Deriving and Documenting Army Specific Occupational Exposure Levels – Time-Weighted Averages (OEL-TWAs)

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USAPHC

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1.0 References

See Appendix A for a list of references used to prepare this U.S. Army Public Health Command technical guide (USAPHC TG).

2.0 Purpose

The purpose of this TG is to provide guidance to Toxicology Portfolio, U.S. Army Institute of Public Health (AIPH), personnel in developing and documenting Occupational Exposure Levels – Time-Weighted Averages (OEL-TWAs). This TG does not address the derivation of Ceiling or 15-minute Short-Term Exposure Limits which may be necessary for some chemicals.

3.0 Applicability

This TG applies to all AIPH personnel who derive OEL-TWA values.

4.0 Abbreviations and Terms

See the glossary for a list of abbreviations and definitions of terms used to prepare this TG.

5.0 Discussion.

Occupational exposure levels are guidance or regulatory values which establish an upper bound limit to the airborne levels of chemicals allowed in the workplace. These OELs are typically established by regulatory agencies such as the Occupational Safety and Health Administration (OSHA) or professional organizations such as the American Conference of Governmental Industrial Hygienists (ACGIH). In Army workplaces, industrial hygiene regulations require use of the more stringent of the ACGIH Threshold Limit Value (TLV) or OSHA Permissible Exposure Limit (PEL) (reference 1). Additionally, there are U.S. Army OELs for chemical warfare agents that must be followed (reference 2). In the absence of a TLV or PEL, other sources may also provide OEL guidance including values published by the Workplace Emergency Exposure Level (WEEL) committee and the National Institutes for Occupational Safety and Health (NIOSH). NIOSH Recommended Exposure Limits should be applied for exposures to specific engineered nanomaterials, such as carbon nanotubes (reference 3) and nanoscale titanium dioxide (reference 4), since neither OSHA nor ACGIH provide OELs for these materials.

In cases where there are no Federal or other recognized criteria for a military compound, the Army may need to derive its own guidance levels to protect Department

of Defense (DOD) personnel. This TG outlines the process for deriving and documenting Army specific OELs. The focus of this document is to provide guidance to develop 8-hour TWA values. These criteria should provide protection for most workers exposed for 8 hours per day, 5 days per week for an entire working career.

6.0 Procedures.

6.1 General

For chemicals that do not cause cancer, the general approach outlined here incorporates the U.S. Environmental Protection Agency (EPA) method used to derive a Reference Dose (RfD) (reference 5). The derived RfD is then subjected to a route-to-route extrapolation for workplace inhalation exposures, and this value is finally adjusted for the standard work cycle to derive the OEL. If inhalation data are available, they can be used without the route-to-route extrapolation step, thus reducing some of the uncertainty in this process. In the absence of inhalation data, the oral RfD is subjected to route-to-route extrapolation to an inhaled dose and finally an OEL. Since systemic effects may differ significantly for the inhalation and oral routes, caution needs to be taken when making this extrapolation. For substances that may cause sensory irritation to the eyes, upper or lower airways, or other local effects on any region of the respiratory tract, a different approach will need to be taken.

6.2 Literature Search

The first step in deriving an OEL is to perform a complete literature search for the compound of interest. All of the relevant health-related information should be gathered including any human epidemiology data, as well as applicable animal toxicity information. In addition to the health and toxicity information, the data package should also include all available physical and chemical data. Search strategies should include electronic databases (such as TOXLINE, Hazardous Substances Database (HSDB), and Registry of Toxic Effects of Chemical Substances (RTECS)), published articles in toxicology journals, technical reports, books, and any available unpublished data from industry, academia, or the government.

At this point in the process a determination should be made as to the adequacy of the database for establishing an OEL. If the only toxicity information available on a candidate compound is an acute oral toxicity study, it would be very difficult to derive an 8-hour TWA with any confidence. If the data do not support the derivation of an OEL, it may be possible to use a hazard banding approach as a temporary measure while additional toxicity data are developed (reference 6). Since the primary purpose of this process is an attempt to derive OELs, the database should ideally include repeated-dose inhalation studies; however, these may not always be available and extrapolations

from repeated-dose oral or other exposure routes may be used with caution. If the OEL will be based on an oral exposure study, the duration of that exposure should be 13 weeks (90 days) at a minimum. If inhalation data are available, a 28-day minimum exposure could be used to derive the OEL. With the exception of the last step (route-to-route extrapolation), the methods described here can be used for inhalation exposures as well as oral dosing or other routes of exposure.

