TLV Development

Threshold Limit Values Are Not Just Numbers

By Theodore J. Hogan and J. Torey Nalbone

IN BRIEF

- **Threshold limit values (TLVs) are guidelines (not regulatory standards) published annually by American Conference of Governmental Industrial Hygienists (ACGIH) that provide contemporary guidance for worker protection.**
- **ACGIH's TLV for Chemical Substances Committee is charged with the ongoing development of TLVs and preparing new and revised *Documentation* that analyze the science supporting each TLV. The public can provide scientific input to this development process year-round.**
- **It is essential to review the *Documentation* and have a clear understanding of the development process to help ensure proper use of the TLVs.**

A 45-year-old portable ladder, with 45-year-old design and safety features, may not provide adequate worker protection. Likewise, a 45-year-old OSHA permissible exposure limit (PEL) may not provide adequate worker protection against health effects caused by airborne chemical exposures. Most of the current OSHA PELs came from ACGIH's 1968 threshold limit values (TLVs). Only 29 PELs have been updated since then, partly due to OSHA's complex rulemaking requirements. OSHA acknowledges this problem on its website, which states:

- OSHA recognizes that many of its permissible exposure limits (PELs) are outdated and inadequate for ensuring protection of worker health.
- OSHA's mandatory PELs in the Z-Tables remain in effect. However, OSHA recommends that employers consider using the alternative occupational exposure limits because the agency believes that exposures above some of these alternative occupational exposure limits may be hazardous to workers, even when the exposure levels are in compliance with the relevant PELs.

TLVs provide more current guidance (not regulations) to help safety and industrial hygiene professionals protect workers from airborne chemical exposures.

Since its beginning in 1938, ACGIH has been at the forefront in developing guidelines for occupational exposures to chemicals. The TLVs were first issued in 1948 and were made publicly available via industrial hygiene journals and other publications. The first TLV book was issued in 1961, and the first edition of the *Documentation of the Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices* (*Documentation*) was issued in 1962. The organization's TLV Chemical Substance Committee (TLV-CS) is charged with the ongoing development of chemical substance TLVs and preparing new and revised *Documentation* that analyze the science supporting each TLV and biological exposure indices (BEI).

Many misconceptions exist about this committee's activities as they relate to the investigation, development, recommendation and annual review of TLVs. This impression persists despite the fact that the method and governing policies are thoroughly detailed in the TLV and BEI Guidelines sections of the ACGIH website (**www.acgih.org**). For example, the website provides access to the Conflict of Interest and Bias Policy as well as the committee's operations manual (which is more than 75 pages long), which explains the development of TLVs and the supporting documentation.

This article is not a restatement of official ACGIH policy and procedures. Rather, it provides an abbreviated explanation of the preparation of TLVs for chemical substances, with a focus on how the public has many opportunities to provide scientific information to assist in the development process. This public input is an integral element of the development process. Public comments are welcome year-round, and the committee considers those comments and data that address issues of health and exposure.

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Development of TLVs is a complex and open effort to arrive at a scientific consensus on protecting workers from adverse health effects.

What a TLV Is & Is Not

TLVs and BEIs are professional opinions that provide guidance for OSH professionals when evaluating workplace exposure. They represent the opinion of the TLV and BEI committees that exposure at or below the published levels does not create an unreasonable risk of disease or injury. The committees use published peer-reviewed data as a basis for determining safe, as distinguished from dangerous, exposure levels. The data supporting these opinions—the literature sources used as the basis for each value—are described in the *Documentation*.

As health-based occupational exposure limits (OELs), the values occupy the top of the hierarchy for effective and efficient protection of workers. TLVs are useful guidance, not regulations, and ACGIH does not recommend that the values be used for regulatory purposes without an analysis of other factors necessary to make appropriate risk management decisions. Specific TLVs are sometimes cited during enforcement or in lawsuits, but the purpose of these values is only for health protection.

The goals of the TLVs are different than those of an OSHA PEL or other regulatory standard. A TLV is a health-based exposure limit selected to provide protection to most workers. When OSHA establishes a PEL, it is required to evaluate not only health effects but also economic and technical feasibility, and the availability of acceptable methods to determine compliance with the required exposure limit. These nonhealth factors can result in a PEL that may not be as protective as other exposure limits.

In contrast, because the TLVs are health-based only, the development process and value recommendations do not consider regulatory issues or business concerns such as financial impacts or technical feasibility, as they are not relevant for a determination of health-based only guidelines.

As stated in the *TLV-CS Operations Manual*:

> The goal of the committee is to develop occupational exposure guidelines for chemical substances that are:
>
> - scientifically credible;
> - leading edge;
> - well-supported (i.e., TLVs are primarily based on ACGIH's review of "peer-reviewed scientific literature");
> - scientifically valid;
> - reliable;
> - understandable and clear;
> - produced with a balanced, unbiased and clearly defined process

Each TLV is substantiated by an official *Documentation*.

