not a standards setting body. As a scientific organiza-tion, it has established committees that review the existing, published, peer-reviewed, scientific litera-ture. ACGIH® publishes guidelines known as Threshold Limit Values (TLVs®) and Biological Exposure Indices (BEIs®) for use by industrial hygienists in making decisions regarding safe levels of exposure to various chemical and physic-cal agents found in the workplace. In using these guidelines, industrial hygienists are cautioned that the TLVs® and BEIs® are only one of multiple factors to be considered in evaluating specific workplace situations and conditions.

Each year, ACGIH® publishes its TLVs® and BEIs® in a book. In the introduction to the book, ACGIH® states that the TLVs® and BEIs® are guidelines to be used by professionals trained in the practice of industrial hygiene. The TLVs® and BEIs® are not designed to be used as standards. Nevertheless, ACGIH ®is aware that in certain instances the TLVs® and the BEIs® are used as standards by national, state, or local governments.

Governmental bodies establish public health standards based on statutory and legal frame-works that include definitions and criteria concerning the approach to be used in assessing and managing risk. In most instances, governmental bodies that set workplace health and safety standards are required to evaluate health effects, economic and technical feasibility, and the avail-ability of acceptable methods to determine compliance.

ACGIH® TLVs® and BEIs® are not consensus standards. Voluntary consensus standards are developed or adopted by voluntary consensus standards bodies. The consensus standards process involves canvassing the opinions, views and positions of all interested parties and then developing a consensus position that is acceptable to these parties. While the process used to develop a TLV® or BEI® includes public notice and requests for all available and relevant scientific data, the TLV® or BEI® does not represent a consensus position that addresses all issues raised by all interested parties (e.g., issues of technical or economic feasibility). The TLVs® and BEIs® represent a scientific opinion based on a review of existing peer-reviewed scientific literature by committees of experts in public health and related sciences.

ACGIH® TLVs® and BEIs® are health-based values. ACGIH® TLVs® and BEIs® are established by committees that review existing published and peer-reviewed literature in various scientific disci-plines (e.g., industrial hygiene, toxicology, occupa-tional medicine, and epidemiology). Based on the available information, ACGIH® formulates a con-clusion on the level of exposure that the typical worker can experience without adverse health effects. The TLVs® and BEIs® represent conditions under which ACGIH believes that nearly all workers may be repeatedly exposed without adverse health effects. They are not fine lines between safe and dangerous exposures, nor are they a relative index of toxicity. The TLVs® and BEIs® are not quantitative estimates of risk at different exposure levels or by different routes of exposure.

Since ACGIH® TLVs® and BEIs® are based solely on health factors, there is no consideration given to economic or technical feasibility. Regula-tory agencies should not assume that it is econom-ically or technically feasible for an industry or em-ployer to meet TLVs® or BEIs®. Similarly, although there are usually valid methods to measure work-place exposures at TLVs® and BEIs®, there can be instances where such reliable test methods have not yet been validated. Obviously, such a situation can create major enforcement difficulties if a TLV® or BEI® was adopted as a standard.

ACGIH® does not believe that TLVs® and BEIs® should be adopted as standards without full compliance with applicable regulatory procedures including an analysis of other factors necessary to make appropriate risk management decisions. However, ACGIH® does believe that regulatory bodies should consider TLVs® or BEIs® as valu-able input into the risk characterization process (hazard identification, dose–response relation-ships, and exposure assessment). Regulatory bodies should view TLVs® and BEIs® as an expression of scientific opinion.

ACGIH® is proud of the scientists and the many members who volunteer their time to work on the TLV® and BEI® Committees. These experts develop written *Documentation* that include an expression of scientific opinion and a description of the basis, rationale, and limitations of the conclu-sions reached by ACGIH®. The *Documentation* provides a comprehensive list and analysis of all the major published peer-reviewed studies that ACGIH® relied upon in formulating its scientific opinion. Regulatory agencies dealing

with hazards addressed by a TLV® or BEI® should obtain a copy of the full written *Documentation* for the TLV or BEI. Any use of a TLV or BEI in a regulatory context should include a careful evaluation of the information in the written *Documentation* and consideration of all other factors as required by the statutes which govern the regulatory process of the governmental body involved.

- ACGIH® is a not-for-profit scientific association.
- ACGIH® proposes guidelines known as TLVs® and BEIs® for use by industrial hygienists in making decisions regarding safe levels of exposure to various hazards found in the workplace.
- ACGIH® is not a standard-setting body.
- Regulatory bodies should view TLVs® and BEIs® as an expression of scientific opinion.
- TLVs® and BEIs® are not consensus standards.
- ACGIH® TLVs® and BEIs® are based solely on health factors; there is not consideration given to economic or technical feasibility. Regulatory agencies should not assume that it is economically or technically feasible to meet established TLVs® or BEIs®.
- ACGIH® believes that TLVs® and BEIs® should NOT be adopted as standards without an analysis of other factors necessary to make appropriate risk management decisions.
- TLVs® and BEIs® can provide valuable input into the risk characterization process. Regulatory agencies dealing with hazards addressed by a TLV® or BEI® should review the full written Documentation for the numerical TLV® or BEI®.

ACGIH® is publishing this Statement in order to assist ACGIH® members, government regulators, and industry groups in understanding the basis and limitations of the TLVs® and BEIs® when used in a regulatory context. This Statement was adopted by the ACGIH® Board of Directors on March 1, 2002.

TLV®/BEI® DEVELOPMENT PROCESS: AN OVERVIEW

Provided below is an overview of the ACGIH® TLV® and BEI® development process. Additional information is available on the ACGIH® website (www.acgih.org). Please also refer to the Process Flowchart (Figure 1).

1. Under Study: When a substance or agent is selected for the development of a TLV® or BEI® or for review of an adopted value, the appropriate Committee places it on its "Under Study" list. This list is published in the annual *TLVs® and BEIs®* book and on the ACGIH® website as a notification and invitation to interested parties to submit substantive data and comments to assist the Committee in its deliberations. Each Committee considers only those comments and data that address the health science, not economic or technical feasibility. Comments must be accompanied by copies of substantiating data, preferably in the form of peer-reviewed literature. Should the data be from unpublished studies, ACGIH® requires written authorization from the owner of the studies granting ACGIH® permission to (1) use, (2) cite within the *Documentation*, and (3) upon request from a third party, release the information. All three permissions must be stated/covered in the written authorization. (See endnote to this document for a sample permission statement.) Electronic submission of all information to the ACGIH® Science Group at science@acgih.org greatly increases the ease and efficiency with which the Committee can consider the comments or data.

   Each committee determines its own selection of chemical substances or physical agents for its Under Study list. A variety of factors is used in this selection process, including prevalence, use, number of workers exposed, avail-ability of scientific data, existence/absence of a TLV® or BEI®, age of TLV® or BEI®, input from the public, etc. The public may offer input to any TLV® or BEI® committee by e-mail to science@acgih.org. Please note that the Under Study lists published in the annual TLV® and BEIs® book are as of January 1 for that year. After this date, please refer to the ACGIH® website (www.acgih.org/TLV/Studies.htm) for the up-to-date list.

2. *Draft Documentation*: One or more members of the appropriate Committee are assigned the task of collecting information and data from the scientific literature, reviewing results of unpub-lished studies submitted for review, and devel-oping a draft TLV® or BEI® *Documentation*. The draft *Documentation* is a critical evaluation of the scientific literature relevant to recom-mending a TLV® or BEI®; however, it is not an exhaustive or broad-based critical review of the scientific literature. Particular emphasis is given to papers that address minimal or no adverse health effect levels in exposed ani-mals or workers, that deal with the reversibility of such effects, or in the case of a BEI®, that assess chemical uptake and provide applic-able determinant(s) as an index of uptake. Human data, when available, are given special emphasis. This draft *Documentation*, with its proposed TLV® or BEI®, is then reviewed and critiqued by additional Committee members, and eventually by the full Committee. This often results in several revisions to the draft *Documentation* before the full Committee accepts the proposed TLV® or BEI® and *Documentation*. The draft *Documentation* is not available to the public through this stage of the development process and is not released until it is at the Notice of Intended Changes (NIC) stage (see item 3 below). Authorship of the *Documentation* is not disclosed.

3. Notice of Intended Changes (NIC): When the full Committee accepts the draft *Documentation* and its proposed TLV® or BEI®, the *Documentation* and proposed values are then recommend-ed to the ACGIH® Board of Directors for ratification as an NIC. If ratified, each proposed TLV® or BEI® is published as an NIC in the *Annual Reports of Committees on TLVs® and BEIs®,* which is published in the ACGIH® member newsletter, *Today! Online* and is also available online for purchase at http://www.acgih.org/store. At the same time, the draft *Documentation* is made available through ACGIH® Customer Service or online at http://www.acgih.org/store. All information contained in the Annual Report is integrated into the annual *TLVs® and BEIs®* book, which is usually available to the general public in February or March of each year. [Note: The physical agents section of the *TLVs® and BEIs®* book also uses the term Notice of Intent to Establish (NIE) in addition to NIC. An NIE follows the same development process as an NIC. For purposes of this process overview, only the term NIC is used.] The proposed TLV® or BEI® is considered a trial limit by ACGIH® for approximately one year following the NIC ratification by the ACGIH® Board of Directors. During this period, interested parties, as well as ACGIH® members, are invited to provide data and substantive comments, preferably in the form of peer-reviewed literature, on the proposed TLVs® or

BEIs® contained in the NIC. Should the data be from unpublished studies, ACGIH® requires written authorization from the owner of the studies granting ACGIH® permission to (1) use, (2) cite within the *Documentation*, and (3) upon request from a third party, release the information. All three permissions must be stated/covered in the written authorization. (See endnote to this document for a sample permission statement.) The most effective and helpful comments are those that address specific points within the draft *Documentation*. Changes or updates are made to the draft *Documentation* as necessary.

4. TLV®/BEI® and *Documentation* Adopted: If, during the year, the Committee neither finds nor receives any substantive data that changes its scientific opinion regarding an NIC TLV® or BEI®, the Committee may then approve its recommendation to the ACGIH® Board of Directors for adoption. Once approved by the Committee and subsequently ratified by the Board, the TLV® or BEI® is published as adopted in the *Annual Reports of the Commit-tees on TLVs® and BEIs®* and in the annual *TLVs® and BEIs®* book, and the draft TLV® or BEI® *Documentation* is finalized for formal publication.

5. Withdraw from Consideration: At any point in the process, the Committee may determine not to proceed with the development of a TLV® or BEI® and withdraw it from further consider-ation. Substances or physical agents that have been withdrawn from consideration can be reconsid-ered by placement on the Under Study list (step #1 above).

There are *several important points* to consider throughout the above process:

i. The appropriate method for an interested party to contribute to the TLV® and BEI® process is through the submission of literature that is peer-reviewed and public. ACGIH® strongly encourages interested parties to publish their studies, and not to rely on unpublished studies as their input to the TLV® and BEI® process. Also, the best time to submit comments to ACGIH® is in the early stages of the TLV® and BEI® development process, preferably while the substance or agent is on the Under Study list.

ii. An additional venue for presentation of new data is an ACGIH®-sponsored symposium or work-shop that provides a platform for public discus-sion and scientific interpretation. ACGIH® encourages input from external parties for suggestions on symposium topics, including suggestions about sponsors, speakers and format. ACGIH® employs several criteria to determine the appropriateness of a symposium. A key criterion is that the symposium must be the most efficient format to present the Committee with information that will assist in the scientific judgment used for writing the *Documentation* and in setting the respective TLVs® or BEIs®. A symposium topic should be suggested while the substance/ agent is Under Study, as symposia require considerable time, commitment, and resources to develop. Symposium topic suggestions submitted while a substance is on the NIC will be considered, but this is usually too late in the decision-making process. A symposium topic will not be favorably considered if its purpose is to provide a forum for voicing opin-ions about existing data. Rather, there must be on-going research, scientific uncertainty about currently available data, or another scientific reason for the symposium. Symposium topic suggestions should be sent to the ACGIH® Science Group (science@acgih.org).

iii. ACGIH® periodically receives requests from external parties to make a presentation to a committee about specific substances or issues. It is *strictly by exception* that such requests are granted. While there are various reasons for this position, the underlying fact is that the Committee focuses on data that have been peer-reviewed and published and not on data presented in a private forum. A committee may grant a request when the data is significantly new, has received peer review, is the best vehicle for receipt of the information, and is essential to the committee's deliberations. The presentation is not a forum to voice opin-ions about existing data. In order for a com-mittee to evaluate such a request, the external party must submit a request in writing that, at a mini-mum, addresses the following elements: (a) a detailed description of the presentation; (b) a clear demonstration of why the informa-tion is important to the Committee's delibera-tions; and (c) a clear demonstration of why a meeting is the necessary method of delivery. This request must be sent to the ACGIH® Science Group (science@acgih.org).

Also, the Committee may initiate contact with outside experts (a) to meet with the Committee to discuss specific issues or to obtain additional knowledge on the subject, and (b) to provide written input or review of a *Documen-tation*. This is only done on an as needed basis, and not as a routine practice.

iv. ACGIH® does *not* commit to deferring consider-ation of a new or revised TLV® or BEI® pending the outcome of proposed or

ongoing research.

***Important dates* to consider throughout each calendar year of the TLV®/BEI® Development Process**

First Quarter:

The TLV®/BEI® Annual Report and the TLV®/BEI® book are published.

Year Round:

- Public comments are accepted.*
- Committees meet.

* *Note*: It is recommended that comments be submitted as early as practical, and preferably no later than July 31st to allow sufficient time for their proper consideration/review. This is particularly important for an NIC TLV®/BEI®.

Fourth Quarter: **

- TLV®/BEI® Committees vote on proposed TLVs®/BEIs® for NIC or final adoption.
- ACGIH® Board of Directors ratifies TLV®/BEI® Committee recommendations.

** *Note*: These actions typically occur early in the fourth quarter, but may occur during other periods of the quarter or year.

Endnote: Sample permission statement granting ACGIH® authorization to use, cite, and release unpublished studies:

[Name], [author or sponsor of the study*] grants permission to ACGIH® to use and cite the documents listed below, and to fully disclose them to parties outside of ACGIH® upon request. Permission to disclose the documents includes permission to make copies as needed.

Example: Joseph D. Doe, PhD, co-author of the study, grants permission to ACGIH® to use and cite the document listed below, and to fully disclose this document to parties outside of ACGIH®. Permission to disclose the document includes permission to make copies as needed.

"Effects of Quartz Status on Pharmacokinetics of Intratracheally Instilled Cristobalite in Rats, March 21, 2003."

*This statement must be signed by an individual authorized to give this permission, and should include contact information such as title and address.

December 20, 2004

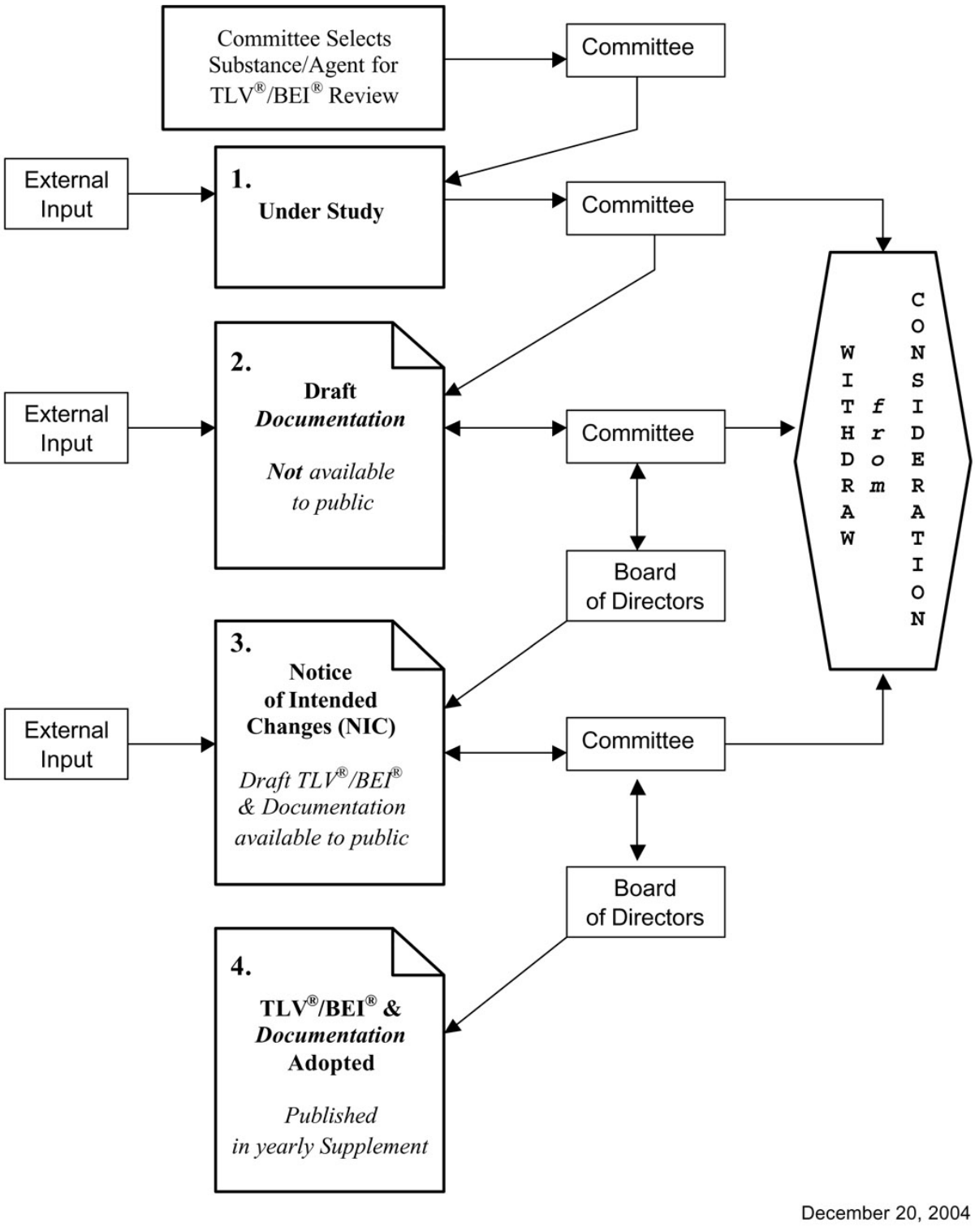

FIGURE 1. The TLV®/BEI® Development Process Flow Chart.

ONLINE TLV® AND BEI® RESOURCES

In an effort to make the threshold limit values (TLVs®) and biological exposure indices (BEIs®) guideline establishment process more transparent, and to assist ACGIH members, government regulators, and industry groups in understanding the basis and limitations of the TLVs® and BEIs®, ACGIH® has recently launched on online TLV®/BEI® Resources Section on its website at www.acgih.org/TLV/.

The TLV®/BEI® Resources section is divided into eight categories, each containing clear and concise information. The categories are:

- **Conflict of Interest Policy** — applies to the Board of Directors, Committee Chairs, and Committee members (including consultant members), and safeguards the integrity and credibility of ACGIH® programs and activities. The Policy, as well as ACGIH®'s oversight and review, each play an important part in the protection of ACGIH®'s programs and activities from inappropriate influences. (www.acgih.org/TLV/COIPolicy.htm)
- **Notice of Intended Changes (NIC)** — a listing of the proposed actions of the TLV®-CS, TLV®-PA, and BEI® Committees. This Notice provides an opportunity for public comment and solicits suggestions of substances or agents to be added to the list. Values remain on the NIC for approximately one year after they have been ratified by the ACGIH® Board of Directors. If no new information is discovered that questions the appropriateness of the value, it will be considered for adoption. (www.acgih.org/TLV/NIC.htm).
- **TLV®/BEI® Policy Statement** — states what the TLVs® and BEIs® are and how they are intended to be used. While the TLVs® and BEIs® do contribute to the overall improvement in worker protection, the user must recognize the constraints and limitations subject to their proper use and bear the responsibility for such use. (www.acgih.org/TLV/PolicyStmt.htm)
- **TLV®/BEI® Position Statement** — expresses ACGIH®'s position on the TLVs® and BEIs® process. ACGIH® is proud of the positive impact that the TLVs® and BEIs=have had on workers worldwide, and stands behind the hard work of it Committees to make the process more transparent and accessible. This section is presented in it entirety on page vi (www.actih.org/TLV/PosStmt.htm).
- **TLV®/BEI® Development Process** — gives an overview of the process the Committees go through when establishing a TLV® or BEI®. This section is presented in its entirety on page viii. (www.acgih.org/TLV/DevProcess.htm)
- **Committee Operations Manuals** — portable data files (PDF) of the Threshold Limit Values for Chemical Substances and the Biological Exposure Indices Committees' Operations Manual. Each Manual covers such areas as the Committee's mission, membership in the Committee, Committee make-up, internal and external communications with the Committee, flow of information, procedures for development of symposia and workshops, etc. (www.acgih.org/TLV/OpsManual.pdf)
- **PowerPoint Presentations** — Stand-alone PowerPoint productions are offered from the annual American Industrial Hygiene Conference and Exposition (AIHce). These forums are open to all AIHce registrants and focus on the process used by ACGIH® and its TLV®, BEIs®, and Bioaerosols Committees. These presentations are posted on the ACGIH® website. (www.acgih.org/TLV/TLVPresentation.htm)
- **Under Study List** — contains substances, agents, and issues that are being considered by the Committees. Each Committee solicits data, comments, and suggestions that may assist in their deliberations about substances, agents, and issues on the Under Study list. (www.acgih.org/TLV/Studies.htm)

If, once you have reviewed the wealth of information in the TLV®/BEI® Resources section, questions remain, please feel free to submit those questions to ACGIH® at science@acgih.org

REVISIONS OR ADDITIONS FOR 2005

All pertinent endnotes, abbreviations, and definitions relating to the materials in this publication appear in the file: 10 Endnotes.doc*.*

Chemical Substances

- *Documentation* was updated for the following without change to the recommended TLVs®. *See* the 2005 Supplements to the *Documentation of the TLVs® and BEIs®*, 7th ed.

  1,3-Dichloropropene

- Proposed TLVs® that appeared on the 2004 NIC are adopted for the following substances:

  Acrylamide
  Borate compounds, Inorganic
  1-Bromopropane
  n-Butyl glycidyl ether
  Dichloroacetic acid
  Ethylene
  Fensulfothion
  Gallium arsenide
  Hydrogen fluoride
  Phorate
  Sulfotepp
  Temephos
  Tetrahydrofuran
  Tetrakis (hydroxylmethyl) phosphonium salts
  Wood dusts

- Appendix D: Commercially Important Tree Species Suspected of Inducing Sensitization, is adopted.

- Documentation and adopted TLVs® are withdrawn for the following substances [see also proposed new Appendix F]:

  Borates, tetra, sodium salts,
  Silica, Crystalline — Tridymite

- New TLVs® are proposed for the following and placed on the NIC.

  Alachlor
  Coumaphos

- Revisions to adopted TLVs® are proposed for the following substances and placed on the NIC:

  Calcium carbonate
  Calcium sulfate
  Carbon disulfide
  Fenamiphos
  Fenthion
  Fonofos
  Iron oxide
  2-Methoxyethanol [EGME]
  2-Methoxyethyl acetate [EGMEA]
  Portland cement
  n-Propanol
  Propylene dichloride
  Ronnel
  Vanadium pentoxide

- Propose to withdraw the *Documentation* and adopted TLV® for *acetylene tetrabromide*, replacing it with its IUPAC name and a new NIC TLV® recommendation for the following:

  1,1,2,2-Tetrabromomethane

- Propose to withdraw the *Documentation* and adopted TLVs® for *Iron oxide (Fe_2O_3) dust & fume* and for *Rouge*, replacing them with a single, new NIC TLV® recommendation for the following:

  Iron oxide

- Propose to withdraw the *Documentation* and adopted TLV® for the following substance due to insufficient data on single-substance exposure, as most are co-exposure with crystalline silica:

  Silica, Amorphous — Diatomaceous earth (uncalcined)

- Propose to withdraw the *Documentation* and adopted TLVs® for the following due to insufficient data:

  Magnesite
  Perlite
  Silica, Amorphous — Precipitated silica and silica gel
  Silica fume
  Silica fused
  Silicon
  Tetrasodium pyrophosphate
  Vegetable oil mist

- The following substance is retained on the NIC with a revised TLV® recommendation:

  Beryllium and compounds

- The following substance is retained on the NIC at its previously proposed TLV® but with a newly drafted *Documentation*:

  Mineral oil

- Previously proposed TLVs® are retained on the NIC for the following substances:

  Arsine
  Copper and inorganic compounds*
  Dimethyl disulfide
  Hydrogen sulfide
  Monochloroacetic acid
  Propylene
  Silica, Crystalline — α-Quartz and cristobalite

  **Note*: The NIC entries for Copper in the 2004 *TLV®/BEI®* book were incorrect due to tabular problems; the NIC listing for 2005 is only a correction. The 2004 draft *Documentation* did contain the correct values and notations.

- The following substances are retained on the NIC as withdrawals until the time their replacements are adopted:

  Copper, Fume, dust, and mists [*see* the NIC

entry for Copper and inorganic compounds]
Oil mist, Mineral [*see* the NIC entry for Mineral oil]
Silica, Crystalline — Tripoli [*see* the NIC entry or Silica, Crystalline — α-Quartz and cristobalite

- A new Appendix is proposed to contain a list of those substances whose Documentation and adopted TLVs have been withdrawn [see NIC section, page 32].

Biological Exposure Indices (BEIs®)

- New *Documentation* was written for the following without change to the recommended BEI®. *See* the 2005 Supplement to the *Documentation of the TLVs® and BEIs®*, 7th ed.

  Methanol

- Proposed BEIs® that appeared on the 2004 Notice of Intended Changes (NIC) are adopted for the following substances:

  Dichloromethane
  Polycyclic aromatic hydrocarbons [PAHs]

- First-time BEIs® are recommended and placed on the NIC for the following:

  1,3-Butadiene 2-Propanol

- Previously proposed BEIs® are retained on the NIC for the following substances:

  Ethyl benzene Trichloroethylene

Physical Agents

- Carcinogenicity Designations are proposed as an additional section to the Introduction.
- Editorial changes were made to the **STATEMENT ON WORK-RELATED MUSCULOSKELETAL DISORDERS**, which follows the *Ergonomics* introductory paragraph, and a "Chronology of the Statement" was added.
- The proposed TLVs® for **LIFTING**, residing under the *Ergonomics* section, are adopted
- Revision to Note 2, found in the **NOISE** TLVs®, is retained as a Notice of Intended Changes.
- Under *Nonionizing Radiation and Fields*, revisions to the adopted TLVs® are proposed and placed on the NIC for both of the **SUB-RADIOFREQUENCY (30 kHz AND BELOW)** entries.
- Under *Nonionizing Radiation and Fields*, a new note is proposed and placed on the NIC for **RADIOFREQUENCY AND MICROWAVE RADIATION**.

Biologically Derived Airborne Contaminants

No new information for 2005.

Under Study

The reader is encouraged to review the "Under Study" lists appearing at the end of each section of this publication. Each Committee solicits informa-tion, especially data, which may assist in its delib-erations regarding substances, agents, and issues listed therein. Comments and suggestions, accompanied by substantiating evidence in the form of peer-reviewed literature, should be forwarded, preferably in electronic format, to The Science Group, ACGIH® at science@acgih.org. In addition, the Committees solicit recommendations for additional substances and issues of concern to the industrial hygiene and occupational health communities. Please refer to the "ACGIH® TLV®/BEI® Development Process" found in the previous pages of this book and on the ACGIH® website for a detailed discussion covering this procedure and methods for input to ACGIH®. (http://www.acgih.org/TLV/DevProcess.htm)

The substances and issues listed in this book are as of January 1, 2005. *After this date, please refer to the ACGIH® website for the up- to-date list.* (http://www.acgih.org/TLV/Studies.htm)

2005

Threshold Limit Values for Chemical Substances in the Work Environment

Adopted by ACGIH© with Intended Changes

Contents

Chemical Substances

2004 CHEMICAL SUBSTANCES TLV® COMMITTEE

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Gerald L. Kennedy, Jr.
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Bruce D. Naumann, Ph.D., DABT [AIHA WEEL Committee Liaison also]
Michelle M. Schaper, Ph.D.
Robert Spirtas, Dr.PH
Barbara Taylor, CIH
Elizabeth K. Weisburger, Ph.D., D.Sc.
W.H. (Bill) Wells, Jr., Ph.D., CIH, CSP

Emertus

Ernest Mastromatteo, M.D.