6.3   Dose Response Extrapolation

6.3.1 Key Study

Once the database has been assembled, the next step is to select the key study. The key study is the primary study on which the OEL is based. In large part, the selection of the key study is dependent on professional judgment, and the rationale for selecting a particular study should be explained in the OEL documentation. Typically, the key study will be a well-run toxicity study that demonstrates a clear dose-response relationship and with some toxic or adverse effect observed. In addition, the key study is generally conducted with the species most sensitive to the toxic effects of the test compound. The data package will likely include information from many sources with variations in study quality. Preference should be given to studies which were performed according to Federal guidelines such as the U.S. Food and Drug Administration (FDA) (reference 7), or EPA Good Laboratory Practices (GLP) (reference 8), or similar guidelines from the European Organization for Economic Cooperation and Development (OECD) (reference 9). In the absence of studies performed under these guidelines, any other available data may still be used but the rationale for its use, including an assessment of the quality of the study, should be described in the OEL documentation. Only information from primary sources should be used to derive the OEL. Data from secondary sources may be included, but it should be used only in a supporting or explanatory role.

6.3.2 Critical Effect

Once the key study has been selected, the next step is to select the critical effect. This is the toxic response from the key study that will be modeled to estimate a comparable toxic response in humans. The critical effect should show a dose-response relationship, be an adverse effect and not simply an adaptive effect, and be a response that is relevant in humans.

6.3.3 No Observed Adverse Effect Level (NOAEL)

In the traditional approach to derive an OEL from animal toxicity data, an NOAEL is identified from the critical study. The NOAEL is the highest dose tested which did not produce the critical toxic effect in the test species. This level then undergoes

adjustments to extrapolate it to a comparable human dose. Due to a number of problems with this approach (reference 10), the current and more generally accepted procedure is to use the Bench Mark Dose (BMD).

6.3.4 Bench Mark Dose (BMD)

BMD (or Bench Mark Concentration (BMC) for inhalation studies) is a statistical extrapolation of the entire dose-response curve for a given toxicological endpoint. In addition to the advantages of utilizing data from all of the study animals, it also allows for a BMD estimate to be derived even when the study was not able to identify an NOAEL. Finally, the BMD also allows a given level of response to be selected such as a 10 percent (%) effective concentration or a concentration that causes a given response in 10% of the population (reference 11). The BMD software (BMDS) program is available to download from the EPA Web site at http://epa.gov/NCEA/bmds/. This site also provides online tutorials and other instructional materials for running the BMDS. More detailed information on using the BMDS in performing dose-response extrapolations and modeling the dose-response curve can be found in the EPA BMDS technical guide (reference 11). In order to be reasonably sure the exposure levels derived are safe for the workers, the more conservative (protective) 95% lower confidence limit on the 10% response level should be used; this value is identified as the $BMDL_{10}$ (reference 10).

The BMD/BMC approach is the preferred method for data extrapolation. In the event that a satisfactory fit cannot be accomplished for any of the available BMD models, it is reasonable to use the NOAEL/Lowest Observed Adverse Effect Level (LOAEL) approach and select a Point of Departure (POD) using this method. The NOAEL/LOAEL or the $BMDL_{10}$ becomes the POD for further dose extrapolations to derive the OEL.

6.4 Mode of Action/Mechanism of Action

Any available information on the general nature of the key events that describe the toxic interactions between the test chemical and the cells of the animal model (Mode of Action (MOA)) or key biological and molecular events impacted by the test chemical (Mechanism of Action) should be described in detail in the documentation (reference 12). This information may not currently have a direct application to the risk assessment process, but mechanistic and pharmacokinetic data may be considered in the overall assessment and could be used to reduce uncertainty in the animal-to-human extrapolations.