TLV-CS Committee: Membership & Role

ACGIH's website identifies the current membership of the TLV-CS Committee. Individuals for all ACGIH committees are volunteers who come from academia, government, industry and labor; they are chosen for their expertise in their various disciplines.

This diversity is an essential part of the TLV development process. An industrial hygienist may provide information on how and where exposures may occur. An inhalation toxicologist may help in

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evaluating animal toxicity studies. Occupational epidemiologists may assist in interpreting studies of workplace human exposures. Occupational medicine physicians may help in understanding human health effects of exposures.

Ultimately, each member can contribute his/her expertise to the development of each value and its supporting documentation. These highly experienced volunteers may work over several years preparing the *Documentation* for each TLV.

The TLV & *Documentation* Development Process

The primary work of all ACGIH OEL-setting committee members is the preparation of *Documentation*. Its primary purpose is to describe the basis and analyze the scientific literature that supports the derivation of a TLV, BEI and any associated notations.

Once selected for review, the TLV-CS Committee assigns chemical substances to one of three subcommittees (Hydrogen, Oxygen and Carbon Compounds; Dusts and Inorganic Compounds; Miscellaneous Compounds). One or more subcommittee members is assigned to review the scientific literature and prepare a new or revised TLV and *Documentation*.

This review is an arduous process of conducting a detailed review of the toxicology, epidemiology and industrial hygiene literature. Committee members are assisted by qualified ACGIH staff, including a research science librarian, who conducts a broad search specific to the chemical of interest. The subcommittee members then summarize the findings and conclusions of the studies that are relevant to establishing an exposure guideline.

The primary purpose is to identify specific studies within the literature that provide useful data on quantitative exposures and related potential health effects. Well-designed human epidemiological data with quantitative exposure information are desirable, but often other human exposure studies or long- and short-term animal studies are the best available information for selecting exposure guidelines. The multiple studies are reviewed and discussed in the *Documentation*, including the reasons for selecting one or more of these as a basis for the TLV.

Each new or revised *Documentation* includes information on:

1) TLV recommendation:

- Studies that provide rationale for deriving the recommendation, which include human studies; animal studies that identify routes of exposures, doses and responses; and key health effects.
- Particle size fraction chosen: inhalable (throughout respiratory system); thoracic (lung airways and gas exchange areas); respirable (gas exchange areas).
- Reasoning for selecting the recommended value.
- Time frame of exposure: ceiling (not to be exceeded), short-term exposure limit (15 minutes), time-weighted average (8 hours).
- Assigned notations (carcinogenicity, sensitizer, skin) and reason assigned.

2) TLV basis: The critical health effect(s) that supports the derivation of TLV (which is also listed in the TLVs and BEIs book).

3) Chemical and physical properties: The substance's chemical and physical characteristics and properties.

4) Major sources of occupational exposures:

- How a substance is produced and used; estimates of production volumes and number of workers exposed; major routes of exposure during manufacture and use.
- Form encountered (vapor, particulate matter, aerosol, other).
- Particle size issues and characterizations as appropriate.

5) Animal studies (acute, subacute, subchronic, chronic, carcinogenicity, genotoxicity, reproductive/developmental toxicity). This includes:

- A summary of relevant animal studies (not a detailed description of each animal toxicological study).
- Information on: 1) species, sex, route and mode of administration, duration of dosing, specific doses tested, relevant toxic effects (including no observed adverse effect levels, lowest-observed adverse effect levels, higher dose toxic responses); 2) studies that explain the mechanisms of the toxic effect; and 3) brief relevant summaries of published expert reviews.

6) Absorption, distribution, metabolism and excretion (for both animal and human studies):

- This specifically addresses: 1) how the substance gets into the body; 2) how the substance is transported around the body; 3) how the substance might be transformed by metabolic processes; and 4) how the substance is eliminated from the body.

7) Human studies: This encompasses case reports, epidemiological studies and cancer studies.

8) TLV chronology: Listing of dates and values of proposed and accepted TLVs for the substance.

9) References.

The extensive *Documentation* clearly demonstrates that a TLV is much more than a number. TLV users need to review the *Documentation* to understand the bases and limitations of a specific value.

Internal Review Process

Preparation of the initial TLV and *Documentation* is just the beginning of the process. Subcommittee members review the initial results of the process and provide substantial input and revisions, including providing additional literature and helping to develop a specific recommendation. This can involve several cycles of review over multiple years. While the draft *Documentation* is not made available for public review during this process, the public can continue to provide scientific input for these substances.