Consultant

Kimberly R. McDonald

ACGIH® also appreciates the contributions of the following individuals.

Prof. Dr. Helmut Greim — German MAK Commission Liaison
Dr. Heidrun Greim — German MAK Commission Liaison
Larry K. Lowry, Ph.D. — BEI® Committee Liaison
Maureen Meldrum — Health and Safety Executive (U.K.) Liaison
Michael S. Morgan, Sc.D., CIH. — BEI® Committee Liaison
Robert McCleary — ACGIH® Bloomfield Awardee

INTRODUCTION TO THE CHEMICAL SUBSTANCES

General Information

The TLVs® are guidelines to be used by professional industrial hygienists. The values presented in this book are intended for use only as guidelines or recommendations to assist in the evaluation and control of potential workplace health hazards and for no other use (e.g., neither for evaluating or controlling community air pollution; nor for estimating the toxic potential of continuous, uninterrupted exposures or other extended work periods; nor for proving or disproving an existing disease or physical condition in an individual). Further, these values are not fine lines between the safe and dangerous conditions and should not be used by anyone who is not trained in the discipline of industrial hygiene. TLVs® are not regulatory or consensus standards.

Definition of the TLVs®

Threshold limit values (TLVs®) refer to airborne concentrations of chemical substances and represent conditions under which it is believed that *nearly all* workers may be repeatedly exposed, day after day, over a working lifetime, without adverse health effects. TLVs® are developed to protect workers who are normal, healthy adults.

Those who use the TLVs® **MUST** consult the latest *Documentation* to ensure that they understand the basis for the TLV® and the information used in its development. The amount and quality of the information that is available for each chemical substance varies over time.

Chemical substances with equivalent TLVs® (i.e., same numerical values) cannot be assumed to have similar toxicologic effects or similar biologic potency. In this book, there are columns listing the TLVs® for each chemical substance (that is, airborne concentrations in parts per million [ppm] or milligrams per cubic meter [mg/m^3]) and critical effects produced by the chemical sub-stance. These critical effects form the basis of the TLV®.

ACGIH® recognizes that there will be considerable variation in the level of biological response to a particular chemical substance, regardless of the airborne concentration. Indeed, TLVs® do not represent a fine line between a healthy versus an unhealthy work environment or the point at which material impairment of health will occur. TLVs® will not adequately protect all workers. Some individ-uals may experience discomfort or even more serious adverse health effects when exposed to a chemical substance at the TLV® or even at con-centrations below the TLV®. There are numerous possible reasons for increased susceptibility to a chemical substance, including age, gender, ethnicity, genetic factors (predisposition), lifestyle choices (e.g., diet, smoking, abuse of alcohol and other drugs), medications, and pre-existing medical conditions (e.g., aggravation of asthma or cardiovascular disease). Some individuals may become more responsive to one or more chemical substances following previous exposures (e.g., sensitized workers). Susceptibility to the effects of chemical substances may be altered during different periods of fetal development and throughout an individual's reproductive lifetime. Some changes in susceptibility may also occur at different work levels (e.g., light versus heavy work) or at exercise — situations in which there is increased cardiopulmonary demand. Additionally, variations in temperature (e.g., extreme heat or cold) and relative humidity may alter an individual's response to a toxicant. The *Documentation* for any given TLV® must be reviewed, keeping in mind that other factors may modify biological responses.

Although TLVs® refer to airborne levels of chemical exposure, dermal exposures may possibly occur in the workplace (see "Skin" in the ***Definitions and Notations*** section [file name: 05-Definitions&US.doc].

Three categories of TLVs® are specified: time-weighted average (TWA); short-term exposure limit (STEL); and a Ceiling (C). For most substances, a TWA alone or with a STEL is relevant. For some substances (e.g., irritant gases), only the TLV–Ceiling is applicable. If any of these TLV® types are exceeded, a potential hazard from that substance is presumed to exist.

Threshold Limit Value–Time-Weighted Average (TLV–TWA): The TWA concentration for a conventional 8-hour workday and a 40-hour workweek, to which it is believed that nearly all workers may be repeatedly exposed, day after day, for a working lifetime without adverse effect. Although calculating the average concentration for a workweek, rather than a workday, may be appropriate in some instances, ACGIH® does not offer guidance regarding such exposures.

Threshold Limit Value–Short-Term Exposure Limit (TLV–STEL): A 15-minute TWA exposure that should not be exceeded at any time during a workday, even if the 8-hour TWA is within the TLV–TWA. The TLV–STEL is the concentration to which it is believed that workers can be exposed continuously for a short period of time without suffering from 1) irritation, 2) chronic or irreversible tissue damage, 3) dose-rate-

dependent toxic effects, or 4) narcosis of sufficient degree to increase the likelihood of accidental injury, impaired self-rescue, or materially reduced work efficiency. The TLV–STEL will not necessarily protect against these effects if the daily TLV–TWA is exceeded. The TLV–STEL is not a separate, independent exposure guideline; rather, it supplements the TLV–TWA where there are recognized acute effects from a substance whose toxic effects are primarily of a chronic nature. Exposures above the TLV–TWA up to the TLV–STEL should be less than 15 minutes, should occur less than four times per day, and there should be at least 60 minutes between successive exposures in this range. An averaging period other than 15 minutes may be recommended when this is warranted by observed biological effects.

Threshold Limit Value–Ceiling (TLV–C): The concentration that should not be exceeded during any part of the working exposure. If instantaneous measurements are not available, sampling should be conducted for the minimum period of time sufficient to detect exposures at or above the ceiling value.

ACGIH® believes that TLVs® 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 adverse health effects through interaction with other chemical or biologic agents or through other mechanisms.

Excursion Limits

For many substances with a TLV–TWA, there is no TLV–STEL. Nevertheless, excursions above the TLV–TWA should be controlled, even where the 8-hour TLV–TWA is within recommended limits. Excursion limits apply to those TLV–TWAs that do not have TLV–STELs.

> *Excursions in worker exposure levels may exceed 3 times the TLV–TWA for no more than a total of 30 minutes during a workday, and under no circumstances should they exceed 5 times the TLV–TWA, provided that the TLV–TWA is not exceeded.*

The approach here is that the maximum recommended excursion should be related to the variability generally observed in actual industrial processes. In reviewing large numbers of industrial hygiene surveys conducted by the U.S. National Institute for Occupational Safety and Health, Leidel et al. (1975) found that short-term exposure measurements were generally lognormally distributed.

While a complete discussion of the theory and properties of the lognormal distribution is beyond the scope of this section, a brief description of some important terms is presented. The measure of central tendency in a lognormal distribution is the antilog of the mean logarithm of the sample values. The distribution is skewed, and the geometric mean (m_g) is always smaller than the arithmetic mean by an amount that depends on the geometric standard deviation. In the lognormal 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 will exceed 3.13 times the geometric mean. If a process displays variability greater than this, it is not under good control, and efforts should be made to restore control.

The approach is a considerable simplification of the lognormal concentration distribution concept but is considered more convenient. 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. It is recognized that the geometric standard deviations of some common workplace exposures may exceed 2.0 (Buringh and Lanting, 1991). If such distributions are known and workers are not at increased risk of adverse health effects, recommended excursion limits should be modified, based upon workplace-specific data. When the toxicologic data for a specific substance are available to establish a TLV–STEL or a TLV–C, these values take precedence over the excursion limit.

TWA and STEL versus Ceiling (C)

A substance may have certain toxicological properties that require the use of a TLV-C rather than a TLV–TWA excursion limit or a TLV-STEL. The amount by which the TLVs® 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 TWA concentration provides the most satisfactory, practical way of monitoring

airborne agents for compliance with the TLVs®, there are certain substances for which it is inappropriate. In the latter group are substances that are predominantly fast-acting and whose TLV® is more appropriately based on this particular response. Substances with this type of response are best controlled by a TLV–C that should not be exceeded. It is implicit in these definitions that the manner of sampling to determine noncompliance with the TLVs® for each group must differ. Consequently, a single, brief sample that is applicable to a TLV–C is not appropriate to the TLV–TWA; here, a sufficient number of samples are needed to permit determination of a TWA concentration throughout a complete cycle of operation or throughout the workshift.

Whereas, the TLV–C places a definite boundary that exposure concentrations should not be permitted to exceed, the TLV–TWA requires an explicit limit to the excursions, which are acceptable above the recommended TLV–TWAs.

Mixtures

Special consideration should also be given to the application of the TLVs® in assessing the health hazards that may be associated with exposure to a mixture of two or more substances. A brief discussion of basic considerations involved in developing TLVs® for mixtures and methods for their development, amplified by specific examples, is given in Appendix E.

Deviations in Work Conditions and Work Schedules

Application of TLVs® to Unusual Ambient Conditions

When workers are exposed to air contaminants at temperatures and pressures substantially different than those at normal temperature and pressure (NTP) conditions (25°C and 760 torr), care should be taken in comparing sampling results to the applicable TLVs®. For aerosols, the TWA exposure concentration (calculated using sample volumes not adjusted to NTP conditions) should be compared directly to the applicable TLVs® published in the TLVs® and BEIs® book. For gases and vapors, there are a number of options for comparing air-sampling results to the TLV®, and these are discussed in detail by Stephenson and Lillquist (2001). One method that is simple in its conceptual approach is 1) to determine the exposure concentration, expressed in terms of mass per volume, at the sampling site using the sample volume not adjusted to NTP conditions, 2) if required, to convert the TLV® to mg/m^3 (or other mass per volume measure) using a molar volume of 24.45 L/mole, and 3) to compare the exposure concentration to the TLV®, both in units of mass per volume.

A number of assumptions are made when comparing sampling results obtained under unusual atmospheric conditions to the TLVs®. One such assumption is that the volume of air inspired by the worker per workday is not appreciably different under moderate conditions of temperature and pressure as compared to NTP (Stephenson and Lillquist, 2001). An additional assumption for gases and vapors is that absorbed dose is correlated to the partial pressure of the inhaled compound. Sampling results obtained under unusual conditions cannot easily be compared to the published TLVs®, and extreme care should be exercised if workers are exposed to very high or low ambient pressures.

Unusual Work Schedules

Application of TLVs® to work schedules markedly different from the conventional 8-hour day, 40-hour workweek requires particular judgment to provide protection for these workers equal to that provided to workers on conventional work shifts. Short workweeks can allow workers to have more than one job, perhaps with similar exposures, and may result in overexposure, even if neither job by itself entails overexposure.

Numerous mathematical models to adjust for unusual work schedules have been described. In terms of toxicologic principles, their general objective is to identify a dose that ensures that the daily peak body burden or weekly peak body burden does not exceed that which occurs during a normal 8-hour/day, 5-day/week shift. A comprehensive review of the approaches to adjusting occupational exposure limits for unusual work schedules is provided in *Patty's Industrial Hygiene* (Paustenbach, 2000). Other selected readings on this topic include Lapare et al. (2003), Brodeur et al. (2001), Caldwell et al. (2001), Eide (2000), Verma (2000), Rouch (1978), and Hickey and Reist (1977).

Another model that addresses unusual work schedules is the Brief and Scala model (1986), which is explained in detail in *Patty's Industrial Hygiene* (Paustenbach, 2000). This model reduces the TLV® proportionately for both increased exposure time and reduced recovery (i.e., non-exposure) time, and is generally intended to apply to work schedules longer than 8 hours/day or 40 hours/week. The model should not be used to justify very high exposures as "allowable" where the exposure periods are short (e.g., exposure to 8 times the TLV–TWA for 1 hour and zero exposure during the remainder of

the shift). In this respect, the general limitations on TLV–TWA excursions and TLV–STELs should be applied to avoid inappropriate use of the model with very short exposure periods or shifts.

The Brief and Scala model is easier to use than some of the more complex models based on pharmacokinetic actions. The application of such models usually requires knowledge of the biological half-life of each substance, and some models require additional data. Another model developed by the University of Montreal and the Institute de Recherche en Sante et en Securite du Travail (IRSST) uses the Haber method to calculate adjusted exposure limits (Brodeur et al., 2001). This method generates values close to those obtained from physiologically based pharmacokinetic (PBPK) models.

Because adjusted TLVs® do not have the benefit of historical use and long-time observation, medical supervision during initial use of adjusted TLVs® is advised. Unnecessary exposure of workers should be avoided, even if a model shows such exposures to be "allowable." Mathematical models should not be used to justify higher-than-necessary exposures.

Conversion of TLVs® in ppm to mg/m³

An inhaled chemical substance may exist as a gas, vapor, or aerosol.

- A gas is a chemical substance whose molecules are moving freely within a space in which they are confined (e.g., cylinder/tank) at normal temperature and pressure. Gases assume no shape or volume.A vapor is the gaseous phase of a chemical substance that exists as a liquid or a solid at normal temperature and pressure. The amount of vapor given off by a chemical substance is expressed as the vapor pressure and is a function of temperature and pressure.
- An aerosol is a suspension of solid particles or liquid droplets in a gaseous medium. Other terms used to describe an aerosol include dust, mist, fume, fog, fiber, smoke, and smog. Aerosols may be characterized by their aerodynamic behavior and the site(s) of deposition in the human respiratory tract.

TLVs® for gases and vapors are usually established in terms of parts of vapor or gas per million parts of contaminated air by volume (ppm). For convenience to the user, these TLVs® also reference molecular weights. Where 24.45 = molar volume of air in liters at NTP conditions (25°C and 760 torr), the conversion equation for mg/m^3 is:

$$\text{TLV in mg/m}^3 = \frac{\text{(TLV in ppm) (gram molecular weight of substance)}}{24.45}$$

TLVs® for aerosols are usually established in terms of mass of the chemical substance in air by volume. These TLVs® are often expressed in mg/m^3.

The equation for converting TLVs® in mg/m^3 to ppm is:

$$\text{TLV in ppm} = \frac{\text{(TLV in mg/m}^3\text{) (24.45)}}{\text{(gram molecular weight of substance)}}$$

When converting values expressed as an element (e.g., as Fe, as Ni), the molecular weight of the element should be used, not that of the entire compound.

In making conversions for substances with variable molecular weights, appropriate molecular weights should be estimated or assumed (see the TLV® *Documentation*).

User Information

Each TLV® is supported by a comprehensive *Documentation*. It is imperative to consult the latest *Documentation* when applying the TLV®.

Additional copies of the *TLVs® and BEIs®* book and the multi-volume *Documentation of the Threshold Limit Values and Biological Exposure Indices,* upon which this book is based, are available from ACGIH®. *Documentation* of individual TLVs® is also available. Consult the ACGIH® website (www.acgih.org/store) for additional information and availability concerning these publications.

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

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All pertinent notes relating to the material in the Chemical Substances section of this book appear in the appendices for this section or in the 10-Endnotes.doc file.

Substance [CAS No.]	2005 ADOPTED VALUES TWA	STEL	Notations	MW	TLV® Basis — Critical Effect(s)
Acetaldehyde [75-07-0]	—	C 25 ppm	A3	44.05	Irritation
Acetic acid [64-19-7]	10 ppm	15 ppm	—	60.00	Irritation
Acetic anhydride [108-24-7]	5 ppm	—	—	102.09	Irritation
Acetone [67-64-1]	500 ppm	750 ppm	A4; BEI	58.05	Irritation
Acetone cyanohydrin [75-86-5] , as CN	—	C 4.7 ppm	Skin	85.10	CNS; anoxia
Acetonitrile [75-05-8]	20 ppm	—	Skin; A4	41.05	Lung
Acetophenone [98-86-2]	10 ppm	—	—	120.15	Irritation; ocular
Acetylene [74-86-2]		Simple asphyxiant (D)		26.02	Asphyxiation
‡ (Acetylene tetrabromide [79-27-6])	(1 ppm)	(—)	(—)	(345.70)	(Irritation; liver)
Acetylsalicylic acid (Aspirin) [50-78-2]	5 mg/m^3	—	—	180.15	Blood
Acrolein [107-02-8]	—	C 0.1 ppm	Skin; A4	56.06	Irritation; pulmonary edema
* Acrylamide [79-06-1]	0.03 mg/m^3 (IV)	—	Skin; A3	71.08	CNS; cancer
Acrylic acid [79-10-7]	2 ppm	—	Skin; A4	72.06	Irritation; reproductive
Acrylonitrile [107-13-1]	2 ppm	—	Skin; A3	53.05	Cancer
Adipic acid [124-04-9]	5 mg/m^3	—	—	146.14	Neurotoxicity; GI; irritation
Adiponitrile [111-69-3]	2 ppm	—	Skin	108.10	Lung
Aldrin [309-00-2]	0.25 mg/m^3	—	Skin; A3	364.93	Liver
Aliphatic hydrocarbon gases					
Alkane [C_1–C_4]	1000 ppm	—	—	Varies	CNS; depression; cardiac sensitization
Allyl alcohol [107-18-6]	0.5 ppm	—	Skin; A4	58.08	Irritation
Allyl chloride [107-05-1]	1 ppm	2 ppm	A3	76.50	Liver
Allyl glycidyl ether (AGE) [106-92-3]	1 ppm	—	A4	114.14	Irritation; dermatitis; sensitization
Allyl propyl disulfide [2179-59-1]	0.5 ppm	—	SEN	148.16	Irritation
Aluminum [7429-905] and compounds, as Al					
Metal dust	10 mg/m^3	—	—	26.98	Irritation
Pyro powders	5 mg/m^3	—	—		Lung
Soluble salts	2 mg/m^3	—	—		Irritation
Alkyls (NOS)	2 mg/m^3	—	—		Irritation
Aluminum oxide [1344-28-1]	10 mg/m^3 (E)	—	A4	101.96	Lung; irritation
4-Aminodiphenyl [92-67-1]	—(L)	—	Skin; A1	169.23	Cancer (bladder)
2-Aminopyridine [504-29-0]	0.5 ppm	—	—	91.11	CNS
Amitrole [61-82-5]	0.2 mg/m^3	—	A3	84.08	Reproductive; thyroid
Ammonia [7664-41-7]	25 ppm	35 ppm	—	17.03	Irritation
Ammonium chloride fume [12125-02-9]	10 mg/m^3	20 mg/m^3	—	53.50	Irritation
Ammonium perfluorooctanoate [3825-26-1]	0.01 mg/m^3	—	Skin; A3	431.00	Liver
Ammonium sulfamate [7773-06-0]	10 mg/m^3	—	—	114.13	Irritation

Substance [CAS No.]	2005 ADOPTED VALUES TWA	STEL	Notations	MW	TLV® Basis — Critical Effect(s)
tert-Amyl methyl ether (TAME) [994-05-8]	20 ppm	—	—	102.2	Neurologic, reproductive
Aniline [62-53-3]	2 ppm	—	Skin; A3; BEI	93.12	Anoxia
o-Anisidine [90-04-0]	0.5 mg/m^3	—	Skin; A3; BEI_M	123.15	Anoxia
p-Anisidine [104-94-9]	0.5 mg/m^3	—	Skin; A4; BEI_M	123.15	Anoxia
Antimony [7440-36-0] and compounds, as Sb	0.5 mg/m^3	—	—	121.75	Irritation; lung; CVS
Antimony hydride [7803-52-3]	0.1 ppm	—	—	124.78	Irritation; blood
Antimony trioxide [1309-64-4] production	—[(L)]	—	A2	291.5	Cancer (lung); pneumoconiosis
ANTU [86-88-4]	0.3 mg/m^3	—	A4	202.27	Lung; irritation
Argon [7440-37-1]	Simple asphyxiant [(D)]			39.95	Asphyxiation
Arsenic [7440-38-2] and inorganic compounds, as As	0.01 mg/m^3	—	A1; BEI	74.92 Varies	Cancer (lung, skin); lung
‡ Arsine [7784-42-1]	(0.05 ppm)	—	(—)	77.95	Blood; kidney
Asbestos, all forms	0.1 f/cc [(F)]	—	A1	NA	Asbestosis.; cancer
Asphalt (Bitumen) fume [8052-42-4], as benzene-soluble aerosol	0.5 mg/m^3 [(I)]	—	A4	—	Irritation
Atrazine [1912-24-9]	5 mg/m^3	—	A4	216.06	Irritation
Azinphos-methyl [86-50-0]	0.2 mg/m^3 [(IV)]	—	Skin; SEN;A4; BEI_A	317.34	Cholinergic
Barium [7440-39-3] and soluble compounds, as Ba	0.5 mg/m^3	—	A4	137.30	Irritation; GI; muscles
Barium sulfate [7727-43-7]	10 mg/m^3	—	—	233.43	Pneumoconiosis (baritosis)
Benomyl [17804-35-2]	10 mg/m^3	—	A4	290.32	Dermatitis; irritation; reproductive
Benz[a]anthracene [56-55-3]	—[(L)]	—	A2	228.3	Cancer
Benzene [71-43-2]	0.5 ppm	2.5 ppm	Skin; A1; BEI	78.11	Cancer
Benzidine [92-87-5]	—[(L)]	—	Skin; A1	184.23	Cancer (bladder)
Benzo[b]fluoranthene [205-99-2]	—[(L)]	—	A2	252.30	Cancer
Benzo[a]pyrene [50-32-8]	—[(L)]	—	A2	252.30	Cancer
Benzotrichloride [98-07-7]	—	C 0.1 ppm	Skin; A2	195.50	Irritation; cancer
Benzoyl chloride [98-88-4]	—	C 0.5 ppm	A4	140.57	Irritation
Benzoyl peroxide [94-36-0]	5 mg/m^3	—	A4	242.22	Irritation
Benzyl acetate [140-11-4]	10 ppm	—	A4	150.18	Irritation
Benzyl chloride [100-44-7]	1 ppm	—	A3	126.58	Irritation; lung
‡ Beryllium [7440-41-7] and compounds, as Be	(0.002 mg/m^3)	(0.01 mg/m^3)	(—); A1	9.01	Cancer (lung); berylliosis
Biphenyl [92-52-4]	0.2 ppm	—	—	154.20	Lung
Bis(2-dimethylaminoethyl)ether (DMAEE) [3033-62-3]	0.05 ppm	0.15 ppm	Skin	160.26	Irritation; vision
Bismuth telluride Undoped [1304-82-1]	10 mg/m^3	—	A4	800.83	Irritation

Substance [CAS No.]	2005 ADOPTED VALUES TWA	STEL	Notations	MW	TLV® Basis — Critical Effect(s)
Se-doped, as Bi_2Te_3	5 mg/m^3	—	A4		Irritation; lung
* Borate compounds, Inorganic [1330-43-4; 1303-96-4; 10043-35-3; 12179-04-3]	2 mg/m^3 (I)	6 mg/m^3 (I)	A4	Varies	Irritation (eyes, nose, respiratory tract, skin); reproductive and developmental
Boron oxide [1303-86-2]	10 mg/m^3	—	—	69.64	Irritation
Boron tribromide [10294-33-4]	—	C 1 ppm	—	250.57	Irritation; burns
Boron trifluoride [7637-07-2]	—	C 1 ppm	—	67.82	Irritation
Bromacil [314-40-9]	10 mg/m^3	—	A3	261.11	Irritation
Bromine [7726-95-6]	0.1 ppm	0.2 ppm	—	159.81	Irritation
Bromine pentafluoride [7789-30-2]	0.1 ppm	—	—	174.92	Irritation
Bromoform [75-25-2]	0.5 ppm	—	Skin; A3	252.80	Irritation; liver
* 1-Bromopropane [106-94-5]	10 ppm	—	—	122.99	Neurotoxicity; hepatotoxicity; reproductive; developmental
1,3-Butadiene [106-99-0]	2 ppm	—	A2	54.09	Cancer
Butane, All isomers [106-97-8; 75-28-5]	*See* Aliphatic hydrocarbon gases: Alkane [C_1–C_4]				58.12
n-Butanol [71-36-3]	20 popm	—	—	74.12	Irritation
sec-Butanol [78-92-2]	100 ppm	—	—	74.12	Irritation; narcosis
tert-Butanol [75-65-0]	100 ppm	—	A4	74.12	Narcosis; irritation
2-Butoxyethanol (EGBE) [111-76-2]	20 ppm	—	A3	118.17	Irritation; CNS
2-Butoxyethyl acetate (EGBEA) [112-07-2]	20 ppm	—	A3	160.2	Irritation; CNS
n-Butyl acetate [123-86-4]	150 ppm	200 ppm	—	116.16	Irritation
sec-Butyl acetate [105-46-4]	200 ppm	—	—	116.16	Irritation
tert-Butyl acetate [540-88-5]	200 ppm	—	—	116.16	Irritation
n-Butyl acrylate [141-32-2]	2 ppm	—	SEN; A4	128.17	Irritation; reproductive
n-Butylamine [109-73-9]	—	C 5 ppm	Skin	73.14	Irritation
Butylated hydroxytoluene (BHT) [128-37-0]	2 mg/m^3 (IV)	–	A4	220.34	Irritation
tert-Butyl chromate, as CrO_3 [1189-85-1]	—	C 0.1 mg/m^3	Skin	230.22	Irritation; lung
* n-Butyl glycidyl ether (BGE) [2426-08-6]	3 ppm	—	Skin; SEN	130.21	Reproductive; sensitization
n-Butyl lactate [138-22-7]	5 ppm	—	—	146.19	Irritation; headache
n-Butyl mercaptan [109-79-5]	0.5 ppm	—	—	90.19	Irritation; CNS; reproductive
o-sec-Butylphenol [89-72-5]	5 ppm	—	Skin	150.22	Irritation
p-tert-Butyl toluene [98-51-1]	1 ppm	—	—	148.18	Irritation; CNS; CVS
Cadmium [7440-43-9] and compounds, as Cd	0.01 mg/m^3	—	A2; BEI	112.40	Kidney
	0.002 mg/m^3 (R)	—	A2; BEI	Varies	
‡ Calcium carbonate [471-34-1]	(10 mg/m^3 (E))	(—)	(—)	100.09	Irritation
Calcium chromate [13765-19-0], as Cr	0.001 mg/m^3	—	A2	156.09	Cancer
Calcium cyanamide [156-62-7]	0.5 mg/m^3	—	A4	80.11	Irritation; dermatitis
Calcium hydroxide [1305-62-0]	5 mg/m^3	—	—	74.10	Irritation

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Calcium oxide [1305-78-8]	2 mg/m^3	—	—	56.08	Irritation
Calcium silicate, Synthetic nonfibrous [1344-95-2]	10 mg/m^3 (E)	—	A4	—	Irritation
‡ Calcium sulfate [7778-18-9]	(10 mg/m^3 (E))	(—)	(—)	136.14	Irritation
Camphor, synthetic [76-22-2]	2 ppm	4 ppm	A4	152.23	Irritation; anosmia
Caprolactam [105-60-2]	5 mg/m^3 (IV)	—	A5	113.16	Irritation
Captafol [2425-06-1]	0.1 mg/m^3	—	Skin; A4	349.06	Dermatitis; sensitization
Captan [133-06-2]	5 mg/m^3 (I)	—	SEN; A3	300.60	Irritation
Carbaryl [63-25-2]	5 mg/m^3	—	A4	201.20	Cholinergic; reproductive
Carbofuran [1563-66-2]	0.1 mg/m^3 (IV)	—	A4; BEI_A	221.30	Cholinergic
Carbon black [1333-86-4]	3.5 mg/m^3	—	A4	—	Lung
Carbon dioxide [124-38-9]	5000 ppm	30,000 ppm	—	44.01	Asphyxiation
‡ Carbon disulfide [75-15-0]	(10 ppm)	(—)	Skin; (BEI)	76.14	CVS; CNS
Carbon monoxide [630-08-0]	25 ppm	—	BEI	28.01	Anoxia; CVS; CNS; reproductive
Carbon tetrabromide [558-13-4]	0.1 ppm	0.3 ppm	—	331.65	Irritation; liver
Carbon tetrachloride [56-23-5]	5 ppm	10 ppm	Skin; A2	153.84	Liver; cancer
Carbonyl fluoride [353-50-4]	2 ppm	5 ppm	—	66.01	Irritation; bone; fluorosis
Catechol [120-80-9]	5 ppm	—	Skin; A3	110.11	Irritation; CNS; lung
Cellulose [9004-34-6]	10 mg/m^3	—	—	NA	Irritation
Cesium hydroxide [21351-79-1]	2 mg/m^3	—	—	149.92	Irritation
Chlordane [57-74-9]	0.5 mg/m^3	—	Skin; A3	409.80	Seizures; liver
Chlorinated camphene [8001-35-2]	0.5 mg/m^3	1 mg/m^3	Skin; A3	414.00	Seizures; liver
o-Chlorinated diphenyl oxide [31242-93-0]	0.5 mg/m^3	—	—	377.00	Chloracne; liver
Chlorine [7782-50-5]	0.5 ppm	1 ppm	A4	70.91	Irritation
Chlorine dioxide [10049-04-4]	0.1 ppm	0.3 ppm	—	67.46	Irritation; bronchitis
Chlorine trifluoride [7790-91-2]	—	C 0.1 ppm	—	92.46	Irritation; lung
Chloroacetaldehyde [107-20-0]	—	C 1 ppm	—	78.50	Irritation
Chloroacetone [78-95-5]	—	C 1 ppm	Skin	92.53	Irritation
2-Chloroacetophenone [532-27-4]	0.05 ppm	—	A4	154.59	Irritation; sensitization
Chloroacetyl chloride [79-04-9]	0.05 ppm	0.15 ppm	Skin	112.95	Irritation; lung
Chlorobenzene [108-90-7]	10 ppm	—	A3; BEI	112.56	Liver
o-Chlorobenzylidene malononitrile [2698-41-1]	—	C 0.05 ppm	Skin; A4	188.61	Irritation
Chlorobromomethane [74-97-5]	200 ppm	—	—	129.39	CNS; liver
Chlorodifluoromethane [75-45-6]	1000 ppm	—	A4	86.47	CVS
Chlorodiphenyl (42% chlorine) [53469-21-9]	1 mg/m^3	—	Skin	266.50	Irritation; chloracne; liver
Chlorodiphenyl (54% chlorine) [11097-69-1]	0.5 mg/m^3	—	Skin; A3	328.40	Irritation; chloracne; liver
Chloroform [67-66-3]	10 ppm	—	A3	119.38	Liver; reproductive