6.5 Body Weight Scaling

The animal dose should be adjusted to a human dose based on scaled body weight using the following equation (reference 13).

$$Dose_{Human} = Dose_{Animal} \times (BW_A / BW_H)^{1/4}$$

6.6 Dosimetry

If a repeated-dose inhalation study is used for the OEL derivation, alternate methods may be utilized to improve the accuracy of the dosimetry estimates. If the test compound is a particulate, then the EPA's Regional Dose Deposition Ratio model (reference 14) or the newer Multiple-Path Particle Dosimetry (reference 15) software may be utilized to derive adjustment factor dosimetric corrections to the NOAEL or BMC. For gases with effects on the respiratory system, the EPA's Regional Gas Dose Ratio model can be used to estimate human lung effects (reference 16). Since the Army will rarely have repeated-dose inhalation studies available for deriving OELs for military compounds, the reader is referred to the cited references for more details on these methods.

6.7 Selection of Uncertainty Factors (UFs)

Due to the uncertainty in all of the assumptions made to this point in extrapolating the animal data to humans, the estimated human dose is generally divided by UFs. The following is a list of the most common UFs (reference 10).

6.7.1 Intraspecies – (UF H)

This factor is intended to account for the variation in sensitivity among the members of the human population. It is intended to provide protection for sensitive subpopulations but not ultrasensitive individuals. The maximum value is generally 10, and a number of studies support the idea that this value provides protection for most members of the general population (reference 10). A lower UF (generally 3 [the rounded square root of 10] or 1) may be used if supporting data are available. For example, if a number of studies on a variety of compounds with a similar MOA show a relatively narrow range of responses (ED/EC$_{50}$ values) a lower UF may be reasonable. The rationale should be detailed in the OEL documentation.

6.7.2 Interspecies – (UF A)

This factor is intended to account for the differences in toxicity between humans and the test species; a value of 10 is generally used as the starting point. Again, there is flexibility in the value chosen, and if data are available to support a number less than 10 it should be presented in the OEL documentation. Examples of this type of supporting rationale include basing the OEL on toxicity data from the most sensitive species. Information that humans are less sensitive than the animal models for the toxic endpoint may also be used to support a reduced UF. Information from medical surveillance should also be considered as a possible source of human exposure information. Mechanistic and MOA information may also be used to argue for a UF less than the default value. A more in-depth discussion of interspecies extrapolation may be found in reference 10.

6.7.3 Subchronic to Chronic – (UF S)

An additional 10-fold factor may be warranted when extrapolating from less-than-chronic animal data to chronic human exposures. As with the other UFs, if a reasonable argument can be presented then a reduced (or no) UF can be used. Examples of this rationale include data to show that the particular toxic effect does not increase in severity with longer term exposures.

6.7.4 Extrapolating from an LOAEL – (UF L)

An additional 10-fold factor should be used when deriving an RfD from an LOAEL instead of an NOAEL. This factor is intended to account for the uncertainty involved in extrapolating from shorter term data to lifetime exposures. As discussed above, calculation of a BMD eliminates the need for identifying an NOAEL.

6.7.5 Inadequate Database – (UF-D)

If the toxicity data for a compound is very limited, an adjustment is sometimes made to account for the uncertainty in the extrapolation. Suggested guidelines for this UF include a UF of 3 for lack of systemic toxicity data in a second species and a value of 3 for lack of reproductive toxicity information (reference 17). There is flexibility in using this UF, and a final decision should be based on professional judgment.

6.7.6 Composite UF

Once UFs for each of the factors are selected they are multiplied together to form a composite UF. In actual practice the composite UF could become quite large with a resulting very low exposure criterion. The EPA has concluded that the composite UF should not be greater than 3000. Higher total UFs indicate there is little confidence in

the estimate and the level of uncertainty in the overall assessment is too great to be reliable (reference 18). It is advisable to follow EPA practices when developing RfD type numbers and not attempt to derive an OEL if the total UF would be greater than 3000.