Next, the full committee reviews the TLV and *Documentation*, makes corrections and offers recommendations for additional work. Only after full committee approval is the TLV and *Documentation* presented to ACGIH's board for review. If the board ratifies the committee's recommendation, the TLV is placed on the Notice of Intended Changes (NIC). Throughout this process, ACGIH's board of directors oversees the TLV-CS Committee's activities to ensure that it is following the established development process. A board member is present during the full committee meetings. Ultimately, as many as 30 sci-

entists will have participated in the development of the proposed TLV and its *Documentation* before it is issued for public review under the NIC.

Public Review Process

As noted, the public can provide scientific input to the TLV development process. This can occur when:

- ACGIH identifies substances as "under study" on the annual report (by Feb. 1) and periodically throughout the year on its website. The under-study list is updated by July 31 each year into a two-tiered list. Tier 1 entries indicate which substances may move forward on the NIC in the following year. Tier 2 indicates those substances that will not move forward on the NIC. Substances that may move forward on the NIC will remain on Tier 1 for the balance of the year prior to the committee recommending a proposed TLV. Public scientific input is accepted on under-study substances via e-mail (**science@acgih.org**).
- ACGIH publishes a proposed TLV (and its *Documentation*) with a NIC (also by Feb. 1). Comments are accepted year-round. However, the comment period for any NIC draft is from Feb. 1 (when it is first published) to May 31 each year. This deadline is not to limit stakeholder participation, but rather to ensure that all comments are received in time for full consideration by the committee regarding the outcome of any NIC. This does not mean other comments are ignored. Instead, comments received after the May 31 deadline are fully considered in the following year. Substances stay on the NIC list for at least 1 year before final adoption.

Due to the international impact of the TLVs, comments are received from individuals and organizations from around the world. ACGIH requires that comments be limited to 10 pages (not including appendixes of citable literature) and contain an executive summary, list of recommendations or actions and a rationale for each, and citable literature. This is not to limit input, but to ensure that clearly identified specific recommendations/actions can be reviewed and considered by the committee before any recommendation is made to ACGIH's board. The board reviews the committee activity to ensure that the external commentary is considered during the revision process.

The TLV-CS Committee acknowledges receipt of all comments. It is the committee's policy to review all submitted comments regarding chemical substances on the under-study list, as well as NICs or currently adopted TLVs. However, the committee does not provide a point-by-point response to comments; rather it communicates with its users and interested parties by publishing its decisions as *Documentation*.

Submitted comments may include helpful scientific information; as a consequence of reviewing such information, the committee may change its scientific opinion regarding a NIC for a TLV. This may result in substantive revisions to the *Documentation* or a change in the TLV or its notations.

This revised *Documentation* is again made available for 1 year on the NIC for public review and input. New comments are again received and considered. If the committee neither finds nor receives any substantive data that change its scientific opinion, the committee may then submit its recommendation for approval by ACGIH's board for adoption. Only after the board reviews and approves these final documents does ACGIH issue a new or revised TLV and its *Documentation*.

Issues of economic or technical feasibility raised by commentators are not considered by the committee. As noted, a TLV is a health-based guideline, not a regulatory standard. Commentators need to provide substantiation for their comments, which should be in the form of peer-reviewed literature. Unpublished studies may be submitted, but they must come with authorization from the study's source to allow ACGIH to use, cite and release the information. This ensures that each study cited in a *Documentation* is available for review by the public if desired.

Addressing the Potential for Conflict of Interest

ACGIH recognizes that each individual who is knowledgeable about a subject brings his/her own biases and experiences to any committee effort. Therefore, organization established its Conflict of Interest and Bias Policy to safeguard the integrity and credibility of the committee's activities. In addition to following this policy throughout its entire decision-making process, ACGIH's board exercises oversight and review of all committee membership and leadership appointments.

All committee members must acknowledge that the Conflict of Interest and Bias Policy has been received and read. Pursuant to this policy, the committee conducts an annual closed session discussion on bias and conflict of interest. During this session, committee members can share questions and concerns, and identify any circumstances or relationships that could be viewed as a potential conflict. In addition, each committee member must identify in detail his/her perceived and actual conflicts of interests, including those that may exist for a specific substance.

Any member with a potential, real or perceived conflict of interest with respect to a chemical substance or issue under consideration by the committee must annually disclose the conflict of interest orally to the full committee. A contemporaneous written declaration must also be completed. This process must be repeated when material changes arise.

It is essential that potential, real or perceived conflicts of interest be identified before the TLV process begins. Likewise, committee members must recognize and identify their particular technical or scientific biases, so that these differing perspectives can be balanced during committee deliberations. Open and free discussion is important to this process. When a conflict of interest is identified or a question of balance arises, the committee will act. If it is a question of balance, the committee may add members with opposing viewpoints to achieve the appropriate balance.