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bis(Chloromethyl) ether [542-88-1]	0.001 ppm	—	A1	114.96	Cancer (lung)
Chloromethyl methyl ether [107-30-2]	—(L)	—	A2	80.50	Cancer (lung); irritation
1-Chloro-1-nitropropane [600-25-9]	2 ppm	—	—	123.54	Irritation; liver; lung
Chloropentafluoroethane [76-15-3]	1000 ppm	—	—	154.47	CVS
Chloropicrin [76-06-2]	0.1 ppm	—	A4	164.39	Irritation; lung
1-Chloro-2-propanol [127-00-4 and 2-Chloro-1-propanol [78-89-7]	1 ppm	—	Skin ; A4	94-54	Reproductive; genotoxic
β-Chloroprene [126-99-8]	10 ppm	—	Skin	88.54	Irritation; liver; reproductive
2-Chloropropionic acid [598-78-7]	0.1 ppm	—	Skin	108.53	Irritation; reproductive
o-Chlorostyrene [2039-87-4]	50 ppm	75 ppm	—	138.60	Kidney; CNS; neurotoxic; liver
o-Chlorotoluene [95-49-8]	50 ppm	—	—	126.59	Irritation
Chlorpyrifos [2921-88-2]	0.1 mg/m^3 (IV)	—	Skin; A4; BEI_A	350.57	Cholinergic
Chromite ore processing (Chromate), as Cr	0.05 mg/m^3	—	A1	—	Cancer (lung)
Chromium [7440-47-3] and inorganic compounds, as Cr					
Metal and Cr III compounds	0.5 mg/m^3	—	A4	Varies	Irritation; dermatitis
Water-soluble Cr VI compounds	0.05 mg/m^3	—	A1; BEI	Varies	Liver; kidney; respiratory
Insoluble Cr VI compounds	0.01 mg/m^3	—	A1	Varies	Cancer; irritation
Chromyl chloride [14977-61-8]	0.025 ppm	—	—	154.92	Kidney; liver; respiratory
Chrysene [218-01-9]	—(L)	—	A3	228.30	Skin
Clopidol [2971-90-6]	10 mg/m^3	—	A4	192.06	Irritation
Coal dust					
Anthracite	0.4 mg/m^3 (R)	—	A4	—	Lung fibrosis; lung function
Bituminous	0.9 mg/m^3 (R)	—	A4	—	Lung fibrosis; lung
Coal tar pitch volatiles [65996-93-2], as benzene soluble aerosol	0.2 mg/m^3	—	A1	—	Cancer
Cobalt [7440-48-4] and inorganic compounds, as Co	0.02 mg/m^3	—	A3; BEI	58.93 Varies	Asthma; lung; CVS
Cobalt carbonyl [10210-68-1], as Co	0.1 mg/m^3	—	—	341.94	Lung edema
Cobalt hydrocarbonyl [16842-03-8], as Co	0.1 mg/m^3	—	—	171.98	Lung edema
‡ Copper [7440-50-8]				63.55	(Irritation; GI; metal fume fever)
‡ Fume	(0.2 mg/m^3)	—	—		
‡ Dusts and mists, as Cu	(1 mg/m^3)	—	—		
Cotton dust, raw	0.2 mg/m^3 (G)	—	—	—	Lung; byssinosis
Cresol, all isomers [1319-77-3; 95-48-7; 108-39-4; 106-44-5]	5 ppm	—	Skin	108.14	Dermatitis; irritation; CNS
Crotonaldehyde [4170-30-3]	—	C 0.3 ppm	Skin; A3	70.09	Irritation
Crufomate [299-85-5]	5 mg/m^3	—	A4; BEI_A	291.71	Cholinergic

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Cumene [98-82-8]	50 ppm	—	—	120.19	Irritation; CNS
Cyanamide [420-04-2]	2 mg/m^3	—	—	42.04	Irritation
Cyanogen [460-19-5]	10 ppm	—	—	52.04	Irritation
Cyanogen chloride [506-77-4]	—	C 0.3 ppm	—	61.48	Irritation; lung function
Cyclohexane [110-82-7]	100 ppm	—	—	84.16	CNS
Cyclohexanol [108-93-0]	50 ppm	—	Skin	100.16	Irritation; CNS
Cyclohexanone [108-94-1]	20 ppm	50 ppm	Skin; A3	94.18	Irritation; CNS; liver; kidney
Cyclohexene [110-83-8]	300 ppm	—	—	82.14	Irritation
Cyclohexylamine [108-91-8]	10 ppm	—	A4	99.17	Irritation
Cyclonite [121-82-4]	0.5 mg/m^3	—	Skin; A4	222.26	Irritation; CNS; liver; blood
Cyclopentadiene [542-92-7]	75 ppm	—	—	66.10	Irritation
Cyclopentane [287-92-3]	600 ppm	—	—	70.13	Irritation; narcosis
Cyhexatin [13121-70-5]	5 mg/m^3	—	A4	385.16	Irritation
2,4-D [94-75-7]	10 mg/m^3	—	A4	221.04	Irritation
DDT [50-29-3]	1 mg/m^3	—	A3	354.50	Seizures; liver
Decaborane [17702-41-9]	0.05 ppm	0.15 ppm	Skin	122.31	CNS; lung function
Demeton [8065-48-3]	0.05 mg/m^3 (IV)	—	Skin; BEI_A	258.34	Cholinergic
Demeton-S-methyl [919-86-8]	0.05 mg/m^3 (IV)	—	Skin; SEN; A4; BEI_A	230.3	Cholinergic
Diacetone alcohol [123-42-2]	50 ppm	—	—	116.16	Irritation
Diazinon [333-41-5]	0.01 mg/m^3 (IV)	—	Skin; A4; BEI_A	304.36	Cholinergic
Diazomethane [334-88-3]	0.2 ppm	—	A2	42.04	Irritation; cancer (lung)
Diborane [19287-45-7]	0.1 ppm	—	—	27.69	CNS; lung function
2-N-Dibutylaminoethanol [102-81-8]	0.5 ppm	—	Skin; BEI_A	173.29	Irritation; cholinergic
Dibutyl phenyl phosphate [2528-36-1]	0.3 ppm	—	Skin; BEI_A	286.26	Irritation; cholinergic
Dibutyl phosphate [107-66-4]	1 ppm	2 ppm	—	210.21	Irritation
Dibutyl phthalate [84-74-2]	5 mg/m^3	—	—	278.34	Reproductive; irritation
* Dichloroacetic acid [79-43-6]	0.5 ppm	—	Skin; A3	128.95	Upper respiratory tract; CNS; male reproductive effects; developmental toxicity; cancer
Dichloroacetylene [7572-29-4]	—	C 0.1 ppm	A3	94.93	GI; neurotoxicity; irritation
o-Dichlorobenzene [95-50-1]	25 ppm	50 ppm	A4	147.01	Irritation; liver
p-Dichlorobenzene [106-46-7]	10 ppm	—	A3	147.01	Irritation; kidney
3,3'-Dichlorobenzidine [91-94-1]	— (L)	—	Skin; A3	253.13	Irritation; dermatitis
1,4-Dichloro-2-butene [764-41-0]	0.005 ppm	—	Skin; A2	124.99	Cancer; irritation
Dichlorodifluoromethane [75-71-8]	1000 ppm	—	A4	98.97	CVS
1,3-Dichloro-5,5-dimethyl hydantoin [118-52-5]	0.2 mg/m^3	0.4 mg/m^3	—	197.03	Irritation

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1,1-Dichloroethane [75-34-3]	100 ppm	—	A4	98.97	Liver; kidney; irritation
1,2-Dichloroethylene, All isomers [540-59-0; 156-59-2; 156-60-5]	200 ppm	—	—	96.95	Liver
Dichloroethyl ether [111-44-4]	5 ppm	10 ppm	Skin; A4	143.02	Irritation; lung
Dichlorofluoromethane [75-43-4]	10 ppm	—	—	102.92	Liver
Dichloromethane [75-09-2]	50 ppm	—	A3; BEI	84.93	CNS; anoxia
1,1-Dichloro-1-nitroethane [594-72-9]	2 ppm	—	—	143.96	Irritation
1,3-Dichloropropene [542-75-6]	1 ppm	—	Skin; A3	110.98	Irritation
2,2-Dichloropropionic acid [75-99-0]	5 mg/m^3 (I)	—	A4	142.97	Irritation
Dichlorotetrafluoroethane [76-14-2]	1000 ppm	—	A4	170.93	CVS; narcosis; asphyxiation
Dichlorvos (DDVP)[62-73-7]	0.1 mg/m^3 (IV)	—	Skin; SEN;A4; BEI_A	220.98	Cholinergic
Dicrotophos [141-66-2]	0.05 mg/m^3 (IV)	—	Skin; A4; BEI_A	237.21	Cholinergic
Dicyclopentadiene [77-73-6]	5 ppm	—	—	132.21	Irritation
Dicyclopentadienyl iron [102-54-5]	10 mg/m^3	—	—	186.03	Blood; liver
Dieldrin [60-57-1]	0.25 mg/m^3	—	Skin; A4	380.93	Liver; CNS
Diesel fuel [68334-30-5; 68476-30-2; 68476-31-3 68476-34-6; 77650-28-3], as total hydrocarbons	100 mg/m^3 (V)	—	Skin; A3`	Varies	Skin; irritation
Diethanolamine [111-42-2]	2 mg/m^3	—	Skin	105.14	Liver; kidney; blood
Diethylamine [109-89-7]	5 ppm	15 ppm	Skin; A4	73.14	Irritation
2-Diethylaminoethanol [100-37-8]	2 ppm	—	Skin	117.19	Irritation; CNS
Diethylene triamine [111-40-0]	1 ppm	—	Skin	103.17	Irritation; sensitization
Di(2-ethylhexyl)phthalate (DEHP) [117-81-7]	5 mg/m^3	—	A3	390.54	Irritation
Diethyl ketone [96-22-0]	200 ppm	300 ppm	—	86.13	Irritation; narcosis
Diethyl phthalate [84-66-2]	5 mg/m^3	—	A4	222.23	Irritation
Difluorodibromomethane [75-61-6]	100 ppm	—	—	209.83	Irritation; liver; CNS
Diglycidyl ether (DGE [2238-07-5]	0.1 ppm	—	A4	130.14	Irritation; reproductive; blood
Diisobutyl ketone [108-83-8]	25 ppm	—	—	142.23	Irritation
Diisopropylamine [108-18-9]	5 ppm	—	Skin	101.19	Vision; irritation
N,N-Dimethylacetamide [127-19-5]	10 ppm	—	Skin; A4; BEI	87.12	Reproductive; liver
Dimethylamine [124-40-3]	5 ppm	15 ppm	A4	45.08	Irritation
Dimethylaniline (N,N-Dimethylaniline) [121-69-7]	5 ppm	10 ppm	Skin; A4; BEI_M	121.18	Anoxia; neurotoxicity
Dimethyl carbamoyl chloride [79-44-7]	—(L)	—	A2	107.54	Cancer (lung)
Dimethylethoxysilane [14857-34-2]	0.5 ppm	1.5 ppm	—	104.20	Irritation; headache
Dimethylformamide [68-12-2]	10 ppm	—	Skin, A4; BEI	73.09	Liver
1,1-Dimethylhydrazine [57-14-7]	0.01 ppm	—	Skin; A3	60.12	Irritation; neoplasia
Dimethylphthalate [131-11-3]	5 mg/m^3	—	—	194.19	Irritation
Dimethyl sulfate [77-78-1]	0.1 ppm	—	Skin; A3	126.10	Irritation

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Dimethyl sulfide [75-18-3]	10 ppm	—	—	62.14	Irritation
Dinitolmide [148-01-6]	5 mg/m^3	—	A4	225.16	Irritation; liver
Dinitrobenzene, all isomers [528-29-0; 99-65-0; 100-25-4; 25154-54-5]	0.15 ppm	—	Skin; BEI_M	168.11	Anoxia
Dinitro-o-cresol [534-52-1]	0.2 mg/m^3	—	Skin	198.13	Metabolic disorders
Dinitrotoluene [25321-14-6]	0.2 mg/m^3	—	Skin; A3; BEI_M	182.15	CVS; reproductive
1,4-Dioxane [123-91-1]	20 ppm	—	Skin; A3	88.10	Irritation; liver; kidney
Dioxathion [78-34-2]	0.1 mg/m^3 (IV)	—	Skin; A4; BEI_A	456.54	Cholinergic
1,3-Dioxolane [646-06-0]	20 ppm	—	—	74.08	Blood; reproductive
Diphenylamine [122-39-4]	10 mg/m^3	—	A4	169.24	Liver; kidney; blood
Dipropyl ketone [123-19-3]	50 ppm	—	—	114.80	Irritation; liver; kidney; neurotoxicity
Diquat [85-00-7; 2764-72-9; 6385-62-2]	0.5 mg/m^3 (I)	—	Skin; A4	Varies	Irritation; eye
	0.1 mg/m^3 (R)	—	Skin; A4		Irritation; eye
Disulfiram [97-77-8]	2 mg/m^3	—	A4	296.54	GI; CVS
Disulfoton [298-04-4]	0.05 mg/m^3 (IV)	—	Skin; A4; BEI_A	274.38	Cholinergic
Diuron [330-54-1]	10 mg/m^3	—	A4	233.10	Irritation; blood
Divinyl benzene [1321-74-0]	10 ppm	—	—	130.19	Irritation
Dodecyl mercaptan [112-55-0]	0.1 ppm	—	SEN	202.4	Irritation
Emery [1302-74-5]	10 mg/m^3 (E)	—	—	—	Irritation
Endosulfan [115-29-7]	0.1 mg/m^3	—	Skin; A4	406.95	Liver; CNS
Endrin [72-20-8]	0.1 mg/m^3	—	Skin; A4	380.93	CNS; liver
Enflurane [13838-16-9]	75 ppm	—	A4	184.50	CNS; CVS
Epichlorohydrin [106-89-8]	0.5 ppm	—	Skin; A3	92.53	Irritation; liver; kidney
EPN [2104-64-5]	0.1 mg/m^3 (I)	—	Skin; A4; BEI_A	323.31	Cholinergic
Ethane [74-84-0]	*See* Aliphatic hydrocarbon gases: Alkane [C_1–C_4]			30.08	
Ethanol [64-17-5]	1000 ppm	—	A4	46.07	Irritation
Ethanolamine [141-43-5]	3 ppm	6 ppm	—	61.08	Irritation
Ethion [563-12-2]	0.05 mg/m^3 (IV)	—	Skin; A4; BEI_A	384.48	Cholinergic
2-Ethoxyethanol (EGEE) [110-80-5]	5 ppm	—	Skin; BEI	90.12	Reproductive
2-Ethoxyethyl acetate (EGEEA) [111-15-9]	5 ppm	—	Skin; BEI	132.16	Reproductive
Ethyl acetate [141-78-6]	400 ppm	—	—	88.10	Irritation
Ethyl acrylate [140-88-5]	5 ppm	15 ppm	A4	100.11	Irritation; cancer; sensitization
Ethylamine [75-04-7]	5 ppm	15 ppm	Skin	45.08	Irritation
Ethyl amyl ketone [541-85-5]	25 ppm	—	—	128.21	Irritation
Ethyl benzene [100-41-4]	100 ppm	125 ppm	A3; BEI	106.16	Irritation; CNS
Ethyl bromide [74-96-4]	5 ppm	—	Skin; A3	108.98	Liver; kidney; CVS

Substance [CAS No.]	2005 ADOPTED VALUES TWA	STEL	Notations	MW	TLV® Basis — Critical Effect(s)
Ethyl tert-butyl ether (ETBE) [637-92-3]	5 ppm	—	—	102.18	Irritation; lung function; reproductive
Ethyl butyl ketone [106-35-4]	50 ppm	75 ppm	—	114.19	Irritation; narcosis
Ethyl chloride [75-00-3]	100 ppm	—	Skin; A3	64.52	Liver; CNS
Ethyl cyanoacrylate [7085-85-0]	0.2 ppm	—	—	125.12	Irritation; necrosis
* Ethylene [74-85-1]	200 ppm	—	A4	28.05	Asphyxiant
Ethylene chlorohydrin [107-07-3]	—	C 1 ppm	Skin; A4	80.52	Irritation; liver; kidney; GI; CVS; CNS
Ethylenediamine [107-15-3]	10 ppm	—	Skin; A4	60.10	Irritation; asthma; sensitization
Ethylene dibromide [106-93-4]	—	—	Skin; A3	187.88	Irritation; liver; kidney
Ethylene dichloride [107-06-2]	10 ppm	—	A4	98.96	Liver; narcosis
Ethylene glycol [107-21-1]	—	C 100 mg/m^3 (H)	A4	62.07	Irritation
Ethylene glycol dinitrate (EGDN) [628-96-6]	0.05 ppm	—	Skin	152.06	CVS
Ethylene oxide [75-21-8]	1 ppm	—	A2	44.05	Cancer; reproductive
Ethylenimine [151-56-4]	0.5 ppm	—	Skin; A3	43.08	Irritation; bronchitis
Ethyl ether [60-29-7]	400 ppm	500 ppm	—	74.12	Irritation; narcosis
Ethyl formate [109-94-4]	100 ppm	—	—	74.08	Irritation
2-Ethylhexanoic acid [149-57-5]	5 mg/m^3 (IV)	—	—	144.24	Reproductive
Ethylidene norbornene [16219-75-3]	—	C 5 ppm	—	120.19	Irritation
Ethyl mercaptan [75-08-1]	0.5 ppm	—	—	62.13	Irritation
N-Ethylmorpholine [100-74-3]	5 ppm	—	Skin	115.18	Irritation; ocular
Ethyl silicate [78-10-4]	10 ppm	—	—	208.30	Irritation; kidney
‡ Fenamiphos [22224-92-6]	(0.1 mg/m^3)	—	Skin; A4; BEI_1	303.40	Cholinesterase inhibition
* Fensulfothion [115-90-2]	0.01 mg/m^3 (IV)	—	Skin; A4; BEI_A	308.35	Cholinesterase inhibition
‡ Fenthion [55-38-9]	(0.2 mg/m^3)	—	Skin; A4; BEI_A	278.34	Cholinesterase inhibition
Ferbam [14484-64-1]	10 mg/m^3	—	A4	416.50	Irritation
Ferrovanadium dust [12604-58-9]	1 mg/m^3	3 mg/m^3	—	—	Irritation
Flour dust	0.5 mg/m^3 (I)	–	SEN	—	Asthma; lung function; bronchitis
Fluorides, as F	2.5 mg/m^3	—	A4; BEI	Varies	Irritation; bone; fluorosis
Fluorine [7782-41-4]	1 ppm	2 ppm	—	38.00	Irritation
‡ Fonofos [944-22-9]	(0.1 mg/m^3)	—	Skin; A4; BEI_A	246.32	Cholinesterase inhibition
Formaldehyde [50-00-0]	—	C 0.3 ppm	SEN; A2	30.03	Irritation; cancer (nasal)
Formamide [75-12-7]	10 ppm	—	Skin	45.04	Irritation; liver
Formic acid [64-18-6]	5 ppm	10 ppm	—	46.02	Irritation
Furfural [98-01-1]	2 ppm	—	Skin; A3; BEI	96.08	Irritation
Furfuryl alcohol [98-00-0]	10 ppm	15 ppm	Skin	98.10	Irritation
* Gallium arsenide [1303-00-0]	0.0003 mg/m^3 (R)	—	A3	144.64	Pulmonary inflammation
Gasoline [86290-81-5]	300 ppm	500 ppm	A3	—	Irritation; CNS

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Germanium tetrahydride [7782-65-2]	0.2 ppm	—	—	76.63	Blood
Glutaraldehyde [111-30-8], activated and inactivated	—	C 0.05 ppm	A4; SEN	100.11	Irritation; sensitization
Glycerin mist [56-81-5]	10 mg/m^3	—	—	92.09	Irritation
Glycidol [556-52-5]	2 ppm	—	A3	74.08	Irritation; neoplasia
Glyoxal [107-22-2]	0.1 mg/m^3 (IV)	—	SEN; A4	58.04	Irritation
Grain dust (oat, wheat, barley)	4 mg/m^3 (E)	—	—	NA	Irritation; bronchitis; pulmonary function
Graphite (all forms except graphite fibers) [7782-42-5]	2 mg/m^3 (R)	—	—	—	Pneumoconiosis
Hafnium [7440-58-6] and compounds, as Hf	0.5 mg/m^3	—	—	178.49	Liver; irritation
Halothane [151-67-7]	50 ppm	—	A4	197.39	CNS; CVS; liver; reproductive
Helium [7440-59-7]		Simple asphyxiant (D)		4.00	Asphyxiation
Heptachlor [76-44-8] and Heptachlor epoxide [1024-57-3]	0.05 mg/m^3	—	Skin; A3	373.32 389.40	CNS; liver; blood
Heptane [142-82-5] (n-Heptane)	400 ppm	500 ppm	—	100.20	Irritation; narcosis
Hexachlorobenzene [118-74-1]	0.002 mg/m^3	—	Skin; A3	284.78	Liver; metabolic disorders
Hexachlorobutadiene [87-68-3]	0.02 ppm	—	Skin; A3	260.76	Irritation; kidney
Hexachlorocyclopentadiene [77-47-4]	0.01 ppm	—	A4	272.75	Irritation; pulmonary edema
Hexachloroethane [67-72-1]	1 ppm	—	Skin; A3	236.74	Irritation; liver; kidney
Hexachloronaphthalene [1335-87-1]	0.2 mg/m^3	—	Skin	334.74	Liver; chloracne
Hexafluoroacetone [684-16-2]	0.1 ppm	—	Skin	166.02	Reproductive; kidney
Hexahydrophthalic anhydride, All isomers [85-42-7; 13149-00-3; 14166-21-3]	—	C 0.005 mg/m^3 (IV)	SEN	154.17	Sensitization
Hexamethylene diisocyanate [822-06-0]	0.005 ppm	—	—	168.22	Irritation; sensitization
Hexamethyl phosphoramide [680-31-9]	—	—	Skin; A3	179.20	Lung
n-Hexane [110-54-3]	50 ppm	—	Skin; BEI	86.18	Neuropathy; CNS; irritation
Hexane, Isomers, other than n-hexane	500 ppm	1000 ppm	—	86.18	CNS; irritation
1,6-Hexanediamine [124-09-4]	0.5 ppm	—	—	116.21	Irritation
1-Hexene [592-41-6]	50 ppm	—	—	84.16	CNS; irritation
sec-Hexyl acetate [108-84-9]	50 ppm	—	—	144.21	Irritation
Hexylene glycol [107-41-5]	—	C 25 ppm	—	118.17	Irritation
Hydrazine [302-01-2]	0.01 ppm	—	Skin; A3	32.05	Irritation; liver
Hydrogen [1333-74-0]		Simple asphyxiant (D)		1.01	Asphyxiation
Hydrogenated terphenyls (nonirradiated) [61788-32-7]	0.5 ppm	—	—	241.00	Irritation; liver
Hydrogen bromide [10035-10-6]	—	C 2 ppm	—	80.92	Irritation
Hydrogen chloride [7647-01-0]	—	C 2 ppm	A4	36.47	Irritation; corrosion

Substance [CAS No.]	2005 ADOPTED VALUES TWA	STEL	Notations	MW	TLV® Basis — Critical Effect(s)
Hydrogen cyanide and Cyanide salts, as CN					CNS; irritation; anoxia; lung; thyroid
Hydrogen cyanide [74-90-8]	—	C 4.7 ppm	Skin	27.03	
Cyanide salts	—	C 5 mg/m^3	Skin	Varies	
* Hydrogen fluoride [7664-39-3], as F	0.5 ppm	C 2 ppm	BEI	20.01	Pulmonary inflammation [TWA]; lung damage [Ceiling]
Hydrogen peroxide [7722-84-1]	1 ppm	—	A3	34.02	Irritation; pulmonary edema
Hydrogen selenide [7783-07-5]	0.05 ppm	—	—	80.98	Irritation; GI
‡ Hydrogen sulfide [7783-06-4]	(10 ppm)	(15 ppm)	—	34.08	Irritation; CNS
Hydroquinone [123-31-9]	2 mg/m^3	—	A3	110.11	CNS; dermatitis; ocular
2-Hydroxypropyl acrylate [999-61-1]	0.5 ppm	—	Skin; SEN	130.14	Irritation; sensitization
Indene [95-13-6]	10 ppm	—	—	116.15	Irritation; liver; kidney
Indium [7440-74-6] and compounds, as In	0.1 mg/m^3	—	—	49.00	Pulmonary edema; bone; GI
Iodine [7553-56-2]	—	C 0.1 ppm	—	253.81	Irritation
Iodoform [75-47-8]	0.6 ppm	—	—	393.78	CNS; liver; kidney; CVS
‡ Iron oxide (Fe_2O_3) [1309-37-1] (dust & fume), as Fe	(5 mg/m^3)	(—)	(A4)	159.70	(Pneumoconiosis)
Iron pentacarbonyl [13463-40-6]	0.1 ppm	0.2 ppm	—	195.90	Pulmonary edema; CNS
Iron salts, soluble, as Fe	1 mg/m^3	—	—	Varies	Irritation
Isoamyl alcohol [123-51-3]	100 ppm	125 ppm	—	88.15	Irritation
Isobutanol [78-83-1]	50 ppm	—	—	74.12	Irritation, ocular
Isobutyl acetate [110-19-0]	150 ppm	—	—	116.16	Irritation
Isobutyl nitrite [542-56-3]	—	C 1 ppm (IV)	A3; BEI_M	103.12	Anoxia; blood
Isooctyl alcohol [26952-21-6]	50 ppm	—	Skin	130.23	Irritation
Isophorone [78-59-1]	—	C 5 ppm	A3	138.21	Irritation; narcosis
Isophorone diisocyanate [4098-71-9]	0.005 ppm	—	—	222.30	Dermatitis; asthma; sensitization
Isopropanol [67-63-0]	200 ppm	400 ppm	A4	60.09	Irritation; CNS
2-Isopropoxyethanol [109-59-1]	25 ppm	—	Skin	104.15	Blood
Isopropyl acetate [108-21-4]	100 ppm	200 ppm	—	102.13	Irritation; eye
Isopropylamine [75-31-0]	5 ppm	10 ppm	—	59.08	Irritation
N-Isopropylaniline [768-52-5]	2 ppm	—	Skin; BEI_M	135.21	Blood
Isopropyl ether [108-20-3]	250 ppm	310 ppm	—	102.17	Irritation
Isopropyl glycidyl ether (IGE) [4016-14-2]	50 ppm	75 ppm	—	116.18	Irritation; dermatitis
Kaolin [1332-58-7]	2 mg/m^3 (E,R)	—	A4	—	Pneumoconiosis
Kerosene [8008-20-6; 64742-81-0]/Jet fuels, as total hydrocarbon vapor	200 mg/m^3 (P)	—	Skin; A4	Varies	Irritation; CNS; skin
Ketene [463-51-4]	0.5 ppm	1.5 ppm	—	42.04	Lung irritation; lung edema