6.8 Time Scaling

The animal dose, either BMD or the NOAEL/LOAEL, needs to be converted to an estimated human equivalent dose (HED) (references 13 and 14). If the animal study was based on dosing 7 days per week, an adjustment should be made to scale this regimen to a typical work week of 5 days per week. This can be accomplished by multiplying the $BMDL_{10}$ or NOAEL by 5/7.

6.9 Route-to-Route Extrapolation

The final step in the process to derive an OEL is conversion of the HED dose, which is in milligrams of substance per kilogram of body weight (mg/kg) units, to an airborne concentration. This is accomplished through the following equation:

$$\text{Airborne Concentration (mg/m}^3) = [\text{HED(mg/kg) x70 kg}] / 10\text{m}^3$$

The value in milligrams per cubic meter (mg/m^3) units represents the final 8-hour TWA as the OEL. The derived OEL should be further evaluated before finalized. The OEL should be compared to analogous substances with published OELs in terms of the overall toxic effects as well as the derivation and rationale used for the published OEL. Industrial hygiene surveillance data may also be useful in any final determinations made regarding the newly derived OEL.

6.10. Size-Selective OELs for Particulates

When an OEL is derived for a particulate material the toxic effects depend on the particle size, mass, and other physical/chemical properties (e.g., solubility). The ACGIH has recently begun assigning Particle Size-Selective OELs (reference 19). Based on this guidance, an atmosphere with mixed particle sizes of the same material could result in multiple OELs. These OELs are designated as inhalable, thoracic, or respirable depending on the particle size and toxic properties.

6.10.1 Inhalable Fraction OELs

Inhalable fraction OELs are materials that are toxic when deposited anywhere in the respiratory tract and which produce effects in organ systems distal to the respiratory

system. An example is manganese which has an OEL based on central nervous system impairment.

6.10.2 Thoracic Fraction OELs

Thoracic fraction OELs address materials that are directly toxic when deposited anywhere within the lung airways and the gas exchange region. Sulfuric acid is an example of a material with a T designation following the TLV.

6.10.3 Respirable Fraction OELs

Respirable fraction OELs are based on the respirable fraction of the particulate. This is the fraction that reaches the deep lung and is toxic when deposited in the gas exchange region. Examples include mica, silica, and coal dust.

6.11 Carcinogens

If the available chemical toxicity information suggests that a chemical is a carcinogen, an alternative procedure to derive an OEL to protect workers from these effects may be necessary. First, the determination that a compound is carcinogenic should be based on a weight of all available evidence. This should include structure-activity information, *in vitro* and *in vivo* mutagenicity data, and information on the MOA for tumor formation, long-term animal studies, and available human data. This TG outlines an approach to derive OELs for potential carcinogens using two scenarios which depend on the available toxicity data.

6.11.1 Scenario One

The first scenario assumes that there are inadequate human data to perform a dose-response assessment, and that there are no chronic animal data, but that the mutagenicity data are positive. In this case, the mutagenicity data should show positive responses in more than one test and preferably positive results in *in vitro* tests with mammalian cell lines and *in vivo* tests in mammals. The mutagenicity data should also be correlated with Structure-Activity Relationship (SAR) data and any other MOA information from structurally similar compounds which are carcinogens. If these conditions are met, the suggested approach to protect workers from potential carcinogenic effects is to add an additional UF to the animal-to-human extrapolation described above. Selection of the UF should be based on professional judgment and factor in all of the available data. There are no specific guidelines for the selection of this UF, but a default value of 10 is recommended unless there is additional information suggesting a different value.

6.11.2 Scenario Two

In the second scenario, the human data are again inadequate for a dose-response assessment but there are positive data from one or more chronic animal studies. In this case, the weight of evidence should still be considered. Are there positive results from more than one species? Do both species and genders show a positive response and is the response dose-related? Are the tumor types likely to be found in humans? Given that these conditions are met, a dose-response extrapolation of the animal data may be performed and used to derive the OEL. As described for the non-cancer effects, the OEL should be based on inhalation data, but this type of information is unlikely to be available so data from other routes of exposure may be used with caution. Key considerations include the types of tumors and their relevance to humans. In addition, the tumors should be a result of systemic compound effects and not direct acting or localized responses (reference 17). If the decision is made to proceed with the extrapolation, an adaptation of the methods described by the EPA is recommended and outlined below.