Members with high conflicts may not participate in voting on the specific topic. This even includes members whose research work is cited in the specific *Documentation*. In some cases, the member does not participate at all, leaving the room during committee discussions on that substance. This may happen if a committee member is affiliated with an

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academic institution and performs research central to the TLV, or if a member works for a company that is a major producer of a chemical substance under review by the committee. For more severe or extensive conflicts, the individual may be asked to resign.

Other Exposure Limit Efforts of ACGIH Committees

In addition to chemical substances, ACGIH publishes other types of TLVs. The TLV for Physical Agents (TLV-PA) Committee develops workplace exposure guidelines on noise, many forms of radiation, heat/cold stress, vibration and repetitive motion (ergonomics). This committee includes engineers and scientists with specific experience in and research on these types of hazards. The TLV and *Documentation* for heat stress is an example of detailed guidance on the many factors responsible for heat stress (beyond air temperature).

A separate committee composed primarily of researchers develops BEIs. These values provide guidance on measuring workplace chemicals or their metabolites that can be quantitatively measured in exhaled air, blood and urine. These are based on a detailed understanding of the absorption, distribution, metabolism and excretion of the material, and provide specific guidance on when and how samples are collected, how they should be analyzed and how to interpret the results.

These indices are unique in that they offer occupational health practitioners guidelines in the evaluation of biological by-products that provide one way to estimate impacts of multiple routes of exposure (e.g., inhalation, ingestion). The BEIs offer important guidance for some substances, such as lead, where ingestion can be the dominant route of occupational exposure.

Proper Use of TLVs

After all this effort, it is important that the TLVs are properly used in the evaluation of workplace health hazards. A TLV is not just a number, so an essential first step is to review a substance's *Documentation* to establish a solid understanding of the philosophical and practical bases for the uses and limitations of the TLVs.

For example, to extend those uses of the TLVs to include other applications, such as use without the judgment of someone specifically trained in the discipline of industrial hygiene, to a different population, development of new exposure/recovery time model or new effect endpoint stretches the reliability and even viability of the database for the TLVs or BEIs as evidenced by the individual *Documentation*.

Documentation are available for purchase. But it is important to note that the money received is used to support the TLV/BEI development process, which allows for this important process to continue. With the *Documentation*, safety and industrial hygiene professionals assessing worker exposures have more meaningful information about the potential health effects of a substance than just a number can provide. What is the cost of the *Documentation* when compared to the cost of an incorrect or incomplete exposure assessment?

TLVs are sometimes improperly used as an index of toxicity. Consider two workplace solvents where one may be a substitute for another. The substances may have the same TLV number, but that does not mean they are similar in their potential adverse health effects. The substances may have completely different TLV bases, and many other substance-specific factors may exist for each TLV (as described in the *Documentation*). For example, the basis for one solvent TLV may be liver cancer while the TLV for another solvent with the same number may be for eye irritation.

Understanding the development process described here helps OSH professionals better understand the uses and limitations of TLVs. ACGIH's guidance on proper use includes this essential information:

> ACGIH TLVs and BEIs are health-based values. [They] are established by committees that review existing published and peer-reviewed literature in various scientific disciplines (e.g., industrial hygiene, toxicology, occupational medicine, epidemiology). Based on the available information, ACGIH formulates a conclusion 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 toxicology. The TLVs and BEIs are not quantitative estimates of risk at different exposure levels or by different routes of exposure.

Conclusion: Why TLVs Are Not Just Numbers

The development of TLVs and their associated *Documentation* is a complex and open effort to arrive at a scientific consensus on protecting workers from adverse health effects. The *Documentation of the Threshold Limit Values and Biological Exposure Indices* is the support publication for the TLVs and BEIs issued by ACGIH. It provides OSH professionals with pertinent scientific information and data along with references to literature sources used as the basis for each TLV or BEI. One must review this information and have a clear understanding of the development process to properly use the TLVs and BEIs to effectively protect workers. OSH and industrial hygiene professionals should take into consideration the science and the substantial effort contained in the TLV *Documentation* when using a TLV in the workplace. **PS**

References

ACGIH. (2001). Introduction to the chemical substances. In *Documentation of the threshold limit values and biological exposure indices* (7th ed.). Cincinnati, OH: Author.

ACGIH. (2008). *ACGIH operations manual: Threshold Limit Values for Chemical Substances Committee.* Cincinnati, OH: Author.

ACGIH. (2015). 2015 TLVs and BEIs based on the *Documentation of the threshold limit values for chemical substances and physical agents and biological exposure indices.* Cincinnati, OH: Author.

OSHA. Permissible exposure limits—Annotated tables. Retrieved from www.osha.gov/dsg/annotated-pels/