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Lead [7439-92-1] and inorganic compounds, as Pb	0.05 mg/m^3	—	A3; BEI	207.20 Varies	CNS; blood; kidney; reproductive
Lead arsenate [3687-31-8], as $Pb_3(AsO_4)_2$	0.15 mg/m^3	—	BEI	347.13	CNS; anemia; kidney; reproductive
Lead chromate [7758-97-6], as Pb as Cr	0.05 mg/m^3 0.012 mg/m^3	— —	A2; BEI A2	323.22	Cancer; CVS; reproductive
Lindane [58-89-9]	0.5 mg/m^3	—	Skin; A3	290.85	CNS; liver
Lithium hydride [7580-67-8]	0.025 mg/m^3	—	—	7.95	Irritation
L.P.G. (Liquefied petroleum gas) [68476-85-7]	*See* Aliphatic hydrocarbon gases: Alkane [C_1–C_4]				
‡ (Magnesite [546-93-0])	(10 mg/m$^{3\,(E)}$)	(—)	(—)	(84.33)	(Irritation; pneumoconiosis)
Magnesium oxide [1309-48-4]	10 mg/m$^{3\,(I)}$	—	A4	40.32	Irritation; metal fume fever
Malathion [121-75-5]	1 mg/m$^{3\,(IV)}$	—	Skin; A4; BEI_A	330.36	Cholinergic
Maleic anhydride [108-31-6]	0.1 ppm	—	SEN; A4	98.06	Irritation; asthma
Manganese [7439-96-5] and inorganic compounds, as Mn	0.2 mg/m^3	—	—	54.94 Varies	CNS; manganism; lung; reproductive
Manganese cyclopentadienyl tricarbonyl [12079-65-1], as Mn	0.1 mg/m^3	—	Skin	204.10	CNS; pulmonary edema
Mercury [7439-97-6], as Hg				200.59	
Alkyl compounds	0.01 mg/m^3	0.03 mg/m^3	Skin	Varies	CNS
Aryl compounds	0.1 mg/m^3	—	Skin	Varies	CNS; neuropathy; vision; kidney
Elemental and inorganic forms	0.025 mg/m^3	—	Skin; A4; BEI	Varies	CNS; kidney; reproductive
Mesityl oxide [141-79-7]	15 ppm	25 ppm	—	98.14	Irritation; narcosis; liver; kidney
Methacrylic acid [79-41-4]	20 ppm	—	—	86.09	Irritation
Methane [74-82-8]	*See* Aliphatic hydrocarbon gases: Alkane [C_1–C_4]				
Methanol [67-56-1]	200 ppm	250 ppm	Skin; BEI	32.04	Neuropathy; vision; CNS
Methomyl [16752-77-5]	2.5 mg/m^3	—	A4; BEI_A	162.20	Cholinergic
Methoxychlor [72-43-5]	10 mg/m^3	—	A4	345.65	CNS; liver
‡ 2-Methoxyethanol (EGME) [109-86-4]	(5 ppm)	—	Skin; (BEI)	76.09	Blood; reproductive; CNS
‡ 2-Methoxyethyl acetate (EGEMA) [110-49-6]	(5 ppm)	—	Skin; (BEI)	118.13	Blood; reproductive; CNS
(2-Methoxymethylethoxy)propanol (DPGME) [34590-94-8]	100 ppm	150 ppm	Skin	148.20	Irritation; CNS
4-Methoxyphenol [150-76-5]	5 mg/m^3	—	—	124.15	Eye; depigmentation
1-Methoxy-2-propanol (PGME) [107-98-2]	100 ppm	150 ppm	—	90.12	Irritation; anesthesia
Methyl acetate [79-20-9]	200 ppm	250 ppm	—	74.08	Irritation; narcosis
Methyl acetylene [74-99-7]	1000 ppm	—	—	40.07	Anesthesia
Methyl acetylene-propadiene mixture (MAPP) [59355-75-8]	1000 ppm	1250 ppm	—	40.07	Anesthesia

Substance [CAS No.]	2005 ADOPTED VALUES TWA	STEL	Notations	MW	TLV® Basis — Critical Effect(s)
Methyl acrylate [96-33-3]	2 ppm	—	Skin; SEN; A4	86.09	Irritation
Methylacrylonitrile [126-98-7]	1 ppm	—	Skin	67.09	Irritation; CNS
Methylal [109-87-5]	1000 ppm	—	—	76.10	Irritation; CNS
Methylamine [74-89-5]	5 ppm	15 ppm	—	31.06	Irritation
Methyl n-amyl ketone [110-43-0]	50 ppm	—	—	114.18	Irritation
N-Methyl aniline [100-61-8]	0.5 ppm	—	Skin; BEI_M	107.15	Anoxia; blood
Methyl bromide [74-83-9]	1 ppm	—	Skin; A4	94.95	Irritation
Methyl tert-butyl ether (MTBE) [1634-04-4]	50 ppm	—	A3	88.17	Kidney; reproductive
Methyl n-butyl ketone [591-78-6]	5 ppm	10 ppm	Skin ; BEI	100.16	Neuropathy
Methyl chloride [74-87-3]	50 ppm	100 ppm	Skin; A4	50.49	Kidney; CNS; reproductive
Methyl chloroform [71-55-6]	350 ppm	450 ppm	A4; BEI	133.42	Anesthesia; CNS
Methyl 2-cyanoacrylate [137-05-3]	0.2 ppm	—	—	111.10	Irritation; dermatitis
Methylcyclohexane [108-87-2]	400 ppm	—	—	98.19	Narcosis; irritation
Methylcyclohexanol [25639-42-3]	50 ppm	—	—	114.19	Irritation; narcosis; liver; kidney
o-Methylcyclohexanone [583-60-8]	50 ppm	75 ppm	Skin	112.17	Irritation; narcosis
2-Methylcyclopentadienyl manganese tricarbonyl [12108-13-3], as Mn	0.2 mg/m^3	—	Skin	218.10	CNS; liver; kidney
Methyl demeton [8022-00-2]	0.5 mg/m^3	—	Skin; BEI_A	230.30	Irritation; cholinergic
Methylene bisphenyl isocyanate (MDI) [101-68-8]	0.005 ppm	—	—	250.26	Irritation; lung edema; sensitization
4,4'-Methylene bis(2-chloroaniline) [MBOCA; MOCA®] [101-14-4]	0.01 ppm	—	Skin; A2; BEI	267.17	Anoxia; kidney; cancer (bladder)
Methylene bis(4-cyclohexylisocyanate) [5124-30-1]	0.005 ppm	—	—	262.35	Irritation; sensitization
4,4'-Methylene dianiline [101-77-9]	0.1 ppm	—	Skin; A3	198.26	Liver
Methyl ethyl ketone (MEK) [78-93-3]	200 ppm	300 ppm	BEI	72.10	Irritation; CNS
Methyl ethyl ketone peroxide [1338-23-4]	—	C 0.2 ppm	—	176.24	Irritation; liver; kidney
Methyl formate [107-31-3]	100 ppm	150 ppm	—	60.05	Irritation; narcosis.; lung edema
Methyl hydrazine [60-34-4]	0.01 ppm	—	Skin; A3	46.07	Irritation; liver
Methyl iodide [74-88-4]	2 ppm	—	Skin	141.95	CNS; irritation
Methyl isoamyl ketone [110-12-3]	50 ppm	—	—	114.20	Irritation; narcosis; liver; kidney
Methyl isobutyl carbinol [108-11-2]	25 ppm	40 ppm	Skin	102.18	Irritation; anesthesia
Methyl isobutyl ketone [108-10-1]	50 ppm	75 ppm	BEI	100.16	Irritation; kidney
Methyl isocyanate [624-83-9]	0.02 ppm	—	Skin	57.05	Irritation; lung edema; sensitization
Methyl isopropyl ketone [563-80-4]	200 ppm	—	—	86.14	Irritation
Methyl mercaptan [74-93-1]	0.5 ppm	—	—	48.11	Irritation; CNS
Methyl methacrylate [80-62-6]	50 ppm	100 ppm	SEN; A4	100.13	Irritation; dermatitis
Methyl parathion [298-00-0]	0.2 mg/m^3	—	Skin; A4; BEI_A	263.23	Cholinergic
Methyl propyl ketone [107-87-9]	200 ppm	250 ppm	—	86.17	Irritation; narcosis

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Methyl silicate [681-84-5]	1 ppm	—	—	152.22	Eye; lung
α-Methyl styrene [98-83-9]	50 ppm	100 ppm	—	118.18	Irritation; dermatitis; CNS
Methyl vinyl ketone [78-94-4]	—	C 0.2 ppm	Skin; SEN	70.10	Irritation; sensitization
Metribuzin [21087-64-9]	5 mg/m^3	—	A4	214.28	Blood; liver
Mevinphos [7786-34-7]	0.01 mg/m^3 (IV)	—	Skin; A4; BEI_A	224.16	Cholinergic
Mica [12001-26-2]	3 mg/m^3 (R)	—	—	—	Pneumoconiosis
Molybdenum [7439-98-7], as Mo				95.95	
Soluble compounds	0.5 mg/m^3 (R)	—	A3		Lung; irritation
Metal and Insoluble compounds	10 mg/m^3 (I)	—	—	Varies	Lung; CNS
	3 mg/m^3 (R)	—	—	Varies	Lung; CNS
Monocrotophos [6923-22-4]	0.05 mg/m^3 (IV)	—	Skin; A4; BEI_A	223.16	Cholinergic
Morpholine [110-91-8]	20 ppm	—	Skin; A4	87.12	Irritation; vision
Naled [300-76-5]	0.1 mg/m^3 (IV)	—	Skin; SEN; A4; BEI_A	380.79	Cholinergic; dermatitis
Naphthalene [91-20-3]	10 ppm	15 ppm	A4	128.19	Irritation; ocular; blood
β-Naphthylamine [91-59-8]	— (L)	—	A1	143.18	Cancer (bladder)
Natural gas [8006-14-2]	*See* Aliphatic hydrocarbon gases: Alkane [C_1–C_4]				
Natural rubber latex [9006-04-6], as Total proteins	0.001 mg/m^3 (I)	—	Skin; SEN	Varies	Sensitization
Neon [7440-01-9]		Simple asphyxiant (D)		20.18	Asphyxiation
Nickel [7440-02-0], as Ni					
Elemental [7440-02-0]	1.5 mg/m^3 (I)	—	A5	58.71	Dermatitis; pneumoconiosis
Soluble compounds (NOS)	0.1 mg/m^3 (I)	—	A4	Varies	CNS; irritation; dermatitis
Insoluble compounds (NOS)	0.2 mg/m^3 (I)	—	A1	Varies	Cancer; irritation; dermatitis
Nickel subsulfide [12035-72-2]	0.1 mg/m^3 (I)	—	A1	240.19	Cancer; irritation; dermatitis
Nickel carbonyl [13463-39-3], as Ni	0.05 ppm	—	—	170.73	Irritation; CNS
Nicotine [54-11-5]	0.5 mg/m^3	—	Skin	162.23	CVS; GI; CNS
Nitrapyrin [1929-82-4]	10 mg/m^3	20 mg/m^3	A4	230.93	Liver
Nitric acid [7697-37-2]	2 ppm	4 ppm	—	63.02	Irritation; corrosion; pulmonary edema
Nitric oxide [10102-43-9]	25 ppm	—	BEI_M	30.01	Anoxia; irritation; cyanosis
p-Nitroaniline [100-01-6]	3 mg/m^3	—	Skin; A4; BEI_M	138.12	Anoxia; anemia; liver
Nitrobenzene [98-95-3]	1 ppm	—	Skin; A3; BEI	123.11	Anoxia
p-Nitrochlorobenzene [100-00-5]	0.1 ppm	—	Skin; A3; BEI_M	157.56	Anoxia; blood; liver
4-Nitrodiphenyl [92-93-3]	— (L)	—	Skin; A2	199.20	Cancer (bladder)
Nitroethane [79-24-3]	100 ppm	—	—	75.07	Irritation; narcosis; liver
Nitrogen [7727-37-9]		Simple asphyxiant (D)		14.01	Asphyxiation
Nitrogen dioxide [10102-44-0]	3 ppm	5 ppm	A4	46.01	Irritation; pulmonary edema
Nitrogen trifluoride [7783-54-2]	10 ppm	—	BEI_M	71.00	Anoxia; blood; liver; kidney

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Nitroglycerin (NG) [55-63-0]	0.05 ppm	—	Skin	227.09	CVS
Nitromethane [75-52-5]	20 ppm	—	A3	61.04	Thyroid
1-Nitropropane [108-03-2]	25 ppm	—	A4	89.09	Irritation; liver
2-Nitropropane [79-46-9]	10 ppm	—	A3	89.09	Liver; cancer
N-Nitrosodimethylamine [62-75-9]	—(L)	—	Skin; A3	74.08	Liver
Nitrotoluene, all isomers [88-72-2; 99-08-1; 99-99-0]	2 ppm	—	Skin; BEI_M	137.13	Anoxia; cyanosis
Nitrous oxide [10024-97-2]	50 ppm	—	A4	44.02	Reproductive; blood; CNS
Nonane [111-84-2], all isomers	200 ppm	—	—	128.26	CNS; skin; irritation
Octachloronaphthalene [2234-13-1]	0.1 mg/m^3	0.3 mg/m^3	Skin	403.74	Liver; dermatitis
Octane, All isomers [111-65-9]	300 ppm	—	—	114.22	Irritation
‡ (Oil mist, mineral)	(5 $mg/m^{3\,(O)}$)	(10 mg/m^3)	(—)	(—)	(Lung)
Osmium tetroxide [20816-12-0]	0.0002 ppm	0.0006 ppm	—	254.20	Irritation; vision
Oxalic acid [144-62-7]	1 mg/m^3	2 mg/m^3	—	90.04	Irritation; burns
p,p'-Oxybis(benzenesulfonyl hydrazide) [80-51-3]	0.1 $mg/m^{3\,(I)}$	—	—	326.00	Irritation
Oxygen difluoride [7783-41-7]	—	C 0.05 ppm	—	54.00	Irritation; kidney
Ozone [10028-15-6]				48	Lung function; irritation
Heavy work	0.05 ppm	—	A4		
Moderate work	0.08 ppm	—	A4		
Light work	0.1 ppm	—	A4		
Heavy, moderate, or light workloads (≤ 2 hours)	0.2 ppm	—	A4		
Paraffin wax fume [8002-74-2]	2 mg/m^3	—	—	—	Irritation
Paraquat [4685-14-7]	0.5 mg/m^3	—	—	257.18	Lung; irritation
	0.1 $mg/m^{3\,(R)}$	—	—		
Parathion [56-38-2]	0.05 $mg/m^{3\,(IV)}$	—	Skin; A4; BEI	291.27	Cholinergic
Particles (Insoluble or Poorly Soluble) Not Otherwise Specified	*See* Appendix B				
Pentaborane [19624-22-7]	0.005 ppm	0.015 ppm	—	63.17	CNS
Pentachloronaphthalene [1321-64-8]	0.5 mg/m^3	—	Skin	300.40	Chloracne; liver
Pentachloronitrobenzene [82-68-8]	0.5 mg/m^3	—	A4	295.36	Liver
Pentachlorophenol [87-86-5]	0.5 mg/m^3	—	Skin; A3; BEI	266.35	CVS; CNS
Pentaerythritol [115-77-5]	10 mg/m^3	—	—	136.15	Irritation
Pentane, all isomers [78-78-4; 109-66-0; 463-82-1]	600 ppm	—	—	72.15	Irritation; narcosis
Pentyl acetate, all isomers [628-63-7; 626-38-0; 123-92-2; 625-16-1; 624-41-9; 620-11-1]	50 ppm	100 ppm	—	130.20	Irritation
Perchloromethyl mercaptan [594-42-3]	0.1 ppm	—	—	185.87	Irritation; pulmonary edema
Perchloryl fluoride [7616-94-6]	3 ppm	6 ppm	—	102.46	Irritation; blood
Perfluorobutyl ethylene [19430-93-4]	100 ppm	—	—	246.1	Hematopoietic, hepatic

Substance [CAS No.]	2005 ADOPTED VALUES TWA	STEL	Notations	MW	TLV® Basis — Critical Effect(s)
Perfluoroisobutylene [382-21-8]	—	C 0.01 ppm	—	200.04	Irritation; pulmonary edema
‡ (Perlite [93763-70-3])	(10 mg/m^3 (E))	(—)	(A4)	—	(Irritation)
Persulfates, as persulfate	0.1 mg/m^3	—	—	Varies	Irritation
Phenol [108-95-2]	5 ppm	—	Skin; A4; BEI	94.11	Irritation; CNS; blood
Phenothiazine [92-84-2]	5 mg/m^3	—	Skin	199.26	Irritation; ocular; liver; kidney
N-Phenyl-beta-naphthylamine [135-88-6]	—	—	A4	219.29	Irritation
o-Phenylenediamine [95-54-5]	0.1 mg/m^3	—	A3	108.05	Irritation; liver; blood
m-Phenylenediamine [108-45-2]	0.1 mg/m^3	—	A4	108.05	Irritation; liver
p-Phenylenediamine [106-50-3]	0.1 mg/m^3	—	A4	108.05	Sensitization; skin; eye
Phenyl ether [101-84-8], vapor	1 ppm	2 ppm	—	170.20	Irritation; nausea
Phenyl glycidyl ether (PGE) [122-60-1]	0.1 ppm	—	Skin; SEN; A3	150.17	Irritation; dermatitis; sensitization
Phenylhydrazine [100-63-0]	0.1 ppm	—	Skin; A3	108.14	Dermatitis; anemia
Phenyl mercaptan [108-98-5]	0.1 ppm	—	Skin	110.18	CNS: irritation (eye, dermal)
Phenylphosphine [638-21-1]	—	C 0.05 ppm	—	110.10	Irritation; dermatitis; blood; reproductive
* Phorate [298-02-2]	0.05 mg/m^3 (IV)	—	Skin; BEI_A	260.40	Cholinesterase inhibition
Phosgene [75-44-5]	0.1 ppm	—	—	98.92	Irritation; anoxia; lung edema
Phosphine [7803-51-2]	0.3 ppm	1 ppm	—	34.00	Irritation; CNS; GI
Phosphoric acid [7664-38-2]	1 mg/m^3	3 mg/m^3	—	98.00	Irritation
Phosphorus (yellow) [12185-10-3]	0.1 mg/m^3	—	—	123.92	Irritation; liver; kidney; CVS; GI
Phosphorus oxychloride [10025-87-3]	0.1 ppm	—	—	153.35	Irritation; kidney
Phosphorus pentachloride [10026-13-8]	0.1 ppm	—	—	208.24	Irritation
Phosphorus pentasulfide [1314-80-3]	1 mg/m^3	3 mg/m^3	—	222.29	Irritation
Phosphorus trichloride [7719-12-2]	0.2 ppm	0.5 ppm	—	137.35	Irritation
Phthalic anhydride [85-44-9]	1 ppm	—	SEN; A4	148.11	Irritation; sensitization
m-Phthalodinitrile [626-17-5]	5 mg/m^3	—	—	128.14	Irritation
Picloram [1918-02-1]	10 mg/m^3	—	A4	241.48	Liver; kidney
Picric acid [88-89-1]	0.1 mg/m^3	—	—	229.11	Dermatitis; irritation; ocular; sensitization
Pindone [83-26-1]	0.1 mg/m^3	—	—	230.25	Liver; kidney; bleeding; dermatitis
Piperazine dihydrochloride [142-64-3]	5 mg/m^3	—	—	159.05	Irritation; burns; asthma; sensitization
Platinum [7440-06-4], as Pt					
Metal	1 mg/m^3	—	—	195.09	Irritation
Soluble salts	0.002 mg/m^3	—	—	Varies	Asthma; irritation; sensitization
‡ Portland cement [65997-15-1]	(10 mg/m^3 (E))	(—)	(—)	—	(Irritation; dermatitis)
Potassium hydroxide [1310-58-3]	—	C 2 mg/m^3	—	56.10	Irritation; corrosion

Substance [CAS No.]	2005 ADOPTED VALUES TWA	STEL	Notations	MW	TLV® Basis — Critical Effect(s)
Propane [74-98-6]	*See* Aliphatic hydrocarbon gases: Alkane [C_1–C_4]			44.09	
Propane sultone [1120-71-4]	—[(L)]	—	A3	122.14	Neoplasia
‡ n-Propanol [71-23-8]	(200 ppm)	(400 ppm)	A3	60.09	Irritation
Propargyl alcohol [107-19-7]	1 ppm	—	Skin	56.06	Irritation; liver; kidney
β-Propiolactone [57-57-8]	0.5 ppm	—	A3	72.06	Irritation
Propionic acid [79-09-4]	10 ppm	—	—	74.08	Irritation
Propoxur [114-26-1]	0.5 mg/m^3	—	A3; BEI_A	209.24	Cholinergic
n-Propyl acetate [109-60-4]	200 ppm	250 ppm	—	102.13	Irritation
‡ Propylene [115-07-1]		(Simple asphyxiant[(D)])		42.08	(Asphyxiation)
‡ Propylene dichloride [78-87-5]	(75 ppm)	(110 ppm)	A4	112.99	(Irritation; CNS; liver; kidney)
Propylene glycol dinitrate [6423-43-4]	0.05 ppm	—	Skin; BEI_M	166.09	CVS; headache; CNS, anoxia
Propylene imine [75-55-8]	2 ppm	—	Skin; A3	57.09	Irritation; CNS
Propylene oxide [75-56-9]	2 ppm	—	SEN; A3	58.08	Irritation; cancer (nasal)
n-Propyl nitrate [627-13-4]	25 ppm	40 ppm	BEI_M	105.09	Blood; cyanosis; anoxia
Pyrethrum [8003-34-7]	5 mg/m^3	—	A4	345 (avg)	Dermatitis; CNS; liver; sensitization
Pyridine [110-86-1]	1 ppm	—	A3	79.10	Irritation; CNS; liver; kidney
Quinone [106-51-4]	0.1 ppm	—	—	108.09	Irritation; eyes
Resorcinol [108-46-3]	10 ppm	20 ppm	A4	110.11	Irritation; dermatitis; blood
Rhodium [7440-16-6], as Rh				102.91	
Metal and insoluble compounds	1 mg/m^3	—	A4	Varies	Irritation
Soluble compounds, as Rh	0.01 mg/m^3	—	A4	Varies	Irritation
‡ Ronnel [299-84-3]	(10 mg/m^3)	—	A4; BEI_A	321.57	Cholinesterase inhibition
Rosin core solder thermal decomposition products (colophony) [8050-09-7]	—[(L)]		SEN	NA	Irritation; asthma; sensitization
Rotenone (commercial) [83-79-4]	5 mg/m^3	—	A4	391.41	Irritation; CNS
‡ (Rouge)	(10 mg/m^3 [(E)])	(—)	(A4)	(159.70)	(Lung; siderosis; irritation)
Rubber solvent (Naphtha) [8030-30-6]	400 ppm	—	—	97(mean)	Irritation; CNS
Selenium [7782-49-2]	0.2 mg/m^3	—	—	78.96	Irritation
and compounds, as Se				Varies	
Selenium hexafluoride [7783-79-1]	0.05 ppm	—	—	192.96	Pulmonary edema
Sesone [136-78-7]	10 mg/m^3	—	A4	309.13	Irritation
(Silica, Amorphous —)					
(Diatomaceous earth (uncalcined) [61790-53-2])	(10 mg/m^3 [(E, I)])	(—)	(—)	(—)	(Irritation; pneumoconiosis)
	(3 mg/m^3 [(E,R)])	(—)	(—)		
(Precipitated silica and silica gel [112926-00-8])	(10 mg/m^3)	(—)	(—)	(—)	(Irritation)
(Silica fume [69012-64-2])	(2 mg/m^3 [(R)])	(—)	(—)	(—)	(Irritation; fever)

Substance [CAS No.]	2005 ADOPTED VALUES TWA	STEL	Notations	MW	TLV® Basis — Critical Effect(s)
(Silica, fused [60676-86-0])	(0.1 mg/m^3 (R))	(—)	(—)	(60.08)	(Lung fibrosis)
‡ Silica, Crystalline —					
‡ Cristobalite [14464-46-1]	(0.05 mg/m^3 (R))	—	(—)	60.08	Lung fibrosis; silicosis
‡ Quartz [14808-60-7]	(0.05 mg/m^3 (R))	—	A2	60.08	Silicosis; lung function; lung fibrosis; cancer
‡ (Tripoli [1317-95-9], as quartz)	(0.1 mg/m^3 (R))	(—)		(—)	(Lung fibrosis)
‡ (Silicon [7440-21-3])	(10 mg/m^3)	(—)	(—)	(28.09)	(Lung)
Silicon carbide [409-21-2]				40.10	
Nonfibrous	10 mg/m^3 (I,E)	—	—		Lung function
	3 mg/m^3 (R,E)	—	—		Lung function]
Fibrous forms (including whiskers)	0.1 f/cc (F)	—	A2		Lung fibrosis; cancer
Silicon tetrahydride [7803-62-5]	5 ppm	—	—	32.12	Irritation
Silver [7440-22-4]					Argyria (skin, eyes, mucosa)
Metal	0.1 mg/m^3	—	—	107.87	
Soluble compounds, as Ag	0.01 mg/m^3	—	—	Varies	
Soapstone	6 mg/m^3 (E)	—	—	—	Pneumoconiosis
	3 mg/m^3 (E,R)	—	—		
Sodium azide [26628-22-8]				65.02	CNS; CVS; lung
as Sodium azide	—	C 0.29 mg/m^3	A4		
as Hydrazoic acid vapor	—	C 0.11 ppm	A4		
Sodium bisulfite [7631-90-5]	5 mg/m^3	—	A4	104.07	Irritation
Sodium fluoroacetate [62-74-8]	0.05 mg/m^3	—	Skin	100.02	CNS; CVS
Sodium hydroxide [1310-73-2]	—	C 2 mg/m^3	—	40.01	Irritation
Sodium metabisulfite [7681-57-4]	5 mg/m^3	—	A4	190.13	Irritation
Starch [9005-25-8]	10 mg/m^3	—	A4	—	Dermatitis; lung
Stearates (J)	10 mg/m^3	—	A4	Varies	Irritation
Stoddard solvent [8052-41-3]	100 ppm	—	—	140.00	Irritation; narcosis; kidney
Strontium chromate [7789-06-2], as Cr	0.0005 mg/m^3	—	A2	203.61	Cancer (lung)
Strychnine [57-24-9]	0.15 mg/m^3	—	—	334.40	CNS
Styrene, monomer [100-42-5]	20 ppm	40 ppm	A4; BEI	104.16	Neurotoxicity; irritation; CNS
Subtilisins [1395-21-7; 9014-01-1], as crystalline active enzyme	—	C 0.00006 mg/m^3	—	—	Irritation; lung; sensitization
Sucrose [57-50-1]	10 mg/m^3	—	A4	342.30	Lung
Sulfometuron methyl [74222-97-2]	5 mg/m^3	—	A4	364.38	Irritation; blood
* Sulfotepp (TEDP)[3689-24-5]	0.1 mg/m^3 (IV)	—	Skin; A4; BEI_A	322.30	Cholinesterase inhibition
Sulfur dioxide [7446-09-5]	2 ppm	5 ppm	A4	64.07	Irritation