6.11.2.1 Step One

The first step of the second scenario is development of a carcinogen slope factor (SF). The SF is a toxicity value that quantifies the dose-response relationship. The SF generally represents the upper 95th percent confidence limit of the slope of the dose-response curve (reference 20) and the units are milligrams per kilogram-day (mg/kg-d). It is derived using the BMD cancer models; these models provide an estimate of the SF as one of the outputs. There are several BMD cancer models to choose from, and the final determination of an SF should be based on the model that provides the best fit to the experimental data (reference 11). If no one model provides a best fit, a composite (average) of the models may be considered.

6.11.2.2 Step Two

Once the SF is obtained it should be converted to an inhalation unit risk (IUR). The IUR represents the carcinogenic risk per unit concentration, and for inhalation exposures the units are expressed as mg/m^3. The SF represents the risk per unit dose; for oral data it is the risk per mg/kg-d. This value is converted to an IUR by the following equation (adapted from reference 17):

$$\text{IUR} = [\text{SF (mg/kg-d)}^{-1} \times 20 \text{ m}^3/\text{day}] \times (70 \text{ kg})^{-1}$$

The 20 m^3/day value represents the mean volume of air inhaled by an adult during a 24-hour day. The 70 kg value is the average weight of a male worker.

6.11.2.3 Step Three

The next step in the process is the assessment of the exposure adjusted for an 8-hour work schedule using Equation 6 from the EPA risk assessment guidance (reference 16).

$$EC = (CA \times ET \times EF \times ED) / AT$$
$$or$$
$$CA = EC \times AT/ET \times EF$$

Where:
EC = exposure concentration (mg/m^3),
CA = contaminant concentration (mg/m^3); the CA is an unknown at this point in the calculation and will be derived in a later step; CA is the OEL.
ET = exposure time for a worker; it is assumed an 8-hour work day.
EF = exposure frequency for workers; conservatively assuming 250 work days per year.
ED = exposure duration; assuming a 30-year working career.
AT = averaging time; the lifetime in years (70) x 365 days per year x 8 hours per day.

Using this equation and the default values:

$$EC = 0.587 \times CA$$

6.11.2.4 Step Four

In the final step the IUR and EC are used to derive the CA (OEL). The EPA general risk equation for inhalation risk (Equation 11 from reference 16) is used to solve for the CA value:

$$RISK = IUR \times EC$$

In this equation, the risk value is set at the desired level and the equation is solved for the CA value from the previous equation:

$$RISK = IUR \times (0.587 \times CA)$$
$$or$$
$$CA = RISK / 0.587 \times IUR$$

In order to perform this calculation a level of risk must be specified. The Army typically uses a maximum carcinogenic risk of 1×10^{-4}. This risk level means that for a population of 10,000 workers exposed at the specified level (CA value) one would predict one excess cancer as a result of this exposure. Typically for general population exposures the acceptable risk levels are lower (generally 1×10^{-6}), but for workers the EPA also suggests risk levels no greater than 1×10^{-4} as being acceptable. The CA value (OEL) represents an airborne concentration and under the stated exposure assumptions in combination with the derived unit risk level, it is expected that workers would experience an increased cancer risk of no more than one excess cancer per 10,000 workers.

6.12 Hazard Notations

The ACGIH uses a number of "Notations" associated with the TLVs. These notations are included as part of the TLV and provide additional information for industrial hygiene personnel on the potential toxic effects of the material. For the Army OELs, we propose adopting the ACGIH notations for several of these toxicity or exposure situations.