Substance [CAS No.]	2005 ADOPTED VALUES TWA	STEL	Notations	MW	TLV® Basis — Critical Effect(s)
Sulfur hexafluoride [2551-62-4]	1000 ppm	—	—	146.07	Asphyxiation
Sulfuric acid [7664-93-9]	0.2 mg/m^3 (T)	—	A2(M)	98.08	Mucostasis; lung function
Sulfur monochloride [10025-67-9]	—	C 1 ppm	—	135.03	Irritation
Sulfur pentafluoride [5714-22-7]	—	C 0.01 ppm	—	254.11	Irritation
Sulfur tetrafluoride [7783-60-0]	—	C 0.1 ppm	—	108.07	Irritation
Sulfuryl fluoride [2699-79-8]	5 ppm	10 ppm	—	102.07	Irritation; CNS
Sulprofos [35400-43-2]	1 mg/m^3	—	A4; BEI$_A$	322.43	Cholinergic
Synthetic Vitreous Fibers					
Continuous filament glass fibers	1 f/cc (F)	—	A4	—	Irritation
Continuous filament glass fibers	5 mg/m^3 (I)	—	A4	—	Irritation
Glass wool fibers	1 f/cc (F)	—	A3	—	Irritation;lung
Rock wool fibers	1 f/cc (F)	—	A3	—	Irritation; lung
Slag wool fibers	1 f/cc (F)	—	A3	—	Irritation; lung
Special purpose glass fibers	1 f/cc (F)	—	A3	—	Irritation; lung
Refractory ceramic fibers	0.2 f/cc (F)	—	A2	—	Pulmonary fibrosis; cancer
2,4,5-T [93-76-5]	10 mg/m^3	—	A4	255.49	Irritation
Talc [14807-96-6]					
Containing no asbestos fibers	2 mg/m^3 (E, R)	—	A4	—	Lung
Containing asbestos fibers	Use asbestos TLV (E, R)	—	A1	—	Asbestosis; cancer
Tantalum metal [7440-25-7] and				180.95	Irritation; lung
Tantalum oxide [1314-61-0] dusts, as Ta	5 mg/m^3	—	—	441.90	Irritation; lung
Tellurium [13494-80-9] and compounds (NOS), as Te, excluding hydrogen telluride	0.1 mg/m^3	—	—	127.60 Varies	CNS; cyanosis; liver
Tellurium hexafluoride [7783-80-4]	0.02 ppm	—	—	241.61	Irritation
* Temephos [3383-96-8]	1 mg/m^3 (IV)	—	Skin; A4; BEI$_A$	466.46	Cholinesterase inhibition
Terbufos [13071-79-9]	0.01 mg/m^3 (IV)	—	Skin; A4; BEI$_A$	288.45	Cholinergic
Terephthalic acid [100-21-0]	10 mg/m^3	—	—	166.13	Lung; urinary
Terphenyls [26140-60-3]	—	C 5 mg/m^3	—	230.31	Irritation
1,1,1,2-Tetrachloro-2,2-difluoroethane [76-11-9]	500 ppm	—	—	203.83	Liver; blood
1,1,2,2-Tetrachloro-1,2-difluoroethane [76-12-0]	500 ppm	—	—	203.83	CNS; pulmonary edema
1,1,2,2-Tetrachloroethane [79-34-5]	1 ppm	—	Skin; A3	167.86	Liver; CNS; GI
Tetrachloroethylene [127-18-4]	25 ppm	100 ppm	A3; BEI	165.80	Irritation; CNS
Tetrachloronaphthalene [1335-88-2]	2 mg/m^3	—	—	265.96	Liver
Tetraethyl lead [78-00-2], as Pb	0.1 mg/m^3	—	Skin; A4	323.45	CNS
Tetraethyl pyrophosphate (TEPP) [107-49-3]	0.05 mg/m^3	—	Skin; BEI$_A$	290.20	Cholinergic

Substance [CAS No.]	2005 ADOPTED VALUES TWA	STEL	Notations	MW	TLV® Basis — Critical Effect(s)
Tetrafluoroethylene [116-14-3]	2 ppm	—	A3	100.20	Kidney; liver
* Tetrahydrofuran [109-99-9]	50 ppm	100 ppm	Skin; A3	72.10	Respiratory irritation; CNS; hepatic; renal
* Tetrakis (hydroxymethyl) phosphonium salts					Body weight; CNS; hepatic
Tetrakis (hydroxymethyl) phosphonium chloride [124-64-1]	2 mg/m^3	—	A4	190.56	
Tetrakis (hydroxymethyl) phosphonium sulfate [55566-30-8]	2 mg/m^3	—	SEN; A4	406.26	
Tetramethyl lead [75-74-1], as Pb	0.15 mg/m^3	—	Skin	267.33	CNS
Tetramethyl succinonitrile [3333-52-6]	0.5 ppm	—	Skin	136.20	CNS
Tetranitromethane [509-14-8]	0.005 ppm	—	A3	196.04	Irritation
Tetrasodium pyrophosphate [7722-88-5]	5 mg/m^3	—	—	265.94	Irritation
Tetryl [479-45-8]	1.5 mg/m^3	—	—	287.15	Liver; dermatitis; sensitization
Thallium [7440-28-0] and soluble compounds, as Tl	0.1 mg/m^3	—	Skin	204.37 Varies	Irritation; CNS; CVS
4,4'-Thiobis(6-tert-butyl-m-cresol) [96-69-5]	10 mg/m^3	—	A4	358.52	Liver; kidney
Thioglycolic acid [68-11-1]	1 ppm	—	Skin	92.12	Irritation
Thionyl chloride [7719-09-7]	—	C 1 ppm	—	118.98	Irritation
Thiram [137-26-8]	1 mg/m^3	—	A4	240.44	Irritation
Tin [7440-31-5], as Sn					
Metal	2 mg/m^3	—	—	118.69	Stannosis
Oxide & inorganic compounds, except tin hydride	2 mg/m^3	—	—	Varies	Stannosis
Organic compounds	0.1 mg/m^3	0.2 mg/m^3	Skin; A4	Varies	CNS; immunotoxicity; irritation
Titanium dioxide [13463-67-7]	10 mg/m^3	—	A4	79.90	Lung
o-Tolidine [119-93-7]	—	—	Skin; A3	212.28	Liver; kidney; blood
Toluene [108-88-3]	50 ppm	—	Skin; A4; BEI	92.13	CNS
Toluene-2,4- or 2,6-diisocyanate (or as a mixture) (TDI) [91-08-7; 584-84-9]	0.005 ppm	0.02 ppm	SEN; A4	174.15	Respiratory; sensitization
o-Toluidine [95-53-4]	2 ppm	—	Skin; A3; BEI_M	107.15	Anoxia; kidney
m-Toluidine [108-44-1]	2 ppm	—	Skin; A4; BEI_M	107.15	Anoxia; kidney
p-Toluidine [106-49-0]	2 ppm	—	Skin; A3; BEI_M	107.15	Anoxia; kidney
Tributyl phosphate [126-73-8]	0.2 ppm	—	BEI_A	266.32	Irritation; cholinergic
Trichloroacetic acid [76-03-9]	1 ppm	—	A3	163.39	Irritation
1,2,4-Trichlorobenzene [120-82-1]	—	C 5 ppm	—	181.46	Irritation
1,1,2-Trichloroethane [79-00-5]	10 ppm	—	Skin; A3	133.41	CNS; liver
Trichloroethylene [79-01-6]	50 ppm	100 ppm	A5; BEI	131.40	CNS; headache; liver

Substance [CAS No.]	2005 ADOPTED VALUES TWA	STEL	Notations	MW	TLV® Basis — Critical Effect(s)
Trichlorofluoromethane [75-69-4]	—	C 1000 ppm	A4	137.38	CVS; CNS
Trichloronaphthalene [1321-65-9]	5 mg/m^3	—	Skin	231.51	Liver
1,2,3-Trichloropropane [96-18-4]	10 ppm	—	Skin; A3	147.43	Liver; kidney
1,1,2-Trichloro-1,2,2-trifluoroethane [76-13-1]	1000 ppm	1250 ppm	A4	187.40	Narcosis; CVS; asphyxiation
Trichlorphon [52-68-6]	1 mg/m^3 (I)	—	A4; BEI_A	257.60	Cholinergic
Triethanolamine [102-71-6]	5 mg/m^3	—	—	149.22	Irritation; liver; kidney
Triethylamine [121-44-8]	1 ppm	3 ppm	Skin; A4	101.19	Irritation; vision
Trifluobromomethane [75-63-8]	1000 ppm	—	—	148.92	CNS; CVS
1,3,5-Triglycidyl-s-triazinetrione [2451-62-9]	0.05 mg/m^3	—	—	297.25	Blood; reproductive; dermatitis; sensitization
Trimellitic anhydride [552-30-7]	—	C 0.04 mg/m^3	—	192.12	Bleeding (lung); immunotoxicity; sensitization
Trimethylamine [75-50-3]	5 ppm	15 ppm	—	59.11	Irritation
Trimethyl benzene (mixed isomers) [25551-13-7]	25 ppm	—	—	120.19	Irritation; CNS; blood
Trimethyl phosphite [121-45-9]	2 ppm	—	—	124.08	Irritation
2,4,6-Trinitrotoluene (TNT) [118-96-7]	0.1 mg/m^3	—	Skin; BEI_M	227.13	Irritation; liver; blood; eye
Triorthocresyl phosphate [78-30-8]	0.1 mg/m^3	—	Skin; A4; BEI_A	368.37	CNS; cholingeric
Triphenyl amine [603-34-9]	5 mg/m^3	—	—	245.33	Irritation
Triphenyl phosphate [115-86-6]	3 mg/m^3	—	A4	326.28	Irritation; dermatitis
Tungsten [7440-33-7], as W				183.85	
Metal and insoluble compounds	5 mg/m^3	10 mg/m^3	—	Varies	Irritation
Soluble compounds	1 mg/m^3	3 mg/m^3	—	Varies	CNS; irritation
Turpentine [8006-64-2] and selected monoterpenes [80-56-8; 127-91-3; 13466-78-9]	20 ppm	—	SEN; A4	136.00 Varies	Irritation; lung
Uranium (natural) [7440-61-1]				238.03	Kidney; blood; cancer
Soluble and insoluble compounds, as U	0.2 mg/m^3	0.6 mg/m^3	A1	Varies	
n-Valeraldehyde [110-62-3]	50 ppm	—	—	86.13	Irritation
‡ Vanadium pentoxide [1314-62-1](, as V_2O_5) (Dust or fume)	(0.05 mg/m^3 (R))	—	(A4); BEI	181.90	Irritation; lung
‡ (Vegetable oil mists (N))	(10 mg/m^3)	(—)	(—)	(—)	(Lung)
Vinyl acetate [108-05-4]	10 ppm	15 ppm	A3	86.09	Irritation
Vinyl bromide [593-60-2]	0.5 ppm	—	A2	106.96	Liver; CNS; cancer
Vinyl chloride [75-01-4]	1 ppm	—	A1	62.50	Cancer (liver)
4-Vinyl cyclohexene [100-40-3]	0.1 ppm	—	A3	108.18	Irritation; CNS; reproductive
Vinyl cyclohexene dioxide [106-87-6]	0.1 ppm	—	Skin; A3	140.18	Irritation; dermatitis; reproductive
Vinyl fluoride [75-02-5]	1 ppm	—	A2	46.05	Liver; cancer
Vinylidene chloride [75-35-4]	5 ppm	—	A4	96.95	CNS; liver; kidney

Substance [CAS No.]	2005 ADOPTED VALUES TWA	STEL	Notations	MW	TLV® Basis — Critical Effect(s)
Vinylidene fluoride [75-38-7]	500 ppm	—	A4	64.04	Liver
N-Vinyl-2-pyrrolidone [88-12-0]	0.05 ppm	—	A3	111.16	Liver; ototoxicity
Vinyl toluene [25013-15-4]	50 ppm	100 ppm	A4	118.18	Irritation
VM & P Naphtha [8032-32-4]	300 ppm	—	A3	114.00	Irritation; CNS
Warfarin [81-81-2]	0.1 mg/m^3	—	—	308.32	Blood; bleeding
* Wood dusts					
Western red cedar	0.5 mg/m^3 (I)	—	SEN; A4		Asthma
All other species	1 mg/m^3 (I)	—	—		Pulmonary function
Carcinogenicity					
Oak and beech	—	—	A1	NA	—
Birch, mahogany, teak, walnut	—	—	A2		—
All other wood dusts	—	—	A4		—
Xylene [1330-20-7] (o, m & p isomers) [95-47-6; 108-38-3; 106-42-3]	100 ppm	150 ppm	A4; BEI	106.16	Irritation
m-Xylene α,α'-diamine [1477-55-0]	—	C mg/m^3	Skin	136.20	Irritation; blood
Xylidine (mixed isomers) [1300-73-8]	0.5 ppm (I,V)	—	Skin; A3; BEI_M	121.18	Cancer; genotoxic
Yttrium [7440-65-5] and compounds, as Y	1 mg/m^3	—	—	88.91	Fibrosis
Zinc chloride [7646-85-7], Fume	1 mg/m^3	2 mg/m^3	—	136.29	Irritation; lung edema
Zinc chromates [13530-65-9; 11103-86-9; 37300-23-5], as Cr	0.01 mg/m^3	—	A1	Varies	Cancer (lung)
Zinc oxide [1314-13-2]	2 mg/m^3 (R)	10 mg/m^3 (R)	—	81.37	Metal fume fever
Zirconium [7440-67-7] and compounds, as Zr	5 mg/m^3	10 mg/m^3	A4	91.22	Lung

NOTICE OF INTENDED CHANGES for 2005

These substances, with their corresponding values and notations, comprise those for which 1) a limit is proposed for the first time, 2) a change in the Adopted value is proposed, 3) retention as an NIC is proposed, or 4) withdrawal of the *Documentation* and adopted TLV® is proposed. In each case, the proposals should be considered trial values during the period they are on the NIC. These proposals were ratified by the ACGIH® Board of Directors and will remain on the NIC for approximately one year following this ratification. If, during the year, the Committee neither finds nor receives any substantive data that changes its scientific opinion regarding an NIC TLV®, the Committee may then approve its recommendation to the ACGIH® Board of Directors for adoption. If the Committee finds or receives substantive data that change its scientific opinion regarding an NIC TLV®, the Committee may change its recommendation to the ACGIH® Board of Directors for the matter to be either retained on or withdrawn from the NIC.

Documentation is available for each of these substances and their proposed values.

This notice provides not only an opportunity for comment on these proposals, but it also solicits suggestions for substances to be considered for TLVs®, such as those found on the current list of "Chemical Substances and Other Issues Under Study." Comments or suggestions should be accompanied by substantiating evidence in the form of peer-reviewed literature and forwarded, preferably in electronic format, to The Science Group, ACGIH® (science@acgih.org). Please refer to the "ACGIH® TLV®/BEI® Development Process" that appears in the front section of this book for a detailed discussion covering this procedure and methods for input to ACGIH®.

	Notice of Intended Changes (for 2005)				
Substance [CAS No.]	**TWA**	**STEL**	**Notations**	**MW**	**TLV® Basis/Critical Effect(s)**
† Acetylene tetrabromide [79-27-6]	Withdraw *Documentation* and Adopted TLVs®; *see* NIC entry for 1,1,2,2-Tetrabromomethane				
† Alachlor [15972-60-8]]	1 mg/m³ (IV)	—	SEN; A2	269.8	Hemosiderosis (liver, spleen, kidneys); sensitization; cancer
Arsine [7784-42-1]	0.005 ppm	—	A4	77.95	Hemolysis
† Beryllium [7440-41-7] and compounds, as Be	0.00002 mg/m³ (I)	—	Skin; SEN; A1	9.01	Sensitization; chronic beryllium disease (beryllosis)
† Calcium carbonate [471-34-1]	1 mg/m³ (I)	—	—	100.09	Nasal symptoms
† Calcium sulfate [7778-18-9; 10034-76-1; 10101-41-4; 13397-24-5]	10 mg/m³ (I)	—		Varies	Nasal symptoms
† Carbon disulfide [75-10-0]	1 ppm	—	Skin; A4	76.14	Mervous system; cardiovascular; reproductive; ophthalmologic; renal effects
Copper [7440-50-8] and inorganic compounds, as Cu				Varies	Respiratory tract irritation; metal fume fever
Elemental/Metal and copper oxides	0.1 mg/m³ (I)		A4		
Soluble compounds	0.05 mg/m³ (R)	—	A4		
Copper [7440-48-4], Fume; Dusts and mists, as Cu	Withdraw *Documentation* and Adopted TLVs®; *see* NIC entry for Copper and inorganic compounds				
Dimethyl disulfide [624-92-0]	0.5 ppm	—	Skin	94.20	Irritation; CNS
† Fenamiphos [22224-92-6]	0.05 mg/m³ (IV)	—	Skin; A4; BEI_A	303.40	Cholinesterase inhibition
† Fenthion [55-38-9]	0.05 mg/m³ (IV)	—	Skin; A4; BEI_A	278.34	Cholinesterase inhibition
† Fonophos [944-22-9]	0.1 mg/m³ (IV)	—	Skin; A4; BEI_A	246.32	Cholinesterase inhibition
Hydrogen sulfide [7783-06-4]	1 ppm	5 ppm	—	34.08	Irritation
† Iron oxide [1309-37-1]	5 mg/m³ (R)	—	A4	159.70	Pulmonary siderosis
† Iron oxide (Fe2O3) [1309-37-1] dust & fume, as Fe	Withdraw *Documentation* and Adopted TLVs®; *see* NIC entry for Iron oxide				
† Magnesite [546-93-0]	Withdraw *Documentation* and Adopted TLV® due to insufficient data				

Substance [CAS No.]	Notice of Intended Changes (for 2005) TWA	STEL	Notations	MW	TLV® Basis/Critical Effect(s)
† 2-Methoxyethanol [EGME] [109-86-4]	0.1 ppm	—	Skin	76.09	Hematologic; reproductive
† 2-Methoxyethyl acetate [EGEMA] [110-49-6]	0.1 ppm	—	Skin	118.13	Hematologic; reproductive
Mineral oil	0.2 mg/m³ (I)	—	—	NA	Respiratory
Carcinogenicity					
Poorly and mildly refined			A2		
Highly refined			A4		
Monochloroacetic acid [79-11-8]	0.5 ppm	—	Skin; A4	94.5	Irritation
Oil mist, mineral	Withdraw *Documentation* and Adopted TLVs®; *see* NIC entry for Mineral oil				
† Perlite [93763-70-3]	Withdraw *Documentation* and Adopted TLV® due to insufficient data				
† Portland cement [65997-15-1]	1 mg/m³ (I)	5 mg/m³ (I)	A2	—	Pulmonary function; respiratory symptoms
† n-Propanol [71-23-8]	100 ppm	200 ppm	A3	60.09	Irritation
Propylene [115-07-1]	500 ppm	—	A4	42.08	Asphyxiant; irritation (nasal)
† Ronnel [299-84-3]	5 mg/m³ (IV)	—	A4; BEI_A	321.57	Cholinesterase inhibition
† Rouge	Withdraw Documentation and Adopted TLV®; *see* NIC entry for Iron oxide				
† Silica, Amorphouse — Diatomaceous earth (uncalcined) [61790-53-2]	Withdraw *Documentation* and Adopted TLV® due to insufficient data on single-substance exposure; most are co-exposur3e with crystalline silica				
Precipitated silica and silica gel [112926-00-8]	Withdraw *Documentation* and Adopted TLV® due to insufficient data				
Silica fume [69012-64-2]	Withdraw *Documentation* and Adopted TLV® due to insufficient data				
Silica fused [60676-86-0	Withdraw *Documentation* and Adopted TLV® due to insufficient data				
Silica, Crystalline — α-Quartz [14808-60-7] and Cristobalite [14464-46-1]	0.02 mg/m³ (R)	—	A2	60.09	Silicosis; fibrosis
Silica, Crystalline — Tripoli [1317-95-9]	Withdraw *Documentation* and Adopted TLV®; *see* NIC entry for Silica, Crystalline — α-Quartz and cristobalite				
† Silicon [[7440-21-3]	Withdraw *Documentation* and Adopted TLV® due to insufficient data				
† 1,1,2,2-Tetrabromoethane [79-27-6]	0.1 ppm (IV)	—	—	345.70	Hepatic; CNS; upper respiratory tract; lower respiratory tract (pulmonary edema)
† Tetrasodium pyrophosphate [7722-88-5]Silicon [[7440-21-3]	Withdraw *Documentation* and Adopted TLV® due to insufficient data				
† Vanadium pentoxide [1314-62-1]	0.01 mg/m³ (I)	—	A3	181.9	Respiratory tract irritation
† Vegetable oil mist (N)	Withdraw *Documentation* and Adopted TLV® due to insufficient data				
† APPENDIX F: Substances Whose *Documentation* and Adopted TLV® have been Withdrawn, see page 32					

APPENDIX F: Substances Whose Documentation and Adopted TLVs® Have Been Withdrawn

Substance [CAS #]	Year Withdrawn*	Reason
Borates, tetra, sodium salts	2005	Combined into "Borate compounds, Inorganic
Butane [106-97-8]	2004	Presently covered by Aliphatic hydrocarbon gases: alkane [C_1—C_4]
Ethane [74-85-1]	2004	Presently covered by Aliphatic hydrocarbon gases: alkane [C_1—C_4]
Liquefied petroleum gas (LPG) [68476-85-7]	2004	Presently covered by Aliphatic hydrocarbon gases: alkane [C_1—C_4]
Methane [74-82-8]	2004	Presently covered by Aliphatic hydrocarbon gases: alkane [C_1—C_4]
Propane [74-98-6]	2004	Presently covered by Aliphatic hydrocarbon gases: alkane [C_1—C_4]
Silica, Crystalline — Tridymite [15468-32-3]	2005	Insufficient data

*Substances listed in this Appendix will remain for a 5-year period.

DEFINITIONS AND NOTATIONS

Definitions

Documentation

The source publication that provides the critical evaluation of the pertinent scientific information and data with reference to literature sources upon which each TLV® or BEI® is based. See the discussion under "TLV®/BEI® Development Process: An Overview" found at the beginning of this book. The general outline used when preparing the *Documentation* may be found in the Operations Manual of the Threshold Limit Values for Chemical Substances (TLV®-CS) Committee, accessible online at: www.acgih.org/TLV/OPSmanual.pdf

Minimal Oxygen Content

An oxygen (O_2)-deficient atmosphere is defined as one with an ambient pO_2 less than 132 torr (NIOSH, 1980). The minimum requirement of 19.5% oxygen at sea level (148 torr O_2, dry air) provides an adequate amount of oxygen for most work assignments and includes a margin of safety (NIOSH, 1987; McManus, 1999). Studies of pulmonary physiology suggest that the above requirements provide an adequate level of oxygen pressure in the lungs (alveolar pO_2 of 60 torr) (Silverthorn, 2001; Guyton, 1991; NIOSH, 1976).

Some gases and vapors, when present in high concentrations in air, act primarily as simple asphyxiants, without other significant physiologic effects. A simple asphyxiant may not be assigned a TLV® because the limiting factor is the available oxygen. Atmospheres deficient in O_2 do not provide adequate warning and most simple asphyxiants are odorless. Account should be taken of this factor in limiting the concentration of the asphyxiant particularly at elevations greater than 5000 feet where the pO_2 of the atmosphere is less than 120 torr. Several simple asphyxiants present an explosion hazard. Consult the *Documentation* for further information on specific simple asphyxiants.

Notation

A notation is a designation that appears as a component of the TLV® in which specific information is listed in the column devoted to Notations.

Notice of Intended Change (NIC)

The NIC is a list of actions proposed by the TLV®-CS Committee for the coming year. This Notice provides an opportunity for public comment and solicits suggestions of substances to be added to the list. Values remain on the NIC for approximately one year after they have been ratified by the ACGIH® Board of Directors. The proposals should be considered trial values during the period they are on the NIC. If during the year, the Committee neither finds nor receives any substantive data that changes its scientific opinion regarding the NIC TLV®, the Committee may then approve its recommendation to the ACGIH® Board of Directors for adoption. If the Committee finds or receives substantive data that changes its scientific opinion regarding an NIC TLV®, the Committee may change its recommendation to the ACGIH® Board of Directors for the matter to be either retained on or withdrawn from the NIC. Values appearing in parentheses in the Adopted TLV® section are to be used during the period in which a proposed change for that value or notation appears on the NIC.

Particulate Matter/Particle Size

For solid and liquid particulate matter, TLVs® are expressed in terms of "total" particulate matter, except where the terms inhalable, thoracic, or respirable particulate mass are used. The intent of ACGIH® is to replace all "total" particulate TLVs® with inhalable, thoracic, or respirable particulate mass TLVs®. Side-by-side sampling using "total" and inhalable, thoracic, or respirable sampling techniques is encouraged to aid in the replacement of current "total" particulate TLVs®. See Appendix C: Particle Size-Selective Sampling Criteria for Airborne Particulate Matter, for the definitions of inhalable, thoracic, and respirable particulate mass.

Particles (insoluble or poorly soluble) Not Otherwise Specified (PNOS)

There are many insoluble particles of low toxicity for which no TLV® has been established. ACGIH® believes that even biologically inert, insoluble, or poorly soluble particles may have adverse effects and suggests that airborne concentrations should be kept below 3 mg/m^3, respirable particles, and 10 mg/m^3, inhalable particles, until such time as a TLV® is set for a particular substance. A description of the rationale for this recommendation and the criteria for substances to which it pertains are provided in Appendix B.

TLV® Basis/Critical Effects

The TLV® Basis/Critical Effect(s) for each TLV® is discussed in each *Documentation.* TLVs® are derived from publicly available information summarized in their respective *Documentations*. Although adherence to the TLV® may prevent several adverse health effects, it is not possible to list all of them in this book. The basis on which the

values are established will differ from agent to agent (e.g., 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). Health impairments considered include those that shorten life expectancy, adversely affect reproductive function or developmental processes, compromise organ or tissue function, or impair the capability for resisting other toxic substances or disease processes.

Each TLV® has a basis, representing the adverse effect(s) that appear at the lowest levels of exposure. Critical effects are indicated in the TLV® Basis/Critical Effects column in this book and are intended to provide a field reference for symptoms of overexposure and as a guide for determining whether components of a mixed exposure should be considered as acting independently or additively. Use of the TLV® Basis/Critical Effects column is not a substitute for reading the *Documentation*. Each *Documentation* is a critical component for proper use of the TLV(s)® and to understand the basis for the identified critical effects.

Notations

Biological Exposure Indices (BEIs®)

The notation "BEI" is listed in the "Notations" column when a BEI® (or BEIs®) is (are) also recommended for the substance. Two subcategories to the "BEI" notation have been added to help the user identify those substances that would use only the BEI® for Acetylcholinesterase Inhibiting Pesticides or Methemoglobin Inducers. They are as follows:

BEI_A = *See* the BEI® for Acetylcholinesterase Inhibiting Pesticide

BEI_M = *See* the BEI® for Methemoglobin Inducers

Biological monitoring should be instituted for such substances to evaluate the total exposure from all sources, including dermal, ingestion, or non-occupational. See the BEI® section in this book and the *Documentation* of the TLVs® and BEIs® for these substances.

Carcinogenicity

A carcinogen is an agent capable of inducing benign or malignant neoplasms. Evidence of carcinogenicity comes from epidemiology, toxicology, and mechanistic studies. Specific notations (i.e., A1, A2, A3, A4, and A5) are used by ACGIH® to define the categories for carcinogenicity and are listed in the Notations column. See Appendix A for these categories and definitions and their relevance to humans in occupational settings.

Sensitization

The designation "SEN" in the "Notations" column refers to the potential for an agent to produce sensitization, as confirmed by human or animal data. The SEN notation ***does not imply*** that sensitization is the critical effect on which the TLV® is based, nor does it imply that this effect is the sole basis for that agent's TLV®. If sensitization data exist, they are carefully considered when recommending the TLV® for the agent. For those TLVs® that are based upon sensitization, they are meant to protect workers from induction of this effect. These TLVs® are not intended to protect those workers who have already become sensitized.

In the workplace, respiratory, dermal, or conjunctival exposures to sensitizing agents may occur. Similarly, sensitizers may evoke respiratory, dermal, or conjunctival reactions. At this time, the notation does not distinguish between sensitization involving any of these organ systems. The absence of a SEN notation does not signify that the agent lacks the ability to produce sensitization but may reflect the paucity or inconclusiveness of scientific evidence.

Sensitization often occurs via an immunologic mechanism and is not to be confused with other conditions or terminology such as hyperreactivity, susceptibility, or sensitivity. Initially, there may be little or no response to a sensitizing agent. However, after a person is sensitized, subsequent exposure may cause intense responses, even at low exposure concentrations (well below the TLV®). These reactions may be life threatening and may have an immediate or delayed onset. Workers who have become sensitized to a particular agent may also exhibit cross-reactivity to other agents that have similar chemical structures. A reduction in exposure to the sensitizer and its structural analogs generally reduces the incidence of allergic reactions among sensitized individuals. For some sensitized individuals complete avoidance of exposure to the sensitizer and structural analogs provides the only means to prevent the specific immune response.

Agents that are potent sensitizers present special problems in the workplace. Respiratory, dermal, and conjunctival exposures should be significantly reduced or eliminated through process control measures and personal protective equipment. Education and training (e.g., review of potential health effects, safe handling procedures, emergency information) are also necessary for those who work with known sensitizing agents.

For additional information regarding the sensitization potential of a particular agent, refer to the TLV® *Documentation* for the specific agent.

Skin

The designation "Skin" in the "Notations" column refers to the potential significant contribu-

tion to the overall exposure by the cutaneous route, including mucous membranes and the eyes by contact with vapors, liquids, and solids. Where dermal application studies have shown absorption that could cause systemic effects following exposure, a Skin notation would be considered. The Skin notation also alerts the industrial hygienist that overexposure may occur following dermal contact, even when exposures are at or below the TLV®.

Vehicles present in solutions or mixtures can also significantly enhance potential skin absorption. While some materials are capable of causing irritation, dermatitis, and sensitization in workers, these properties are not considered relevant when assigning a Skin notation. However, the development of a dermatologic condition could significantly affect the potential for dermal absorption.

While relatively limited quantitative data currently exist with regard to skin absorption of gases, vapors, and liquids by workers, ACGIH® recommends that the integration of data from acute dermal studies and repeated-dose dermal studies in animals and humans, along with the ability of the chemical to be absorbed, be used in deciding on the appropriateness of the Skin notation. In general, available data which suggest that the potential for absorption via the hands and forearms during the workday could be significant, especially for chemicals with lower TLVs®, could justify a Skin notation. From acute animal toxicity data, materials having a relatively low dermal LD_{50} (i.e., 1000 mg/kg of body weight or less) would be given a Skin notation. When chemicals penetrate the skin easily (i.e., higher octanol–water partition coefficients) and where extrapolations of systemic effects from other routes of exposure suggest dermal absorption may be important in the expressed toxicity, a Skin notation would be considered. A Skin notation is not applied to chemicals that cause irritation or corrosive effects in the absence of systemic toxicity.

Substances having a Skin notation and a low TLV® may present special problems for operations involving high airborne concentrations of the material, particularly under conditions where significant areas of the skin are exposed for a long period. Under these conditions, special precautions to significantly reduce or preclude skin contact may be required.

Biological monitoring should be considered to determine the relative contribution to the total dose from exposure via the dermal route. ACGIH® recommends a number of adopted Biological Exposure Indices (BEIs®) which provide an additional tool when assessing the total worker exposure to selected materials. For additional information, refer to *Dermal Absorption* in the "Introduction to the Biological Exposure Indices," Documentation of the Biological Exposure Indices (2001), and to Leung and Paustenbach (1994). Other selected readings on skin absorption and the skin notation include Sartorelli (2000), Schneider et al. (2000), Wester and Maibach (2000), Kennedy et al. (1993), Fiserova-Bergerova et al. (1990), and Scansetti et al. (1988).

The use of a Skin notation is intended to alert the reader that air sampling alone is insufficient to quantify exposure accurately and that measures to prevent significant cutaneous absorption may be required.

References and Selected Reading

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CHEMICAL SUBSTANCES AND OTHER ISSUES UNDER STUDY

The TLV® Chemical Substances Committee solicits infor-mation, especially data, which may assist in its deliberations regarding the following substances and issues. Comments and suggestions, accompanied by substantiating evidence in the form of peer-reviewed literature, should be forwarded, preferably in electronic format, to The Science Group, ACGIH® at science@acgih.org. In addition, the Committee solicits recom-mendations for additional substances and issues of concern to the industrial hygiene and occupational health communities. Please refer to the "ACGIH® TLV®/BEI® Development Process" found on the ACGIH® website for a detailed discussion covering this procedure and methods for input to ACGIH® (http://www.acgih.org/TLV/DevProcess.htm).

The substances and issues listed below are as of January 1, 2004. *After this date, please refer to the ACGIH® website for the up-to-date list.* (http://www.acgih.org/TLV/Studies.htm)

Chemical Substances

Acetaldehyde
Aldrin
Aluminum and compounds
Aluminum oxide
α-Amylase
Atrazine (and related symmetrical triazines)
Benomyl
Benz[a]anthracene
Boron tribromide
Bromochloromethane
Bromodichloromethane
Bromoform
Butene, All isomers (e.g., 1-butene, 2-butene-cis, 2-butene-trans, isobutene)
sec-Butyl acetate
Calcium silicate
Carbaryl
Carbon black
Chrysene
Copper phthalocyanine
Cotton dust, raw
Cresol
2,4-D
Dieldrin
Diesel exhaust
Diesel fuel (individual TLVs® for vapor and aerosol)
Diethanolamine
1,4-Diethyl benzene
Diethylene glycol monobutyl ether
Diethylhydroxyamine [DEHA]
Diglycidyl ether [DGE]
N,N-Dimethylacetamide
Dimethyl carbamoyl chloride
Dimethylformamide
Dimethyl phthalate
3,5-Dinito-o-toluamide [Dinitolmide]
Emery
Endosulfan
Ethanol [Ethyl alcohol]
2-Ethoxyethanol [EGEE]
2-Ethoxyethyl acetate [EGEEA]
Ethyl amyl ketone [5-Methyl-3-heptanone]
Ethyl benzene
Ethyl cyanoacrylate
Ethylenimine
Ethyl formate
Ferbam
Gasoline, all formulations
Hafnium and compounds
Hexafluoropropylene
Hexamethyl diisocyanate
Hydroquinone
Indene
Iodine
Isophorone diisocyanate
Lead arsenate
Maleic anhydride
Manganese and inorganic compounds
Metal working fluids
Methanol
Methomyl
Methylacrylonitrile
Methyl n-amyl ketone [2-Heptanone]
Methyl demeton
Methylene bis(4-cyclohexylisocyanate)
Methylene bisphenyl isocyanate [MDI]
Methyl ethyl ketone [2-Butanone]
5-Methyl-3-heptanone
Methyl isoamyl ketone
Methyl isobutyl ketone
1-Methylnaphthalene
2-Methylnaphthalene
Methyl parathion
Methyl propyl ketone [2-Pentanone]
α-Methyl styrene
Mineral spirits [part of GGV]
Nickel carbonyl
Nitrogen trifluoride
5-Nitro-ortho-toluidine
Nonane [part of GGV]
Paraquat
Pentachlorophenol
Petroleum solvents [part of GGV]
Phthalic anhydride
Polycyclic aromatic hydrocarbons [PAHs]
Polymeric MDI
Polyvinyl chloride (PVC) dust
Propylenimine

Rosin core solder thermal decomposition products (colophony)
Selenium and compounds
Simazine
Soapstone
Subtilisins
Sulfur dioxide
Sulfur hexafluoride
Sulfur pentafluoride
Sulfur tetrafluoride
Sulprofos
Talc
Tantalum and tantalum oxide
1,1,1,2-Tetrachloro-2,2-difluoroethane
1,1,2,2-Tetrachloro-1,2-difluoroethane
Tetraethyl pyrophosphate [TEPP]
Thallium and soluble compounds
Thiram
Titanium dioxide
Toluene [Toluol]
Toluene-2,4- and 2,6-diisocyanate [TDI]
Trichloroacetic acid
Trichloroethylene
1,2,3-Trichloropropane
Triethanolamine
Trimellitic anhydride
Tungsten and compounds
VM&P naphtha
Wood dusts

Other Issues

2. Group Guidance Values (GGV) for highly refined petroleum solvents (C_5–C_{15} hydrocarbons) [formerly Reciprocal Calculation Procedures (RCP)].

CHEMICAL SUBSTANCES TLV®
ADOPTED APPENDICES

APPENDIX A: Carcinogenicity

ACGIH® has been aware of the increasing public concern over chemicals or industrial processes that cause or contribute to increased risk of cancer in workers. More sophisticated methods of bioassay, as well as the use of sophisticated mathematical models that extrapolate the levels of risk among workers, have led to differing interpretations as to which chemicals or processes should be categorized as human carcinogens and what the maximum exposure levels should be. The goal of the ACGIH has been to synthesize the available information in a manner that will be useful to practicing occupational hygienists, without overburdening them with needless details. The notations for carcinogenicity are:

A1 — Confirmed Human Carcinogen

The agent is carcinogenic to humans based on the weight of evidence from epidemiologic studies.

A2 — Suspected Human Carcinogen

Human data are accepted as adequate in quality but are conflicting or insufficient to classify the agent as a confirmed human carcinogen; OR, the agent is carcinogenic in experimental animals at dose(s), by route(s) of exposure, at site(s), of histologic types(s), or by mechanism(s) considered relevant to worker exposure. The A2 notation is used primarily when there is limited evidence of carcinogenicity in humans and sufficient evidence of carcinogenicity in experimental animals with relevance to humans.

A3 — Confirmed Animal Carcinogen with Unknown Relevance to Humans

The agent is carcinogenic in experimental animals at a relatively high dose, by route(s) of administration, at site(s), of histologic types(s), or by mechanism(s) that may not be relevant to worker exposure. Available epidemiologic studies do not confirm an increased risk of cancer in exposed humans. Available evidence does not suggest that the agent is likely to cause cancer in humans except under uncommon or unlikely routes or levels of exposure.

A4 — Not Classifiable as a Human Carcinogen

Agents that cause concern that they could be carcinogenic for humans but which cannot be assessed conclusively because of a lack of data. In vitro or animal studies do not provide indications of carcinogenicity that are sufficient to classify the agent with one of the other notations.

A5 — Not Suspected as a Human Carcinogen

The agent is not suspected to be a human carcinogen on the basis of properly conducted epidemiologic studies in humans. These studies have sufficiently long follow-up, reliable exposure histories, sufficiently high dose, and adequate statistical power to conclude that exposure to the agent does not convey a significant risk of cancer to humans; OR, the evidence suggesting a lack of carcinogenicity in experimental animals is supported by mechanistic data.

Substances for which no human or experimental animal carcinogenic data have been reported are assigned no carcinogenicity notation.

Exposures to carcinogens must be kept to a minimum. Workers exposed to A1 carcinogens without a TLV® should be properly equipped to eliminate to the fullest extent possible all exposure to the carcinogen. For A1 carcinogens with a TLV and for A2 and A3 carcinogens, worker exposure by all routes should be carefully controlled to levels as low as possible below the TLV. Refer to the "Guidelines for the Classification of Occupational Carcinogenicity" in the “Introduction” to the *Documentation of the Chemical Substances TLVs* for a more complete description and derivation of these designations.

APPENDIX B: Particles (insoluble or poorly soluble) Not Otherwise Specified [PNOS]

It is the goal of the TLV® Committee to recommend TLVs® for all substances for which there is evidence of health effects at airborne concentrations encountered in the workplace. When a sufficient body of evidence exists for a particular substance, a TLV® is established. Thus, by definition the substances covered by this recommendation are those for which little data exist. The recommendation at the end of this appendix is supplied as a guideline rather than a TLV® because it is not possible to meet the standard level of evidence used to assign a TLV®. In addition, the PNOS TLV® and its predecessors have been misused in the past and applied to any unlisted particles rather than those meeting the criteria listed below. The recommendations in this appendix apply to particles that:

- Do not have an applicable TLV®;
- Are insoluble or poorly soluble in water (or, preferably, in aqueous lung fluid if data are available); and
- Have low toxicity (i.e., are not cytotoxic, genotoxic, or otherwise chemically reactive with lung tissue, and do not emit ionizing radiation, cause immune sensitization, or cause toxic effects other than by inflammation or the mechanism of "lung overload").

ACGIH® believes that even biologically inert, insoluble, or poorly soluble particles may have adverse effects and recommends that airborne concentrations should be kept below 3 mg/m^3, respirable particles, and 10 mg/m^3, inhalable particles, until such time as a TLV® is set for a particular substance.

APPENDIX C: 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 the 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. ACGIH has been reexamining 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) are expressed in three forms:

1. *Inhalable Particulate Mass* TLVs (IPM–TLVs) for those materials that are hazardous when deposited anywhere in the respiratory tract.
2. *Thoracic Particulate Mass* TLVs (TPM–TLVs) for those materials that are hazardous when deposited anywhere within the lung airways and the gas-exchange region.
3. *Respirable Particulate Mass* TLVs (RPM–TLVs) for those materials that are hazardous when deposited in the gas-exchange region.

The three particulate mass fractions described above are defined in quantitative terms in accordance with the following equations:[1–2]

A. IPM consists of those particles that are captured according to the following collection efficiency regardless of sampler orientation with respect to wind direction:

$$IPM(d_{ae}) = 0.5[1 + \exp(-0.06\, d_{ae})]$$

$$\text{for } 0 < d_{ae} \leq 100\ \mu m$$

where: $IPM(d_{ae})$ = the collection efficiency

d_{ae} = aerodynamic diameter of particle in μm

B. TPM consists of those particles that are captured according to the following collection efficiency:

$$TPM(d_{ae}) = IPM(d_{ae})\,[1 - F(x)]$$

where: $F(x)$ = cumulative probability function of the standardized normal variable, x

$$x = \frac{\ln(d_{ae}/\Gamma)}{\ln(\Sigma)}$$

ln = natural logarithm

$\Gamma = 11.64$

$\Sigma = 1.5$

C. RPM consists of those particles that are captured according to the following collection efficiency:

$$RPM(d_{ae}) = IPM(d_{ae})\,[1 - F(x)]$$

where: $F(x)$ = same as above, but with

$\Gamma = 4.25$ μm and

$\Sigma = 1.5$.

The most significant difference from previous definitions is the increase in the median cut point for a respirable particulate matter sampler from 3.5 μm to 4.0 μm; this is in accord with the International Organization for Standardization/ European Standardization Committee (ISO/CEN) protocol.[4,5] No change is recommended for the measurement of respirable particulates using a 10-mm nylon cyclone at a flow rate of 1.7 liters per minute. Two analyses of available data indicated that the flow rate of 1.7 liters per minute allowed the 10-mm nylon cyclone to approximate the particulate matter concentration that would be measured by an ideal respirable particulate sampler as defined herein.[6,7]

Collection efficiencies representative of several sizes of particles in each of the respective mass fractions are shown in Tables 1, 2, and 3 below. Documentation for the respective algorithms representative of the three mass fractions, is found in the literature.[2–4]

References

1. American Conference of Governmental Industrial Hygienists: Particle Size-Selective Sampling in the Workplace. ACGIH, Cincinnati, OH (1985).
2. American Conference of Governmental Industrial Hygienists: Particulate air Contaminants. J.H. Vincent, Ed. ACGIH, Cincinnati, OH (1999).
3. Soderholm, S.C.: Proposed International Conventions for Particle Size-Selective Sampling. Ann. Occup. Hyg. 33:301–320 (1989).
4. International Organization for Standardization (ISO): Air Quality — Particle Size Fraction Definitions for Health-

TABLE 1. Inhalable

Particle Aerodynamic Diameter (μm)	Inhalable Particulate Mass [IPM] (%)
0	100
1	97
2	94
5	87
10	77
20	65
30	58
40	54.5
50	52.5
100	50

TABLE 2. Thoracic

Particle Aerodynamic Diameter (μm)	Thoracic Particulate Mass [TAPM] (%)
0	100
2	94
4	89
6	80.5
8	67
10	50
12	35
14	23
16	15
18	9.5
20	6
25	2

TABLE 3. Respirable

Particle Aerodynamic Diameter (μm)	Respirable Particulate Mass [RPM] (%)
0	100
1	97
2	91
3	74
4	50
5	30
6	17
7	9
8	5
10	1

Related Sampling. Approved for publication as CD Fraction Definitions for Measurement of Airborne 7708. ISO, Geneva (1991).
5. European Standardization Committee (CEN): Size Particles in the Workplace.Publication prEN 481. CEN, Brussels (1992).
6. Bartley, D.L.: Letter to ACGIH, July 9, 1991.
7. Lidén, G.; Kenny, L.C.: Optimization of the Performance of Existing Respirable Dust Samplers. Appl. Occup. Environ. Hyg. 8(4): 386– 391 (1993).

APPENDIX D: Commercially Important Tree Species Suspected of Inducing Sensitization

Common	Latin
SOFTWOODS	
California redwood	*Sequoia sempervirens*
Eastern white cedar	*Thuja occidentalis*
Pine	*Pinus*
Western red cedar	*Thuja plicata*
HARDWOODS	
Ash	*Fraxinus americana*
Aspen/Poplar/Cottonwood	*Populus*
Beech	*Fagus*
Oak	*Quercus*
TROPICAL WOODS	
Abirucana	*Pouteria*
African zebra	*Microberlinia*
Antiaris	*Antiaris africana, Antiaris toxicara*
Cabreuva	*Myrocarpus fastigiatus*
Cedar of Lebanon	*Cedra libani*
Central American walnut	*Juglans olanchana*
Cocabolla	*Dalbergia retusa*
Arican ebony	*Diospryos crassiflora*
Fernam bouc	*Caesalpinia*
Honduras rosewood	*Dalbergia stevensonii*
Iroko or kambala	*Chlorophora excelsa*
Kejaat	*Pterocarpus angolensis*
Kotibe	*Nesorgordonia papaverifera*
Limba	*Terminalia superba*
Mahogany (African)	*Khaya spp.*
Makore	*Tieghemella heckelii*
Mansonia/Beté	*Mansonia altissima*
Nara	*Pterocarpus indicus*
Obeche/African maple/Samba	*Triplochiton scleroxylon*
Okume	*Aucoumea klaineana*
Palisander/Brazilian rosewood/Tulip wood/Jakaranda	*Dalbergia nigra*
Pau marfim	*Balfourodendron riedelianum*
Ramin	*Gonystylus bancanus*
Soapbark dust	*Quillaja saponaria*
Spindle tree wood	*Euonymus europaeus*
Tanganyike aningre	

APPENDIX E: Threshold Limit Values for Mixtures

Most threshold limit values are developed for a single chemical substance. However, the work environment is often composed of multiple chemical exposures both simultaneously and sequentially. It is recommended that multiple exposures that comprise such work environments be examined to assure that workers do not experience harmful effects.

There are several possible modes of chemical mixture interaction. Additivity occurs when the combined biological effect of the components is equal to the sum of each of the agents given alone. Synergy occurs where the combined effect is greater than the sum of each agent. Antagonism occurs when the combined effect is less.

The general ACGIH® mixture formula applies to the additive model. It is utilized when additional protection is needed to account for this combined effect.

The guidance contained in this Appendix does not apply to substances in mixed phases.

Application of the Additive Mixture Formula

The "TLV® Basis" column found in the table of Adopted Values provides both the target organ or system and effect on which the TLV® was based. This column can alert the reader to the additivity possibilities in a chemical mixture and the need to reduce the combined TLV® of the individual components. Note that the "Critical Effects" column does not list all of the important deleterious effects of the agent, but rather, only those that were determined to be the most sensitive and on which the threshold limit was based. The current *Documentation of the TLVs® and BEIs®* should be consulted for additional toxic effects, which should be considered in mixture exposures.

When two or more hazardous substances have a similar toxicological effect on the same target organ or system, their combined effect, rather than that of either individually, should be given primary consideration. In the absence of information to the contrary, different substances should be considered as additive where the health effect and target organ or system are the same.

That is, if the sum of

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

exceeds unity, the threshold limit of the mixture should be considered as being exceeded (where C_1 indicates the observed atmospheric concentration and T_1 is the corresponding threshold limit; see example). It is essential that the atmosphere is analyzed both qualitatively and quantitatively for each component present in order to evaluate the threshold limit of the mixture.

The additive formula applies to simultaneous exposure for hazardous agents with TWA, STEL, and Ceiling values. The threshold limit value time interval base (TWA, STEL, and Ceiling) should be consistent where possible. When agents with the same toxicological effect do not have a corresponding TLV® type, use of mixed threshold limit value types may be warranted. Table 1 lists possible combinations of threshold limits for the additive mixture formula. Multiple calculations may be necessary.

Where a substance with a STEL or Ceiling limit is mixed with a substance with a TLV–TWA but no STEL, comparison of the short-term limit with the applicable excursion limit may be appropriate. Excursion limits are defined as a value five times the TLV-TWA limit. The amended formula would be:

$$\frac{C_1}{T_{1STEL}}+\frac{C_2}{(T_2)(5)}\le 1$$

where: T_{1STEL} = the TLV–STEL
T_2 = the TLV–TWA of the agent with no STEL.

The additive model also applies to consecutive exposures of agents that occur during a single work shift. Those substances that have TLV–TWAs (and STELs or excursion limits) should generally be handled the same as if they were the same substance, including attention to the recovery periods for STELs and excursion limits as indicated in the "Introduction to Chemical Agents." The formula does not apply to consecutive exposures of TLV–Ceilings.

Limitations and Special Cases

Exceptions to the above rule may be made

TABLE 1. Possible Combinations of Threshold Limits When Applying the Additive Mixture Formula

Full Shift or Short Term	Agent A	Agent B
Full shift	TLV–TWA	TLV–TWA
Full shift	TLV–TWA	TLV–Ceiling
Short term	TLV–STEL	TLV–STEL
Short term	TLV–Ceiling	TLV–Ceiling
Short term	Excursion limits where there is no STEL (5 times TLV–TWA value)	TLV–Ceiling or TLV–STEL
Short term	TLV–STEL	TLV–Ceiling

when there is a good reason to believe that the chief effects of the different harmful agents are not additive. This can occur when neither the toxicological effect is similar nor the target organ is the same for the components. This can also occur when the mixture interaction causes inhibition of the toxic effect. 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.

Another exception occurs when mixtures are suspected to have a synergistic effect. The use of the general additive formula may not provide sufficient protection. Such cases at present must be determined individually. Potentiating effects of exposure to such agents by routes other than that of inhalation are also possible. Potentiation is characteristically exhibited at high concentrations, less probably at low. For situations involving synergistic effects, it may be possible to use a modified additive formula that provides additional protection by incorporating a synergy factor. Such treatment of the TLVs® should be used with caution, as the quantitative information concerning synergistic effects is sparse.

Care must be considered for mixtures containing carcinogens in categories A1, A2, or A3. Regardless of application of the mixture formula, exposure to mixtures containing carcinogens should be avoided or maintained as low as possible. See Appendix A.

The additive formula applies to mixtures with a reasonable number of agents. It is not applicable to complex mixtures with many components (e.g., gasoline, diesel exhaust, thermal decomposition products, fly ash, etc.).

TABLE 2. Example Results

Agent	Full-Shift Results *(TLV–TWA)*	Short-Term Results *(TLV–STEL)*
1) Acetone	160 ppm *(500 ppm)*	490 ppm *(750 ppm)*
2) sec-Butyl acetate	20 ppm *(200 ppm)*	150 ppm (N/A)
3) Methyl ethyl ketone	90 ppm *(200 ppm)*	220 ppm *(300 ppm)*

Example

A worker's airborne exposure to solvents was monitored for a full shift as well as one short-term exposure. The results are presented in Table 2.

According to the *Documentation of the TLVs® and BEIs®*, all three substances indicate irritation effects on the respiratory system and thus would be considered additive. Acetone and methyl ethyl ketone exhibit central nervous system effects.

Full-shift analysis would utilize the formula:

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

thus, $$\frac{160}{500} + \frac{20}{200} + \frac{90}{200} = 0.32 + 0.10 + 0.45 = 0.87$$

The full-shift mixture limit is not exceeded.

Short-term analysis would utilize the formula:

$$\frac{C_1}{T_{1STEL}} + \frac{C_2}{(T_2)(5)} + \frac{C_3}{T_{3STEL}} \leq 1$$

thus, $$\frac{490}{750} + \frac{150}{1000} + \frac{220}{300} = 0.65 + 0.15 + 0.73 = 1.53$$

The short-term mixture limit is exceeded.

2005

Biological Exposure Indices

Adopted by ACGIH©
with Intended Changes

Contents

INTRODUCTION TO THE BIOLOGICAL EXPOSURE INDICES

Biological monitoring provides one of the means to assess the exposure and health risk to workers. It entails the measurement of the concentration of a chemical determinant in the biological media of those exposed and is an indicator of the uptake of a substance. Biological Exposure Indices (BEIs®) are guidance values for assessing biological monitoring results. BEIs® represent the levels of determinants which are most likely to be observed in specimens collected from healthy workers who have been exposed to chemicals to the same extent as workers with inhalation exposure at the Threshold Limit Value (TLV®). The exceptions are the BEIs® for chemicals for which the TLVs® are based on protection against nonsystemic effects (e.g., irritation or respiratory impairment) where biological monitoring is desirable because of the potential for significant absorption via an additional route of entry (usually the skin). Biological monitoring indirectly reflects the dose to a worker from exposure to the chemical of interest. The BEI® generally indicates a concentration below which nearly all workers should not experience adverse health effects. The BEI® determinant can be the chemical itself; one or more metabolite; or a characteristic, reversible biochemical change induced by the chemical. In most cases, the specimen used for biological monitoring is urine, blood, or exhaled air. The BEIs® are not intended for use as a measure of adverse effects or for diagnosis of occupational illness.

Biological monitoring can assist the occupational health professional detect and determine the absorption via the skin or gastrointestinal system, in addition to that by inhalation; assess body burden; reconstruct past exposure in the absence of other exposure measurements; detect nonoccupational exposure among workers; test the efficacy of personal protective equipment and engineering controls; and monitor work practices.

Biological monitoring serves as a complement to exposure assessment by air sampling. The existence of a BEI® does not indicate a need to conduct biological monitoring. Conducting, designing, and interpreting biological monitoring protocols and the application of the BEI® requires professional experience in occupational health and reference to the current edition of the *Documentation of the Threshold Limit Values and Biological Exposure Indicies* (ACGIH®).

DOCUMENTATION

BEIs® are developed by Committee consensus through an analysis and evaluation process. The detailed scientific criteria and justification for each BEI® can be found in the Documentation of the Threshold Limit Values and Biological Exposure Indices. The principal material evaluated by the BEI® Committee includes peer-reviewed, published data taken from the workplace (i.e., field studies), data from controlled exposure studies, and from appropriate pharmacokinetic modeling when available. The results of animal research are also considered when relevant. The Documentation provides essential background information and the scientific reasoning used in establishing each BEI®. Other information given includes the analytical methods, possible potential for confounding exposures, specimen collection recommendations, limitations, and other pertinent information.

In recommending a BEI®, ACGIH® considers whether published data are of reason-able quality and quantity and may also consider unpublished data if verified. There are numerous instances when analytical techniques are available for the measurement of a biological determinant, but published information is unavailable or unsuitable for determining a BEI®. In those instances, occupational health professionals are encouraged to accumulate and report biological monitoring data together with exposure and health data.

Relationship of BEIs® to TLVs®

BEI® determinants are an index of an individual's "uptake" of a chemical(s). Air monitoring to determine the TLV indicates the potential inhalation "exposure" of an individual or group. The up-take within a workgroup may be different for each individual for a variety of reasons, some of which are indicated below. Most BEIs® are based on a direct correlation with the TLV (i.e., the concentration of the determinant which can be expected when the airborne concentration is at the TLV®). Some of the BEIs® (e.g., lead) are not derived from the TLV® but directly relate to the development of an adverse health effect. The basis of each BEI is provided in the Documentation.

Inconsistencies may be observed between the information obtained from air monitoring and biological monitoring for a variety of reasons, including, but not limited to, work-related and methodological factors. Examples are listed below:

Physiological makeup and health status of the worker, such as body build, diet (water and fat intake), metabolism, body fluid composition, age, gender, pregnancy, medication, and disease state.

Occupational exposure factors, such as the work-rate intensity and duration, skin expo-sure, temperature and humidity, co-exposure to other chemicals, and other work habits.

Nonoccupational exposure factors, such as community and home air pollutants, water and food components, personal hygiene, smoking, alcohol and drug intake, exposure to house-hold products, or exposure to chemicals from hobbies or from another workplace.

Methodological factors, such as specimen contamination or deterioration during collection and storage and bias of the selected analytical method.

Location of the air monitoring device in relation to the worker's breathing zone.

Particle size distribution and bioavailability.

Variable effectiveness of personal protective devices.

Specimen Collection

Because the concentration of some determinants can change rapidly, the specimen collection time (sampling time) is very important and must be observed and recorded carefully. The sampling time is specified in the BEI and is determined by the duration of retention of the determinant. Substances and determinants which accumulate may not require a specific sampling time. An explanation of the BEI sampling time is as follows:

Sampling Time	Recommended Collection
1. Prior to shift	16 hours after exposure ceases
2. During shift	Anytime after 2 hours of exposure
3. End of shift	As soon as possible after exposure ceases
4. End of the	After four or five consecutive workweek working days with exposure
5. Discretionary	At any time

Urine Specimen Acceptability

Urine specimens that are highly dilute or highly concentrated are generally not suitable for monitoring. The World Health Organization has adopted guidelines for acceptable limits on urine specimens as follows:

Creatinine concentration: > 0.3 g/L and < 3.0 g/L

or

Specific gravity: > 1.010 and < 1.030

Specimens falling outside either of these ranges should be discarded, and another specimen should be collected. Workers who provide consistently unacceptable urine specimens should be referred for medical evaluation.