6.12.1 Skin

"Skin" notations refer to the potential significant contribution to the overall exposure by the cutaneous route, including mucous membranes and the eyes, by contact with vapors, liquids, and solids (reference 19). Skin notations also alert occupational health personnel that air sampling alone is insufficient to quantify exposures and that overexposure may occur following dermal contact with liquids and aerosols, even when airborne exposures are at or below the OEL. A skin notation is not applied for chemicals that cause irritation or corrosive effects in the absence of systemic toxicity. For the DOD, the guidelines published by the ACGIH for notations should be used. Under these guidelines chemicals with a dermal LD_{50} of 1000 mg/kg or less will be given a skin notation (reference 20). Also, if a compound is demonstrated to penetrate the skin readily (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 will be considered

even in the absence of *in vivo* dermal toxicity data. Skin permeation calculators are available which require two inputs: molecular weight and the base-10 logarithm of the octanol-water partition coefficient (log K_{ow}) (reference 21). Compounds with a molecular weight greater than 500 generally will only be absorbed through the skin in negligible amounts, though this may not be the case for diseased skin (reference 20). The ACGIH Biological Exposure Index Documentation (reference 19) provides additional guidance on skin notation for chemicals based on physical chemical parameters and flux, and the evaluation outlined in that reference should be performed prior to a final decision on the skin notation. Using this methodology, the skin notation takes into consideration the dose inhaled at the OEL and the dose that might be received through skin absorption, and where the relative dose contributed by the skin route reaches a specified fraction of that which would be inhaled at the OEL, a skin notation is assigned. The lower the OEL and the greater the dermal flux, the more relative importance the dermal absorption route becomes as a contributor to the overall systemic dose in the workplace.

6.12.2 SEN

This notation designates that the chemical has been shown to produce sensitization reactions in either animal or human studies. The SEN notation does not imply that the OEL is protective against becoming sensitized to the agent nor does it provide protection for individuals already sensitized.

6.12.3 Carcinogenicity

For compounds which have been shown to produce cancer in humans or animals there are a number of classification systems published. The EPA recently revised its carcinogen assessment guidance (reference 22) and now uses verbal descriptors rather than the older alpha numeric system. The ACGIH uses a 5-level alpha numeric system: confirmed human carcinogens (A1) to not suspected as a human carcinogen (A5) (reference 19). The ACGIH system is relatively concise, easy to understand, and is familiar to DOD occupational health workers. For these reasons, the ACGIH system should be the basis for assigning carcinogen classifications to DOD compounds.

7.0 Recordkeeping, Documentation, and Approvals.

The OEL and documentation of the derivation will be written and published as an AIPH technical report. This report should provide a complete summary of all of the steps outlined above. All calculations should be presented, and the rationale for the key study and toxic endpoint should be provided. Also, for the key study, the methods should be described to include all dose groups, group size, animal species and strain, the response incidence, and statistical and biological significance or nonsignificance of the relevant findings.

The documentation will also include a qualitative assessment of the confidence level in the OEL. The estimated OEL will be assigned to either a Low, Medium, or High category based on professional judgment and taking into account all of the uncertainties associated with the derivation of the OEL. This assessment should also include the quality and quantity of data in the database, uncertainties in extrapolating the animal data to humans, and uncertainties in any route-to-route extrapolation used in estimating human dose levels.

The draft technical report should be staffed within AIPH through the Health Risk Management Portfolio, the Occupational Health Sciences Portfolio, and the Occupational and Environmental Medicine Portfolio. Following concurrence from these 3 organizations and signatures from the Toxicology Evaluation Program Manager and Toxicology Portfolio Director, the draft technical report should enter the Command Review & Concurrence (CRC) process.

The final CRC step is a review and approval (signature) by the AIPH Director and Commander. Upon completion of the CRC the technical report detailing the OEL will be published, and the OEL will be available for Army (DOD) entities as an interim value.

The published technical report should then be staffed through the MEDCOM and OTSG for any additional comments and final approval prior to acceptance as an official Department of the Army OEL.

As new data become available, the published OEL should be reviewed; if warranted, the OEL should be revised. The revised OEL should be published and distributed as a new technical report, and the revised technical report should clearly state that the new OEL is replacing previously published guidance.