Some BEIs® for determinants whose concentration is dependent on urine output are expressed relative to creatinine concentration. For other determinants such as those excreted by diffusion, correction for urine output is not appropriate. In general, the best correction method is chemical-specific, but research data sufficient to identify the best method may not be available. When the field data are only available as adjusted for creatinine, the BEI® will continue to be expressed relative to creatinine; in other circumstances, no correction is recommended, and the BEI® will be expressed as concentration in urine.

Quality Assurance

Each aspect of biological monitoring should be conducted within an effective quality assurance (QA) program. The appropriate specimen must be collected, at the proper time, without contamination or loss, and with use of a suitable container. Donor identification, time of exposure, source of Exposure, and the sampling time must be recorded. The analytical method used by the laboratory must have the accuracy, sensitivity, and specificity needed to produce results consistent with the BEI®. Appropriate quality-control specimens should be included in the analysis, and the laboratory must follow routine quality control rules. The laboratory should participate in an external proficiency program.

Notations

"B" = background

The determinant may be present in biological specimens collected from subjects who have not been occupationally exposed, at a concentration which could affect interpretation of the result. Such background concentrations are incorporated in the BEI® value.

"Nq" = nonquantitative

Biological monitoring should be considered for this compound based on the review; however, a specific BEI® could not be determined due to insufficient data.

"Ns" = nonspecific

The determinant is nonspecific, since it is also observed after exposure to other chemicals.

"Sq" = semi-quantitative

The biological determinant is an indicator of exposure to the chemical, but the quantitative interpretation of the measurement is ambiguous. These determinants should be used as a screening test if a quantitative test is not practical or as a

confirmatory test if the quantitative test is not specific and the origin of the determinant is in question.

Note:

It is essential to consult the specific BEI® Documentation before designing biological monitoring protocols and interpreting BEIs®.

Application of BEIs®

BEIs® are intended as guidelines to be used in the evaluation of potential health hazards in the practice of occupational hygiene. BEIs® do not indicate a sharp distinction between hazardous and nonhazardous exposures. For example, it is possible for an individual's determinant concentration to exceed the BEI® without incurring an increased health risk. If measurements in specimens obtained from a worker on different occasions persistently exceed the BEI®, the cause of the excessive value should be investigated and action taken to reduce the exposure. An investigation is also warranted if the majority of the measurements in specimens obtained from a group of workers at the same workplace and workshift exceed the BEI®. It is desirable that relevant information on related operations in the workplace be recorded.

Due to the variable nature of concentrations in biological specimens, dependence should not be placed on the results of one single specimen. Administrative action should not be normally based on a single isolated measurement, but on measurements of multiple sampling, or an analysis of a repeat specimen. It may be appropriate to remove the worker from exposure following a single high result if there is reason to believe that significant exposure may have occurred. Conversely, observations below the BEI® do not necessarily indicate a lack of health risk.

BEIs® apply to 8-hour exposures, 5 days per week. Although modified work schedules are sometimes used in various occupations, the BEI® Committee does not recommend that any adjustment or correction factor be applied to the BEIs® (i.e., the BEIs® should be used as listed, regardless of the work schedule).

Use of the BEI® should be applied by a knowledgeable occupational health professional. Toxicokinetic and toxicodynamic information is taken into account when establishing the BEI®; thus, some knowledge of the metabolism, distribution, accumulation, excretion, and effect(s) is helpful in using the BEI® effectively. The BEI® is a guideline for the control of potential health hazards to the worker and should not be used for other purposes. The values are inappropriate to use for the general population or for nonoccupational exposures. The BEI® values are neither rigid lines between safe and dangerous concentrations nor are they an index of toxicity.

ADOPTED BIOLOGICAL EXPOSURE DETERMINANTS

2004 ADOPTED BEIs

CHEMICAL [CAS #] ***Determinant***	***Sampling Time***	***BEI®***	***Notation***
ACETONE [67-64-1]			
Acetone in urine	End of shift	50 mg/L	Ns
ACETYLCHOLINESTERASE INHIBITING PESTICIDES			
Cholinesterase activity in red blood cells	Discretionary	40% of individual's baseline	Ns, B, Sq
ANILINE [62-53-3]			
Aniline♥ in urine	End of shift	—	Nq
Aniline released from hemoglobin in blood	End of shift	—	Nq
p-Aminophenol♥ in urine	End of shift	50 mg/L	Ns, Sq, B
♥With hydrolysis			
ARSENIC, ELEMENTAL [7440-38-2] AND SOLUBLE INORGANIC COMPOUNDS			
Inorganic arsenic plus methylated metabolites in urine	End of workweek	35 μg As/L	B
BENZENE [71-43-2]			
S-Phenylmercapturic acid in urine	End of shift	25 μg/g creatinine	B
	End of shift	500 μg/g creatinine	B
CADMIUM AND INORGANIC COMPOUNDS			
Cadmium in urine	Not critical	5 μg/g creatinine	B
Cadmium in blood	Not critical	5 μg/L	B
CARBON DISULFIDE [75-15-0]			
2-Thiothiazolidine-4-carboxylic acid (TTCA) in urine	End of shift	5 mg/g creatinine	
CARBON MONOXIDE [630-08-0]			
Carboxyhemoglobin in blood	End of shift	3.5% of hemoglobin	B, Ns
Carbon monoxide in end-exhaled air	End of shift	20 ppm	B, Ns
CHLOROBENZENE [108-90-7]			
Total 4-chlorocatechol in urine	End of shift	150 mg/g creatinine	Ns
Total p-chlorophenol in urine	End of shift	25 mg/g creatinine	Ns
CHROMIUM (VI), Water-Soluble Fume			
Total chromium in urine	End of shift at end of workweek	25 μg/L	—
Total chromium in urine	Increase during shift	1 μg/Lg/g creatinine)	—
COBALT [7440-48-4]			
Cobalt in urine	End of shift at end of workweek	15 μg/L	B
Cobalt in blood	End of shift at end of workweek	1 μg/L	B, Sq
CYCLOHEXANOL [108-93-0]			
1,2-Cyclohexanediol♥ in urine	End of shift at end of workweek	—	Nq, Ns
Cyclohexanol♥ in urine	End of shift	—	Nq, Ns
♥With hydrolysis			
CYCLOHEXANONE [108-94-1]			
1,2-Cyclohexanedion♥ in urine	End of shift at end of workweek	80 mg/L	Ns, Sq
Cyclohexanol♥ in urine	End of shift	8 mg/L	Ns, Sq
♥With hydrolysis			
* DICHLOROMETHANE [75-09-2]			
Dichloromethane in urine	End of shift	0.3 mg/L	Sq
N,N-DIMETHYLACETAMIDE [127-19-5]			
N-Methylacetamide in urine	End of shift at end of workweek	30 mg/g creatinine	

2004 ADOPTED BEIs

CHEMICAL [CAS #] *Determinant*	*Sampling Time*	*BEI®*	*Notation*
N,N-DIMETHYLFORMAMIDE (DMF) [68-12-2]			
N-Methylformamide in urine	End of shift	15 mg/L	
N-Acetyl-S-(N-methylcarbamoyl) cysteine in urine	Prior to last shift of the workweek	40 mg/L	Sq
2-ETHOXYETHANOL (EGEE) [110-80-5] and 2-ETHOXYETHYL ACETATE (EGEEA) [111-15-9]			
2-Ethoxyacetic acid in urine	End of shift at end of workweek	100 mg/g creatinine	
‡ ETHYL BENZENE [100-41-4]			
(Mandelic acid in urine)	End of shift at end of workweek	(1.5 g/g creatinine)	(Ns)
Ethyl benzene in end-exhaled air	(—)	—	Sq
FLUORIDES			
Fluorides in urine	Prior to shift	3 mg/g creatinine	B, Ns
	End of shift	10 mg/g creatinine	B, Ns
FURFURAL [98-01-1]			
Total furoic acid in urine1	End of shift	200 mg/g creatinine	B, Ns
n-HEXANE [110-54-3]			
2,5-Hexanedione♦ in urine	End of shift at end of workweek	0.4 mg/L	
♦ Without hydrolysis; metabolite is specific to n-hexane and methyl n-butyl ketone.			
LEAD [7439-92-1]			
Lead in blood	Not critical	30 μg/100 ml	
Note: Women of child-bearing potential, whose blood Pb exceeds 10 μg/dl, are at risk of developing a child with a blood Pb over the current Centers for Disease Control Guideline of 10 μg/dl. If the blood Pb of such children remains elevated, they may be at increased risk of cognitive deficits. The blood Pb of these children should be closely monitored and appropriate steps should be taken to minimize the child's exposure to environmental lead. (CDC: Prevention Lead Poisoning in Young Children, October 1991; see BEI and TLV Documentations for Lead).			
MERCURY			
Total inorganic mercury in urine	Preshift	35 μg/g creatinine	B
Total inorganic mercury in blood	End of shift at end of workweek	15 μg/L	B
METHANOL [67-56-1]			
Methanol in urine	End of shift	15 mg/L	B. Ns
METHEMOGLOBIN INDUCERS			
Methemoglobin in blood	During or end of shift	1.5% of hemoglobin	B, Ns, Sq
2-METHOXYETHANOL (EGME) [109-86-4] and 2-METHOXYETHYL ACETTE (EGMEA) [110-49-6]			
2-Methoxyacetic acid in urine	End of shift at end of workweek		Nq
METHYL n-BUTYL KETONE [591-78-6]			
2,5-Hexanedione♦ in urine	End of shift at end of workweek	0.4 mg/L	
♦ Without hydrolysis; metabolite is specific to n-hexane and methyl n-butyl ketone.			
METHYL CHLOROFORM [71-55-6]			
Methyl chloroform in end-exhaled air	Prior to last shift of workweek	40 ppm	
Trichloroacetic acid in urine	End of workweek	10 mg/L	Ns, Sq
Total trichloroethanol in urine	End of shift at end of workweek	30 mg/L	Ns, Sq
Total trichloroethanol in blood	End of shift at end of workweek	1 mg/L	Ns
4,4'-METHYLENE BIS(2-CHLOROANILINE) [MBOCA] [101-14-4]			
Total MBOCA in urine	End of shift		Nq
METHYL ETHYL KETONE (MEK) [78-93-3]			
MEK in urine	End of shift	2 mg/L	
METHYL ISOBUTYL KETONE (MIBK) [108-10-1]			
MIBK in urine	End of shift	2 mg/L	
NITROBENZENE [98-95-3]			

2004 ADOPTED BEIs

CHEMICAL [CAS #] ***Determinant***	***Sampling Time***	***BEI®***	***Notation***
Total p-nitrophenol in urine	End of shift at end of workweek	5 mg/g creatinine	Ns
Methemoglobin in blood	End of shift	1.5% of hemoglobin	B, Ns, Sq
PARATHION [56-38-2]			
Total p-nitrophenol in urine	End of shift	0.5 mg/g creatinine	Ns
Cholinesterase activity in red cells	Discretionary	70% of individual's baseline	B, Ns, Sq
PENTACHLOROPHENOL (PCP) [87-86-5]			
Total PCP in urine	Prior to last shift of workweek	2 mg/g creatinine	B
Free PCP in plasma	End of shift	5 mg/L	B
PHENOL [108-95-2]			
Total phenol in urine	End of shift	250 mg/g creatinine	B, Ns
* POLYCYCLIC AROMATIC HYDROCARBONS (PAHs)			
1-Hydroxypyrene♥ (1-HP) in urine	End of shift at end of workweek	—	Nq
♥With hydroylsis			
STYRENE [100-42-5]			
Maldelic acid plus phenylglyoxylic acid in urine	End of shift	400 mg/g creatinine	Ns
Styrene in venous blood	End of shift	0.2 mg/L	Sq
TETRACHLOROETHYLENE [127-18-4]			
Tetrachloroethylene in end-exhaled air	Prior to last shift of workweek	5 ppm	
Tetrachloroethylene in blood	Prior to last shift of workweek	0.5 mg/L	
Trichloroacetic acid in urine	End of shift at end of workweek	3.5 mg/L	Ns, Sq
TETRAHYDROFURAN [109-99-9]			
Tetrahydrofuran in urine	End of shift	8 mg/L	
TOLUENE [108-88-3]			
o-Cresol in urine	End of shift	0.5 mg/L	B
Hippuric acid in urine	End of shift	1.6 g/g creatinine	B, Ns
Toluene in blood	Prior to last shift of workweek	0.05 mg/L	
‡ TRICHLOROETHYLENE [79-01-6]			
‡ Trichloroacetic acid in urine	(End of workweek)	(100 mg/g creatinine	Ns
‡ (Trichloroacetic acid and trichloroethanol in urine	(End of shift at end of workweek)	(300 mg/g creatinine)	(Ns)
‡ (Free trichloroethanol in blood)	(End of shift at end of workweek)	(4 mg/L)	Ns
‡ Trichloroethylene in blood	(—)	—	Sq
‡ Trichloroethylene in end-exhaled air	(—)	—	Sq
VANADIUM PENTOXIDE [1314-62-1]			
Vanadium in urine	End of shift at end of workweek	50 μg/g creatinine	Sq
XYLENES (Technical grade) [1330-20-7]			
Methylhippuric acids in urine	End of shift	1.5 g/g creatinine	

2005 NOTICE OF INTENDED CHANGES

These substances, with their corresponding indices, comprise those for which 1) a BEI® is proposed for the first time, 2) a change in an Adopted index is proposed, 3) retention as an NIC is proposed, or 4) withdrawl of the *Documentation* and adopted BEI® is proposed. In each case, the proposals should be considered trial indices during the period they are on the NIC. These proposals were ratified by the ACGIH® Board of Directors and will remain on the NIC for approximately one year following this ratification. If, during the year, the Committee neither finds nor receives any substantive data that changes its scientific opinion regarding an NIC BEI®, the Committee may then approve its recommendation to the ACGIH® Board of Directors for adoption. If the Committee finds or receives substantive data that change its scientific opinion regarding an NIC BEI®, the Committee may change its recommendation to the ACGIH® Board of Directors for the matter to be either retained on or withdrawn from the NIC.

Documentation is available for each of these substances and their proposed values.

This notice provides not only an opportunity for comment on these proposals, but it also solicits suggestions for substances to be considered for BEIs®, such as those found on the current list of "Chemical Substances and Other Issues Under Study." Comments or suggestions should be accompanied by substanti-ating evidence in the form of peer-reviewed literature and forwarded, preferably in electronic format, to The Science Group, ACGIH® at science@acgih.org. Please refer to the ACGIH® TLV®/BEI® Development Process on the ACGIH® website (http://www.acgih.org/TLV/DevProcess.htm) for a detailed discus-sion covering this procedure and methods for input to ACGIH®.

NOTICE OF INTENDED CHANGES (for 2005)

CHEMICAL	**[CAS #]**			
Determinant		***Sampling Time***	***BEI®***	***Notation***
† 1,3-BUTADIENE	[106-99-0]			
1,2-Dihydroxybutyl mercapturic acid in urine		End of shift	2.5 mg/L	Sq, B
N-1 and N-2-(hydroxybutenyl)valine hemoglobin (Hb) adducts in blood		Not critical	2.5 pmol/g Hb	Sq
ETHYL BENZENE	[100-41-4]			
† Sum of mandelic acid and phenyl glyoxylic acid in urine		End of shift at end of workweek	1.5 g/g creatinine	Ns, Sq
† Ethyl benzene in end-exhaled air		Not critical	—	Sq
† 2-PROPANOL	[67-63-0]			
Acetone in urine		End of shift at end of workweek	40 mg/L	Ns, B
TRICHLOROETHYLENE	[179-01-6]			
Trichloroacetic acid in urine		End of shift at end of workweek	80mg/L	Ns
Trichloroethanol■ in blood		End of shift at end of workweek	2 mg/L	Ns
Trichloroethylene in blood		End of shift at end of workweek	—	Sq
Trichlorethylene in end-exhaled air		End of shift at end of workweek	—	Sq

■ Without hydrolysis

† = 2005 Revision or Addition to the Notice of Intended Changes

CHEMICAL SUBSTANCES AND OTHER ISSUES UNDER STUDY

The BEI® Committee solicits information, especially data, that may assist in its deliberations regarding the following sub-stances and issues. Comments and suggestions, accompanied by substantiating evidence in the form of peer-reviewed literature, should be forwarded, preferably in electronic format, to The Science Group, ACGIH®, at science@acgih.org. In addition, the Committee solicits recommendations for additional substances and issues of concern to the industrial hygiene and occupational health communities.

Please refer to the ACGIH® TLV®/BEI® Development Process on the ACGIH® website for a detailed discussion covering this procedure and methods for input to ACGIH® (http://www.acgih.org/TLV/DevProcess.htm).

The substances and issues listed below are as of January 1, 2004. *After this date, please refer to the ACGIH® website for the up-to-date list.* (http://www.acgih.org/TLV/Studies.htm)

Chemical Substances

Aluminum	Methyl formate
2-Butoxyethanol	N-Methyl pyrrolidone
Carbon disulfide	Pentachlorophenol
Chlorobenzene	Phenol
Fluorides	Tetrachloroethylene
Furfural	Tetrahydrofuran
Mercury	Uranium, natural

Feasibility Assessment

For the substances listed below, the BEI® Committee has determined that developing a BEI® is not currently feasible owing to inadequate scientific data. However, the Committee believes that these substances may pose important risks to the health of workers, and therefore, it encourages the submission of new data. Field or experimental studies on the relationship between biological indicators and either health risk or environmental exposure are needed for these agents. A brief summary of the current negative feasibility assessment, including data needs, for each of the listed substances is available from The Science Group, ACGIH®.

Substance	Date of Feasibility Assessment
Acrylonitrile	March 1994
Antimony	November 1996
Beryllium	September 2002
Chlorpyrifos	October 1996
1,4-Dichlorobenzene	March 1994
2,4-Dichlorophenoxy acid-	March 1994
2-Ethyl hexanoic acid	September 2001
Hydrazines	March 1994
Inorganic borates	October 1995
Manganese	April 1995
Methyl tert-butyl ether	October 1993
Methyl n-butyl ketone	October 1995
Nickel	November 1996
Selenium	November 1995
Trimethylbenzene	April 1999
Vinyl chloride	August 2002

Other Issues

1. Genetic and macromolecular markers of exposure.
2. Quality control in biological monitoring.
3. Methemoglobin inducers
4. Effect of physical exertion on body burden and the BEI®.

2004 BIOLOGICAL EXPOSURE INDICES COMMITTEE

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CONSULTANT

Philip A. Edelman, M.D.

2005

Biologically Derived

Airborne Contaminants

Contents

INTRODUCTION TO THE BIOLOGICALLY DERIVED AIRBORNE CONTAMINANTS

Biologically derived airborne contaminants include bioaerosols (airborne particles composed of or derived from living organisms) and volatile organic compounds that organisms release. Bioaerosols include microorganisms (i.e., culture-able, nonculturable, and dead microorganisms) and fragments, toxins, and particulate waste products from all varieties of living things. Biologic-ally derived contaminants are ubiquitous in nature and may be modified by human activity. Humans are repeatedly exposed, day after day, to a wide variety of such materials.

TLVs® exist for certain substances of biological origin, including cellulose; some wood, cotton, flour and grain dusts; nicotine; pyrethrum; starch; subtilisins (proteolytic enzymes); sucrose; vegetable oil mist; and volatile compounds produced by living organisms (e.g., ammonia, carbon dioxide, ethanol, and hydrogen sulfide). However, for the reasons identified below, there are no TLVs® against which to compare environmental air concentrations of most materials of biological origin.

ACGIH® has developed and separately published guidance on the assessment, control, remediation, and prevention of biologically derived contamination in indoor environments.(1) Indoor biological contamination is defined as the pres-ence of a) biologically derived aerosols, gases, and vapors of a kind and concentration likely to cause disease or predispose people to disease; b) inappropriate concentrations of outdoor bioaero-sols, especially in buildings designed to prevent their entry; or c) indoor microbial growth and remnants of biological growth that may become aerosolized and to which people may be exposed. The term biological agents refers to a substance of biological origin that is capable of producing an adverse effect, e.g., an infection or a hypersen-sitivity, irritant, inflammatory, or other response.

The ACGIH®-recommended approach to assessing and controlling bioaerosol exposures relies on visually inspecting building, assessing occupant symptoms, evaluating building performance, monitoring potential environmental sources, and applying professional judgment. The published guidance provides background information on the major groups of bioaerosols, including their sources and health effects, and describes methods to collect, analyze, and interpret bioaerosol samples from potential environmental sources. Occasionally, environmental monitoring detects a single or predominating biological contaminant. More commonly, monitoring reveals a mixture of many biologically derived materials, reflecting the diverse and interactive nature of indoor microenvironments. Therefore, environmental sampling for bioaerosols should be conducted only following careful formulation of testable hypotheses about potential bioaerosol sources and mechanisms by which workers may be exposed to bioaerosols from these sources. Even when investigators work from testable hypotheses and well-formulated sampling plans, results from environmental bioaerosol monitoring may be inconclusive and occasionally misleading.

There are no TLVs® for interpreting environmental measurements of a) total culturable or countable bioaerosols (e.g., total bacteria or fungi); b) specific culturable or countable bioaerosols (e.g., *Aspergillus fumigatus*); c) infectious agents (e.g., *Legionella pneumophila* or *Mycobacterium tuberculosis*); or d) assayable biological contami-nants (e.g., endotoxin, mycotoxin, antigens, or microbial volatile organic compounds) for the following reasons.

A. Total culturable or countable bioaerosols. Culturable bioaerosols are those bacteria and fungi that can be grown in laboratory culture. Such results are reported as the number of colony-forming units (CFU). Countable bioaerosols are those pollen grains, fungal spores, bacterial cells, and other material that can be identified and counted by microscope. A general TLV® for culturable or countable bioaerosol concentrations is not scientifically supportable because of the following:

1. Culturable microorganisms and countable biological particles do not comprise a single entity, i.e., bioaerosols in occupational settings are generally complex mixtures of many different microbial, animal, and plant particles.
2. Human responses to bioaerosols range from innocuous effects to serious, even fatal, diseases, depending on the specific material involved and workers' susceptibility to it. Therefore, an appropriate exposure limit for one bioaerosol may be entirely inappropriate for another.
3. It is not possible to collect and evaluate all bioaerosol components using a single sampling method. Many reliable methods are available to collect and analyze bioaerosol materials. However, different methods of sample collection and analysis may result in different estimates of cultureable and countable bioaerosols concentrations.

4. At present, information relating culturable or countable bioaerosol concentrations to health effects is generally insufficient to describe exposure–response relationships.

B. Specific culturable or countable bioaerosols other than infectious agents. Specific TLVs® for individual culturable or countable bioaero-sols have not been established to prevent hypersensitivity, irritant, or toxic responses. At present, information relating culturable or countable bioaerosol concentrations to health effects consists largely of case reports and qualitative exposure assessments. The data available are generally insufficient to describe exposure–response relationships. Reasons for the absence of good epidemiologic data on such relationships include the following.

1. Most data on concentrations of specific bioaerosols are derived from indicator measurements rather than from measurements of actual effector agents. For example, investigators use the air concentration of culturable fungi to represent exposure to airborne fungal antigens. In addition, most measurements are from either area or source samples. These monitoring approaches are less likely to reflect human exposure accurately than would personal sampling for actual effector agents.
2. Bioaerosol components and concentrations vary widely within and among different occu-pational and environmental settings. Unfor-tunately, replicate sampling is uncommon in bioaerosol assessments. Further, the most commonly used air-sampling devices for indoor monitoring are designed to collect "grab" samples over relatively short time intervals. Measurements from single, short-term grab samples may be orders of magni-tude higher or lower than long-term average concentrations and are unlikely to represent workplace exposures accurately. Some organisms and sources release aerosols as "concentration bursts," which may only rarely be detected by limited grab sampling. Nevertheless, such episodic bioaerosol releases may produce significant health effects.

C. Infectious agents. Human dose–response data are available for only a few infectious bioaerosols. At present, air-sampling protocols for infectious agents are limited and suitable primarily for research endeavors. In most routine exposure settings, public health measures, such as immunization, active case finding, and medical treatment, remain the primary defenses against infectious bioaerosols. Facilities associated with increased risks for transmission of airborne infectious diseases (e.g., microbiology laboratories, animal-handling facilities, and health-care settings) should employ engineering controls to minimize air concentrations of infectious agents. Further, such facilities should consider the need for administrative controls and personal protective equipment to prevent the exposure of workers to these bioaerosols.

D. Assayable biological contaminants. Assayable, biologically derived contaminants (e.g., endotoxin, mycotoxins, antigens, and volatile organic compounds) are microbial, animal, or plant substances that can be detected using chemical, immunological, or biological assays. Evidence does not yet support TLVs® for any of these substances. However, assay methods for certain common airborne antigens and endotoxin are steadily improving, and field validation of these assays is also progressing. Dose–response relationships for some assayable bioaerosols have been observed in experimental studies and occasionally in epidemiologic surveys. Therefore, exposure limits for certain assayable, biologically derived, airborne contaminants may be appropriate in the future. In addition, innova-tive molecular techniques are becoming avail-able for specific bioaerosols currently detect-able only by culture or counting.

ACGIH® actively solicits information, comments, and data in form of peer-reviewed literature on health effects associated with bioaerosol exposures in occupational and related environ-ments that may help the Bioaerosols Committee evaluate the potential for proposing exposure guidelines for selected biologically derived airborne contaminants. Such information should be sent, preferably in electronic format, to The Science Group, ACGIH® (.

Reference

1. American Conference of Governmental Industrial Hygienists: Bioaerosols: Assessment and Control. J.M. Macher, Ed.; H.M. Ammann, H.A. Burge, D.K. Milton, and P.R. Morey, Asst. Eds. ACGIH, Cincinnati, Oh (1999).

BIOLOGICALLY DERIVED AGENTS UNDER STUDY

The Bioaerosols Committee solicits information, especially data, which may assist it in the establishment of TLVs® for biologically derived airborne contaminants. Comments and suggestions, accompanied by substantiating evidence in the form of peer-reviewed literature, should be forwarded, preferably in electronic format, to The Science Group, ACGIH®.

Agents

Gram negative bacterial endotoxin
(1-3) beta, D-glucan

2004 BIOAEROSOLS COMMITTEE

CAS NUMBER INDEX

79-24-3 Nitroethane
79-27-6 1,1,2,2-Tetrabromo-ethane [Acetylene tetrabromide]
79-29-8 2,3-Dimethyl butane [see Hexane, Isomers]
79-34-5 1,1,2,2-Tetrachloroethane [Acetylene tetrachloride]
79-41-4 Methacrylic acid
79-43-6 Dichloroacetic acid
79-44-7 Dimethyl carbamoyl chloride
79-46-9 2-Nitropropane
80-51-3 p,p'-Oxybis(benzenesulfonyl hydrazide)
80-56-8 α-Pinene [*see* Turpentine]
80-62-6 Methyl methacrylate [Methacrylic acid, methyl ester]
81-81-2 Warfarin
82-68-8 Pentachloronitrobenzene
83-26-1 Pindone [2-Pivalyl-1,3-indandione]
83-79-4 Rotenone (commercial)
84-66-2 Diethyl phthalate
84-74-2 Dibutyl phthalate
85-42-7 Hexahydrophthalic anhydride
85-44-9 Phthalic anhydride
86-50-0 Azinphos-methyl [Guthion®]
86-88-4 ANTU [α-Naphthylthiourea]
87-68-3 Hexachlorobutadiene
87-86-5 Pentachlorophenol
88-12-0 N-Vinyl-2-pyrrolidone
88-72-2 o-Nitrotoluene
88-89-1 Picric acid [2,4,6-Trinitrophenol]
89-72-5 o-sec-Butylphenol
90-04-0 o-Anisidine
91-08-7 Toluene-2,6-diisocyanate
91-20-3 Naphthalene
91-59-8 β-Naphthylamine
91-94-1 3,3´-Dichlorobenzidine
92-52-4 Biphenyl [Diphenyl]
92-67-1 4-Aminodiphenyl
92-84-2 Phenothiazine
92-87-5 Benzidine
92-93-3 4-Nitrodiphenyl [4-Nitrobiphenyl]
93-76-5 2,4,5-T [2,4,5-Trichlorophenoxyacetic acid]
94-36-0 Benzoyl peroxide [Dibenzoyl peroxide]
94-75-7 2,4-D [2,4-Dichlorophenoxyacetic acid]
95-13-6 Indene
95-47-6 o-Xylene [1,2-Dimethylbenzene]
95-48-7 o-Cresol [*see* Cresol]
95-49-8 o-Chlorotoluene
95-50-1 o-Dichlorobenzene [1,2-Dichlorobenzene]
95-53-4 o-Toluidine
95-54-5 o-Phenylenediamine
96-14-0 3-Methyl pentane [*see* Hexane, Isomers]
96-18-4 1,2,3-Trichloropropane
96-22-0 Diethyl ketone
96-33-3 Methyl acrylate [Acrylic acid, methyl ester]
96-69-5 4,4'-Thiobis(6-tert-butyl-m-cresol]
97-77-8 Disulfiram
98-00-0 Furfuryl alcohol
98-01-1 Furfural
98-07-7 Benzotrichloride
98-51-1 p-tert-Butyltoluene
98-82-8 Cumene
98-83-9 α-Methyl styrene
98-86-2 Acetophenone
98-88-4 Benzoyl chloride
98-95-3 Nitrobenzene
99-08-1 m-Nitrotoluene
99-65-0 m-Dinitrobenzene [*see* Dinitrobenzene]
99-99-0 p-Nitrotoluene
100-00-5 p-Nitrochlorobenzene
100-01-6 p-Nitroaniline
100-21-0 Terephthalic acid
100-25-4 p-Dinitrobenzene [*see* Dinitrobenzene]
100-37-8 2-Diethylaminoethanol
100-40-3 Vinyl cyclohexene
100-41-4 Ethyl benzene
100-42-5 Styrene, monomer [Phenylethylene; Vinyl benzene]
100-44-7 Benzyl chloride
100-61-8 N-Methyl aniline [Monomethyl aniline]
100-63-0 Phenylhydrazine
100-74-3 N-Ethylmorpholine
101-14-4 4,4'-Methylene bis(2-chloroaniline) [MBOCA]
101-68-8 Methylene bisphenyl isocyanate [MDI]
101-77-9 4,4'-Methylene dianiline [4,4'-Diaminodiphenyl-methane]
101-84-8 Phenyl ether
102-54-5 Dicyclopentadienyl iron [Ferrocene]
102-71-6 Triethanolamine
102-81-8 2-N-Dibutylaminoethanol
104-94-9 p-Anisidine
105-46-4 sec-Butyl acetate
105-60-2 Caprolactam
106-35-4 Ethyl butyl ketone [3-Heptanone]
106-42-3 p-Xylene [1,4-Dimethylbenzene]
106-44-5 p-Cresol [*see* Cresol]
106-46-7 p-Dichlorobenzene [1,4-Dichlorobenzene]
106-49-0 p-Toluidine
106-50-3 p-Phenylenediamine
106-51-4 Quinone [p-Benzoquinone]
106-87-6 Vinyl cyclohexene dioxide
106-89-8 Epichlorohydrin [1-Chloro-2,3-epoxypropane]
106-92-3 Allyl glycidyl ether [AGE]
106-93-4 Ethylene dibromide [1,2-Dibromoethane]
106-94-5 1-Bromopropane
106-97-8 Butane
106-99-0 1,3-Butadiene
107-02-8 Acrolein
107-05-1 Allyl chloride
107-06-2 Ethylene dichloride [1,2-Dichloroethane]
107-07-3 Ethylene chlorohydrin [2-Chloroethanol]
107-13-1 Acrylonitrile [Vinyl cyanide]
107-15-3 Ethylenediamine [1,2-Diaminoethane]
107-18-6 Allyl alcohol
107-19-7 Propargyl alcohol
107-20-0 Chloroacetaldehyde
107-21-1 Ethylene glycol
107-22-2 Glyoxal
107-30-2 Chloromethyl methyl ether [Methyl chloromethyl ether; Monochlorodimethyl ether]
107-31-3 Methyl formate [Formic acid, methyl ester]
107-41-5 Hexylene glycol
107-49-3 Tetraethyl pyrophosphate [TEPP]
107-66-4 Dibutyl phosphate
107-83-5 2-Methyl pentane [*see* Hexane, Isomers]
107-87-9 Methyl propyl ketone [2-Pentanone]
107-98-2 1-Methyl-2-propanol [PGME; [Propylene glycol monomethyl ether]
108-03-2 1-Nitropropane
108-05-4 Vinyl acetate
108-10-1 Methyl isobutyl ketone [Hexone]
108-11-2 Methyl isobutyl carbinol [Methyl amyl alcohol; 4-Methyl-2-pentanol]
108-18-9 Diisopropylamine
108-20-3 Isopropyl ether
108-21-4 Isopropyl acetate
108-24-7 Acetic anhydride
108-31-6 Maleic anhydride
108-38-3 m-Xylene [1,3-Dimethylbenzene]

108-39-4 m-Cresol [*see* Cresol]
108-44-1 m-Toluidine
108-45-2 m-Phenylenediamine
108-46-3 Resorcinol
108-83-8 Diisobutyl ketone [2,6-Dimethyl-4-heptanone]
108-84-9 sec-Hexyl acetate
108-87-2 Methylcyclohexane
108-88-3 Toluene [Toluol]
108-90-7 Chlorobenzene [Monochlorobenzene]
108-91-8 Cyclohexylamine
108-93-0 Cyclohexanol
108-94-1 Cyclohexanone
108-95-2 Phenol
108-98-5 Phenyl mercaptan
109-59-1 2-Isopropoxyethanol [Ethylene glycol isopropyl ether]
109-60-4 n-Propyl acetate
109-66-0 Pentane
109-73-9 n-Butylamine
109-79-5 Butyl mercaptan [Butanethiol]
109-86-4 2-Methoxyethanol [Ethylene glycol monomethyl ether]
109-87-5 Methylal [Dimethoxymethane]
109-89-7 Diethylamine
109-94-4 Ethyl formate [Formic acid, ethyl ester]
109-99-9 Tetrahydrofuran
110-12-3 Methyl isoamyl ketone
110-19-0 Isobutyl acetate
110-43-0 Methyl n-amyl ketone [2-Heptanone]
110-49-6 2-Methoxyethyl acetate [Ethylene glycol monomethyl ether acetate]
110-54-3 n-Hexane
110-62-3 n-Valeraldehyde
110-80-5 2-Ethoxyethanol [Ethylene glycol monoethyl ether]
110-82-7 Cyclohexane
110-83-8 Cyclohexene
110-86-1 Pyridine
110-91-8 Morpholine
111-15-9 2-Ethoxyethyl acetate [Ethylene glycol monoethyl ether acetate]
111-30-8 Glutaraldehyde
111-40-0 Diethylene triamine
111-42-2 Diethanolamine
111-44-4 Dichloroethyl ether
111-65-9 n-Octane
111-69-3 Adiponitrile
111-76-2 2-Butoxyethanol [EGBE; Ethylene glycol monobutyl ether]
111-84-2 Nonane
112-07-2 2-Butoxyethyl acetate [EGBEA; Ethylene glycol monobutyl ether acetate]
112-55-0 Dodecyl mercaptan
114-26-1 Propoxur
115-07-1 Propylene
115-29-7 Endosulfan
115-77-5 Pentaerythritol
115-86-6 Triphenyl phosphate
115-90-2 Fensulfothion
116-14-3 Tetrafluoroethylene
117-81-7 Di(2-ethylhexyl]phthalate [DEHP; Di-sec-octyl phthalate]
118-52-5 1,3-Dichloro-5,5-dimethyl hydantoin
118-74-1 Hexachlorobenzene [HCB]
118-96-7 2,4,6-Trinitrotoluene [TNT]
119-93-7 o-Tolidine [3,3'-Dimethylbenzidine]
120-80-9 Catechol [Pyrocatechol]
120-82-1 1,2,4-Trichlorobenzene
121-44-8 Triethylamine
121-45-9 Trimethyl phosphite
121-69-7 Dimethylaniline [N,N-Dimethylaniline]
121-75-5 Malathion
121-82-4 Cyclonite [RDX]
122-39-4 Diphenylamine
122-60-1 Phenyl glycidyl ether [PGE]
123-19-3 Dipropyl ketone
123-31-9 Hydroquinone [Dihydroxybenzene]
123-38-6 Propionaldehyde
123-42-2 Diacetone alcohol [4-Hydroxy-4-methyl-2-pentanone]
123-51-3 Isoamyl alcohol
123-86-4 n-Butyl acetate
123-91-1 1,4-Dioxane [Diethylene dioxide]
123-92-2 Isopentyl acetate [Isoamyl acetate] [*see* Pentyl acetate]
124-04-9 Adipic acid
124-09-4 1,6-Hexanediamine
124-38-9 Carbon dioxide
124-40-3 Dimethylamine
124-64-1 Tetrakis (hydroxymethyl)phosphonium chloride
126-73-8 Tributyl phosphate
126-98-7 Methylacrylonitrile
126-99-8 β-Chloroprene [2-Chloro-1,3-butadiene]
127-00-4 1-Chloro-2-propanol
127-18-4 Tetrachloroethylene [Perchloroethylene]
127-19-5 N,N-Dimethyl acetamide
127-91-3 β-Pinene [*see* Turpentine]
128-37-0 Butylated hydroxytoluene [BHT; 2,6-Di-tert-butyl-p-cresol]
131-11-3 Dimethylphthalate
133-06-2 Captan
135-88-6 N-Phenyl-beta-naphthylamine
136-78-7 Sesone [Sodium-2,4-dichlorophenoxyethyl sulfate; Crag® herbicide]
137-05-3 Methyl 2-cyanoacrylate
137-26-8 Thiram
138-22-7 n-Butyl lactate
140-11-4 Benzyl acetate
140-88-5 Ethyl acrylate [Acrylic acid, ethyl ester]
141-32-2 n-Butyl acrylate [Acrylic acid, n-butyl ester]
141-43-5 Ethanolamine [2-Aminoethanol]
141-66-2 Dicrotophos
141-78-6 Ethyl acetate
141-79-7 Mesityl oxide
142-64-3 Piperazine dihydrochloride
142-82-5 Heptane [n-Heptane]
143-33-9 Sodium cyanide [*see* Hydrogen cyanide]
144-62-7 Oxalic acid
148-01-6 Dinitolmide [3,5-Dinitro-o-toluamide]
149-57-5 2-Ethylhexanoic acid
150-76-5 4-Methoxyphenol
151-50-8 Potassium cyanide [*see* Hydrogen cyanide]
151-56-4 Ethylenimine
151-67-7 Halothane
156-59-2 1,2-Dichloroethene, cis isomer
156-60-5 1,2-Dichloroethene, trans isomer
156-62-7 Calcium cyanamide
205-99-2 Benzo[b]fluoranthene
218-01-9 Chrysene
287-92-3 Cyclopentane
298-00-0 Methyl parathion
298-02-2 Phorate
298-04-4 Disulfoton
299-84-3 Ronnel
299-86-5 Crufomate

300-76-5 Naled [Dibrom]
302-01-2 Hydrazine
309-00-2 Aldrin
314-40-9 Bromacil
330-54-1 Diuron
333-41-5 Diazinon
334-88-3 Diazomethane
353-50-4 Carbonyl fluoride
382-21-8 Perfluoroisobutylene
409-21-2 Silicon carbide
420-04-2 Cyanamide
460-19-5 Cyanogen
463-51-4 Ketene
463-82-1 Neopentane
471-34-1 Calcium carbonate
479-45-8 Tetryl [2,4,6-Trinitrophenylmethylnitramine]
504-29-0 2-Aminopyridine
506-77-4 Cyanogen chloride
509-14-8 Tetranitromethane
528-29-0 o-Dinitrobenzene [*see* Dinitrobenzene]
532-27-4 2-Chloroacetophenone [Phenacyl chloride]
534-52-1 4,6-Dinitro-o-cresol
540-59-0 1,2-Dichloroethylene, sym isomer [Acetylene dichloride]
540-84-1 Isooctane [2,2,4-Trimethylpentane] [*see* Octane]
540-88-5 tert-Butyl acetate
541-85-5 Ethyl amyl ketone [5-Methyl-3-heptanone]
542-56-3 Isobutyl nitrite
542-75-6 1,3-Dichloropropene
542-88-1 bis(Chloromethyl] ether
542-92-7 Cyclopentadiene
546-93-0 Magnesite
552-30-7 Trimellitic anhydride
556-52-5 Glycidol [2,3-Epoxy-1-propanol]
558-13-4 Carbon tetrabromide
563-12-2 Ethion
563-80-4 Methyl isopropyl ketone
583-60-8 o-Methylcyclohexanone
584-84-9 Toluene-2,4-diisocyanate [TDI]
591-78-6 Methyl n-butyl ketone [2-Hexanone]
592-01-8 Calcium cyanide [*see* Hydrogen cyanide]
592-41-6 1-Hexene
593-60-2 Vinyl bromide
594-42-3 Perchloromethyl mercaptan
594-72-9 1,1-Dichloro-1-nitroethane
598-78-7 2-Chloropropionic acid
600-25-9 1-Chloro-1-nitropropane
603-34-9 Triphenyl amine
620-11-1 3-Pentyl acetate [*see* Pentyl acetate]
624-41-9 2-Methylbutyl acetate [*see* Pentyl acetate]
624-83-9 Methyl isocyanate
624-92-0 Methyl disulfide
625-16-1 1,1-Dimethylpropyl acetate [tert-Amyl acetate] [*see* Pentyl acetate]
626-17-5 m-Phthalodinitrile
626-38-0 2-Pentyl acetate [sec-Amyl acetate]
627-13-4 n-Propyl nitrate
628-63-7 1-Pentyl acetate [n-Amyl acetate]
628-96-6 Ethylene glycol dinitrate [EGDN]
630-08-0 Carbon monoxide
637-92-3 Ethyl tert-butyl ether [ETBE]
638-21-1 Phenylphosphine
646-06-0 1,3-Dioxolane
680-31-9 Hexamethyl phosphoramide
681-84-5 Methyl silicate
684-16-2 Hexafluoroacetone
764-41-0 1,4-Dichloro-2-butene
768-52-5 N-Isopropylaniline
822-06-0 Hexamethylene diisocyanate
919-86-8 Demeton-S-methyl
944-22-9 Fonofos
994-05-8 tert-Amyl methyl ether [TAME]
999-61-1 2-Hydroxypropyl acrylate
1024-57-3 Heptachlor epoxide
1120-71-4 Propane sultone
1189-85-1 tert-Butyl chromate
1300-73-8 Xylidine, mixed isomers [Dimethylaminobenzene]
1302-74-5 Emery
1303-00-0 Gallium arsenide
1303-86-2 Boron oxide
1303-96-4 Borates, tetra, sodium salts, Decahydrate
1304-82-1 Bismuth telluride
1330-43-4 Borates, tetra, sodium salts, Anhydrous
1305-62-0 Calcium hydroxide
1305-78-8 Calcium oxide
1309-37-1 Iron oxide fume (Fe_2O_3)
1309-48-4 Magnesium oxide
1309-64-4 Antimony trioxide, Production
1310-58-3 Potassium hydroxide
1310-73-2 Sodium hydroxide
1314-13-2 Zinc oxide
1314-61-0 Tantalum oxide
1314-62-1 Vanadium pentoxide
1314-80-3 Phosphorus pentasulfide
1317-95-9 Silica, Crystalline — Tripoli
1319-77-3 Cresol, all isomers
1321-64-8 Pentachloronaphthalene
1321-65-9 Trichloronaphthalene
1321-74-0 Divinyl benzene
1330-20-7 Xylene, mixed isomers [Dimethylbenzene]
1332-21-4 Asbestos
1332-58-7 Kaolin
1333-74-0 Hydrogen
1333-86-4 Carbon black
1335-87-1 Hexachloronaphthalene
1335-88-2 Tetrachloronaphthalene
1338-23-4 Methyl ethyl ketone peroxide
1344-28-1 Aluminum oxide [α-Alumina]
1344-95-2 Calcium silicate
1395-21-7 Subtilisins [proteolytic enzymes]
1477-55-0 m-Xylene α,α'-diamine
1563-66-2 Carbofuran
1634-04-4 Methyl tert-butyl ether [MTBE]
1912-24-9 Atrazine
1918-02-1 Picloram
1929-82-4 Nitrapyrin [2-Chloro-6-(trichloromethyl) pyridine]
2039-87-4 o-Chlorostyrene
2104-64-5 EPN
2179-59-1 Allyl propyl disulfide
2234-13-1 Octachloronaphthalene
2238-07-5 Diglycidyl ether [DGE]
2425-06-1 Captafol
2426-08-6 n-Butyl glycidyl ether [BGE]
2451-62-9 1,3,5-Triglycidyl-s-triazinetrione
2528-36-1 Dibutyl phenyl phosphate
2551-62-4 Sulfur hexafluoride
2698-41-1 o-Chlorobenzylidene malononitrile
2699-79-8 Sulfuryl fluoride
2764-72-9 Diquat
2921-88-2 Chlorpyrifos
2971-90-6 Clopidol
3033-62-3 Bis(2-dimethylaminoethyl) ether [DMAEE]
3333-52-6 Tetramethyl succinonitrile
3383-96-8 Temephos

3687-31-8	Lead arsenate
3689-24-5	Sulfotep [TEDP]
3825-26-1	Ammonium perfluorooctanoate
4016-14-2	Isopropyl glycidyl ether [IGE]
4098-71-9	Isophorone diisocyanate
4170-30-3	Crotonaldehyde
4685-14-7	Paraquat
5124-30-1	Methylene bis(4-cyclohexylisocyanate)
5714-22-7	Sulfur pentafluoride
6423-43-4	Propylene glycol dinitrate [PGDN]
6923-22-4	Monocrotophos
7085-85-0	Ethyl cyanoacrylate
7429-90-5	Aluminum
7439-92-1	Lead
7439-96-5	Manganese
7439-97-6	Mercury
7439-98-7	Molybdenum
7440-01-9	Neon
7440-02-0	Nickel
7440-06-4	Platinum
7440-16-6	Rhodium
7440-21-3	Silicon
7440-22-4	Silver
7440-25-7	Tantalum
7440-28-0	Thallium
7440-31-5	Tin
7440-33-7	Tungsten
7440-36-0	Antimony
7440-37-1	Argon
7440-38-2	Arsenic
7440-39-3	Barium
7440-41-7	Beryllium
7440-43-9	Cadmium
7440-47-3	Chromium
7440-48-4	Cobalt
7440-50-8	Copper
7440-58-6	Hafnium
7440-59-7	Helium
7440-61-1	Uranium (natural)
7440-65-5	Yttrium
7440-67-7	Zirconium
7440-74-6	Indium
7446-09-5	Sulfur dioxide
7553-56-2	Iodine
7572-29-4	Dichloroacetylene
7580-67-8	Lithium hydride
7616-94-6	Perchloryl fluoride
7631-90-5	Sodium bisulfite
7637-07-2	Boron trifluoride
7646-85-7	Zinc chloride
7647-01-0	Hydrogen chloride
7664-38-2	Phosphoric acid
7664-39-3	Hydrogen fluoride
7664-41-7	Ammonia
7664-93-9	Sulfuric acid
7681-57-4	Sodium metabisulfite
7697-37-2	Nitric acid
7719-09-7	Thionyl chloride
7719-12-2	Phosphorus trichloride
7722-84-1	Hydrogen peroxide
7722-88-5	Tetrasodium pyrophosphate
7726-95-6	Bromine
7727-21-1	Potassium persulfate [*see* Persulfates]
7727-37-9	Nitrogen
7727-43-7	Barium sulfate
7727-54-0	Ammonium persulfate [*see* Persulfates]
7758-97-6	Lead chromate
7773-06-0	Ammonium sulfamate
7775-27-1	Sodium persulfate [*see* Persulfates]
7778-18-9	Calcium sulfate
7782-41-4	Fluorine
7782-42-5	Graphite (natural)
7782-49-2	Selenium
7782-50-5	Chlorine
7782-65-2	Germanium tetrahydride
7783-06-4	Hydrogen sulfide
7783-07-5	Hydrogen selenide
7783-41-7	Oxygen difluoride
7783-54-2	Nitrogen trifluoride
7783-60-0	Sulfur tetrafluoride
7783-79-1	Selenium hexafluoride
7783-80-4	Tellurium hexafluoride
7784-42-1	Arsine
7786-34-7	Mevinphos [Phosdrin®]
7789-06-2	Strontium chromate
7789-30-2	Bromine pentafluoride
7790-91-2	Chlorine trifluoride
7803-51-2	Phosphine
7803-52-3	Antimony hydride [Stibine]
7803-62-5	Silicon tetrahydride [Silane]
8001-35-2	Chlorinated camphene [Toxaphene]
8002-74-2	Paraffin wax fume
8003-34-7	Pyrethrum
8006-14-2	Natural gas [*see* Aliphatic hydrocarbon gases]
8006-64-2	Turpentine
8008-20-6	Kerosene
8022-00-2	Methyl demeton [Demeton-methyl]
8030-30-6	Naphtha [*see* Rubber solvent]
8032-32-4	VM & P Naphtha
8050-09-7	Colophony [*see* Rosin core solder]
8052-41-3	Stoddard solvent
8052-42-4	Asphalt (Bitumen) fume
8065-48-3	Demeton [Systox®]
9002-84-0	Polytetrafluoroethylene
9004-34-6	Cellulose
9005-25-8	Starch
9006-04-6	Natural rubber latex
9014-01-1	Bacillus subtilis [*see* Subtilisins]
10024-97-2	Nitrous oxide
10025-67-9	Sulfur monochloride
10025-87-3	Phosphorus oxychloride
10026-13-8	Phosphorus pentachloride
10028-15-6	Ozone
10035-10-6	Hydrogen bromide
10043-35-3	Boric acid [*see* Borates]
10049-04-4	Chlorine dioxide
10102-43-9	Nitric oxide
10102-44-0	Nitrogen dioxide
10210-68-1	Cobalt carbonyl
10294-33-4	Boron tribromide
11097-69-1	Chlorodiphenyl (54% chlorine)
11103-86-9	Zinc potassium chromate
12001-26-2	Mica
12001-28-4	Crocidolite [*see* Asbestos]
12001-29-5	Chrysotile [*see* Asbestos]
12079-65-1	Manganese cyclopentadienyl tricarbonyl
12108-13-3	2-Methylcyclopentadienyl manganese tricarbonyl
12125-02-9	Ammonium chloride fume
12172-73-5	Amosite [*see* Asbestos]
12179-04-3	Borates, tetra, sodium salts, Pentahydrate
12185-10-3	Phosphorus (yellow)
12604-58-9	Ferrovanadium
13071-79-9	Terbufos
13121-70-5	Cyhexatin [Tricyclohexyltin hydroxide]

13149-00-3	Hexahydrophthqlic anhydride, cis-isomer
13463-39-3	Nickel carbonyl
13463-40-6	Iron pentacarbonyl
13463-67-7	Titanium dioxide
13466-78-9	Δ^3-Carene [*see* Turpentine]
13494-80-9	Tellurium
13530-65-9	Zinc chromate
13765-19-0	Calcium chromate
13838-16-9	Enflurane
14166-21-3	Hexahydrophthalic anhydride, trans-isomer
14464-46-1	Silica,Crystalline — Cristobalite
14484-64-1	Ferbam
14807-96-6	Talc (nonasbestos form)
14808-60-7	Silica, Crystalline — Quartz
14857-34-2	Dimethylethoxysilane
14977-61-8	Chromyl chloride
15468-32-3	Silica, Crystalline — Tridymite
15972-60-8	Alachlor
16219-75-3	Ethylidene norbornene
16752-77-5	Methomyl
16842-03-8	Cobalt hydrocarbonyl
17702-41-9	Decaborane
17804-35-2	Benomyl
19287-45-7	Diborane
19430-93-4	Perfluorobutyl ethylene
19624-22-7	Pentaborane
20816-12-0	Osmium tetroxide
21087-64-9	Metribuzin
21351-79-1	Cesium hydroxide
21651-19-4	Tin oxide
22224-92-6	Fenamiphos
25013-15-4	Vinyl toluene [Methyl styrene, all isomers]
25154-54-5	Dinitrobenzene, all isomers
25321-14-6	Dinitrotoluene
25551-13-7	Trimethyl benzene, mixed isomers
25639-42-3	Methylcyclohexanol
26140-60-3	Terphenyls
26628-22-8	Sodium azide
26952-21-6	Isooctyl alcohol
31242-93-0	Chlorinated diphenyl oxide
34590-94-8	(2-Methoxymethylethoxy)propanol [DPGME; Dipropylene glycol methyl ether; bis-(2-Methoxypropyl) ether]
35400-43-2	Sulprofos
37300-23-5	Zinc yellow
53469-21-9	Chlorodiphenyl (42% chlorine)
55566-30-8	Tetrakis (hydroxymethyl) phosphonium sulfate
59355-75-8	Methyl acetylene-propadiene mixture [MAPP]
60676-86-0	Silica–Amorphous, Silica fused
61788-32-7	Hydrogenated terphenyls
61790-53-2	Silica–Amorphous, Diatomaceous earth (uncalcined)
64742-81-0	Hydrogenated kerosene [*see* Kerosene/Jet fuel]
65996-93-2	Coal tar pitch volatiles
65997-15-1	Portland cement
68334-30-5	Diesel oil
68476-30-2	Fuel oil No. 2 [*see* Diesel fuel]
68476-31-3	Diesel No. 4 [*see* Diesel fuel]
68476-34-6	Diesel No. 2 [*see* Diesel fuel]
68476-85-7	L.P.G. [Liquified petroleum gas]
69012-64-2	Silica–Amorphous, Silica fume
74222-97-2	Sulfometuron methyl
77650-28-3	Diesel No. 4; Marine diesel [*see* Diesel fuel]
86290-81-5	Gasoline
93763-70-3	Perlite
112926-00-8	Silica–Amorphous, Precipitated silica/Silica gel

ENDNOTES

* 2005Adoption.
‡ See Notice of Intended Changes (NIC)
( ) Adopted values enclosed are those for which changes are proposed in the NIC.
† 2005 Revision or Addition to the Notice of Intended Changes.
A Refers to Appendix A: Carcinogens.
C Ceiling limit; *see* definition in the "Introduction to the Chemical Substances."
(D) Simple asphyxiant; see definition covering *Minimal Oxygen Content* found in the "Definitions and Notations" found in file
(E) The value is for particulate matter containing no asbestos and < 1% crystalline silica.
(F) Respirable fibers: length > 5 µm; aspect ratio ≥ 3:1, as determined by the membrane filter method at 400 to 450× magnification (4-mm objective), using phase-contrast illumination.
(G) As measured by the vertical elutriator, cotton-dust sampler. *See* TLV® Documentation
(H) Aerosol only
(I) Inhalable fraction; *see* Appendix C, paragraph A.
(IV) Inhalable fraction and vapor. Because the estimated saturated vapor concentration may significantly contribute to the exposure at the TLV–TWA and evaporative losses of collected particulate matter may occur during sampling, both the particulate mass and vapor phase concentrations should be considered and summed to determine total airborne concentration.
(J) Does not include stearates of toxic metals.
(K) Should not exceed 2 mg/m^3 respirable dust.
(L) Exposure by all routes should be carefully controlled to levels as low as possible.
(M) Classification refers to sulfuric acid contained in strong inorganic acid mists
(N) Except castor cashew nut, or similar irritant oils.
(O) Sampled by method that does not collect vapor.
(P) Application restricted to conditions in which there are negligible aerosol exposures.
(R) Respirable fraction; *see* Appendix C, paragraph C.
(T) Thoracic fraction; *see* Appendix C, paragraph B.
(V) Vapor and aerosol.

BEI = Substances for which there is a Biological Exposure Index or Indices (*see* BEI® section, File 07-2004 BEIs.doc)
BEI_A = *see* BEI® for Acetylcholinesterase Inhibiting Pesticides
BEI_M = *see* BEI® for Methemoglobin Inducers
CNS = Central nervous system
CVS = Cardiovascular system
GI = Gastrointestinal
MW = Molecular weight
NOS = Not otherwise specified
SEN = Sensitizer; *see* definition in the "Definitions and Notations."
Skin = Danger of cutaneous absorption; *see* discussion in the "Definitions and Notations."
STEL = Short-term exposure limit; *see* definition in the "Introduction to the Chemical Substances."
TWA = 8-hour, time-weighted average; *see* definition in the "Introduction to the Chemical Substances."
ppm = Parts of vapor or gas per million parts of contaminated air by volume at NTP conditions (25^{o}C; 760 torr).
mg/m^3 = Milligrams of substance per cubic meter of air.