For some of the chemicals for which OELs are required, the data will be submitted to organizations outside of the DOD in order to obtain consensus guidance values. One of the groups providing these values will be the Workplace Environmental Exposure Level (WEEL) committee. WEELs are OELs published by the Occupational Alliance for Risk Science (OARS). OARS are in turn managed by the Toxicology Excellence in Risk Assessment (TERA) group. WEELs are 8-hour OEL values similar to the TLVs and provide a published OEL from an unbiased organization outside the DOD and Federal Government. To facilitate the WEEL process, the technical content of the OEL documentation should conform to the WEEL report outline included as Appendix B.

APPENDIX A
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APPENDIX B
WORKPLACE ENVIRONMENTAL EXPOSURE LEVEL (WEEL) REPORT OUTLINE

I. IDENTIFICATION
Chemical Name
Synonyms
CAS Number
Molecular Formula
Structural Formula

II. CHEMICAL AND PHYSICAL PROPERTIES

Physical State
Odor Description
Molecular Weight
Conversion Factors
Melting Point
Boiling Point
Vapor Pressure
Saturated Vapor Concentration
Flammability Limits
Flash Point
Autoignition Temperature
Specific Gravity
Vapor Density
Solubility
Stability
Reactivities and Incompatibilities

III. USES

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Section I
Abbreviations

ACGIH
American Conference of Governmental Industrial Hygienists

BMC
Bench Mark Concentration

BMD
Bench Mark Dose

BMDS
Bench Mark Dose Software

CRC
Command Review & Clearance

DOD
Department of Defense

EPA
U.S. Environmental Protection Agency

HED
Human Equivalent Dose

HSDB
Hazardous Substances Data Base

IUR
Inhalation Unit Risk

LOAEL
Lowest Observed Adverse Effect Level

MOA
Mode of Action

NIOSH
National Institutes for Occupational Safety and Health

NLM
National Library of Medicine

NOAEL
No Observed Adverse Effect Level

OARS
Occupational Alliance for Risk Science

OEL
Occupational Exposure Level

OEL-TWA
Occupational Exposure Levels – Time-Weighted Averages

OSHA
Occupational Safety and Health Administration

PBPK
Physiologically Based Pharmacokinetics

PEL
Permissive Exposure Levels

POD
Point of Departure

RfC
Reference Concentration

RfD
Reference Dose

RTECS
Registry of Toxic Effects of Chemical Substances

SAR
Structure-Activity Relationship

SF
Slope Factor

TERA
Toxicology Excellence for Risk Assessment

TG
Technical Guide

TLVs
Threshold Limit Values

TOXNET
Toxicology Data Network

TWA
Time-Weighted Average

UF
Uncertainty Factor

WEEL
Workplace Environmental Exposure Level

Section II
Terms

American Conference of Governmental Industrial Hygienists (ACGIH). The ACGIH is a member-based organization. It provides occupational health exposure guidance in the form of Threshold Limit Values (TLVs).

Dosimetry. The use of quantitative methods in pharmacokinetics and toxicokinetics to better estimate the dose of a chemical received through inhalation.

Hazardous Substances Data Base (HSDB). The HSDB is a toxicology data file on the NLM's Toxicology Data Network (TOXNET®). It focuses on the toxicology of potentially hazardous chemicals.

Human Equivalent Dose (HED). This human dose is anticipated to provide the same degree of effect as that observed in animals at a given dose.

National Institutes for Occupational Safety and Health (NIOSH). This organization is part of the Centers for Disease Control and Prevention and its mission is to conduct occupational health research. They also publish occupational exposure guidance in the form of Recommended Exposure Levels.

Occupational Exposure Levels – Time-Weighted Average (OEL-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 health effects.

Occupational Safety and Health Administration (OSHA). The OSHA is the primary Federal agency responsible for establishing and enforcing occupational health exposure guidelines. OSHA has regulatory authority and publishes Permissive Exposure Levels (PEL) for substances.

Registry of Toxic Effects of Chemical Substances (RTECS). The RTECS database contains toxicity values for over 150,000 chemicals. The data entries are not peer reviewed and, consequently, the toxicity values are considered to be less reliable than other sources.

TOXLINE. The TOXLINE database (http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?TOXLINE) is the National Library of Medicine's (NLM) bibliographic database for toxicology.