U.S. Army Center for Health Promotion and Preventive Medicine

Reference Document 230A - Short-Term Chemical Exposure Guidelines for Deployed Military Personnel

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Short-Term Chemical Exposure Guidelines for Deployed Military Personnel
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USACHPPM Soldier Exposure Criteria Work Group

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SECTION 1 – PURPOSE

Reference Document (RD) 230A provides details of the scientific rationale and decision making behind the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) Technical Guide (TG) 230A – *Short-Term Exposure Guidelines for Deployed Military Personnel*. Specifically, TG 230A presents a number of chemical concentration level exposures which cause a range of health effects. This RD presents the notes and sources from which these concentration guidelines were derived. The scope, audience, application, and specific guidelines are detailed in TG 230A.

SECTION 2 – INTRODUCTION

2.1 General Background

Deployed military personnel may be exposed to a variety of environmental air, water, and soil contaminants. Existing exposure criteria for assessing health risks associated with such contaminants are neither specific nor appropriate for applications to the military. These existing health-based criteria were developed by regulatory agencies, such as the Occupational Safety and Health Administration (OSHA) for application to occupational environments, and the Environmental Protection Agency (EPA) for application to civilian or general populations. The latter are designed to protect sensitive civilian sub-populations (e.g., children, the elderly, the infirm). The exposure scenarios upon which these criteria are based are often quite different than those faced by deployed military personnel.

Recently, the Department of Defense (DOD) has focused on the health impacts of contaminants to deployed military personnel. Environmental sampling and surveillance has been initiated in various deployment scenarios to evaluate these possible impacts (i.e., before, during, and after deployment). Assessment of these effects or impacts requires a consistent set of criteria and guidelines that address performance impairments, emphasizes potential acute and chronic health effects from less than lifetime exposures, and is applicable to generally healthy and fit military populations. In addition, the deployment exposure criteria and guidelines must support the "real-time" process of evaluating exposures and determining acceptable risks in order to accomplish the military mission. Therefore, in order to protect deployed military personnel from health and performance risks associated with exposure to environmental contaminants during deployment, this effort was initiated to establish exposure criteria and guidelines which are applicable to deployed populations of generally healthy and fit military personnel.

2.2 Project Strategy

The Soldier Exposure Criteria Working Group (SECWG) is a multi-disciplinary USACHPPM working group composed of toxicologists, risk assessors, physicians, industrial hygienists, chemists, and environmental engineers. The SECWG determined that instead of creating new criteria, subject-matter experts (SMEs) should assess the applicability of existing standards, criteria, guidelines, and toxicological databases for deployment scenarios. The SMEs then developed modified criteria and guidelines for specific application to deployed military personnel. The SECWG was tasked with completing two TGs (TG 230A and the associated TG 230B, *Long-Term Chemical Exposure Guidelines for Deployed Military Personnel*, addressing longer-term exposures such as deployment scenarios of up to one year).

2.3 General Approach

The SECWG evaluated different approaches to establish chemical concentration guidelines specifically derived for a deployed military population. The SECWG determined that the most efficient approach was to start with existing guidelines, standards, or other concentration criteria derived by nationally recognized organizations. The types of existing standards/guidelines were evaluated on the basis of populations of concern, degree of health effects expected, and the degree of technical scrutiny under which these standards/guidelines had been reviewed. Based on considerations pertinent to the deployed military personnel, a hierarchy was established from which to select the values to represent deployed military guidelines. In several cases, the hierarchy approach was modified due to inconsistencies from the differences in underlying national standards/guidelines or when the health basis for a given value was clearly not applicable to a deployed military population. Details on the approaches used to establish the air guidelines and the drinking water guidelines presented in TG 230A are described in the following sections.

During the development process, reviews were performed which included the DOD as well as non-DOD individuals representing a wide range of expertise. This included the military operational community as well as technical experts from the toxicological, medical, and preventive medicine communities. Some of the more significant issues and technical concerns are discussed in Appendix F. In addition, some reviewers requested additional input on various issues that were considered to be outside the scope TG 230A. A listing of suggested points of contacts/sources for additional information is provided on inside of the back cover of this document.

SECTION 3 – MILITARY AIR GUIDELINES–SHORT TERM (MAGs-S)

3.1 Sources of Chemicals and Guidelines in TG 230A Appendix C

A list of substances to which deployed military personnel may be exposed was taken from the report of Stuempfle et al. (1998). Chemicals were ranked according to the likelihood of airborne exposures and relative toxicity. Based on continental distribution, physical properties (e.g., vapor pressure) and relative acute toxicity, these substances were categorized into groups of high, medium, and low risk. Additional substances that were added to the air list by the SECWG included chemical warfare agents, smokes and obscurants, riot control agents, and some pesticides. A variety of sources was used to identify the actual guidelines for the compounds. Substances for which existing values were not available were excluded from the tables.

3.2 One-Hour Values

The one-hour MAGs-S for TG 230A were developed to delineate three major categories of risk: minimum, significant, and severe. These MAGs-S were selected from a hierarchy and evaluation of existing values. Several sources that provide 1-hour air values were evaluated in selecting these values. These sources included: Emergency Response Planning Guidelines (ERPGs, Levels 1-3) from the American Industrial Hygiene Association (AIHA); Emergency Exposure Guidance Levels (EEGLs) from the National Academy of Sciences (NAS), National Research Council (NRC)/Committee on Toxicology (COT); Acute Exposure Guideline Levels (AEGLs, Levels 1-3) from the EPA; Short-term Public Emergency Guidance Levels (SPEGLs) from the NAS; and, Temporary Emergency Exposure Limits (TEELs) from the Department of Energy (DOE). For certain chemicals, the American Conference of Governmental Hygienists (ACGIH) Ceiling Limit values (concentrations not to be exceeded during the 8-hr workday by workers) were considered. Two criteria were used in determining the priority for each class of values: 1) the rigor and quality of the scientific review, and 2) the appropriateness of the intended values with the application outlined in this document. Each source described above established values for a specific application. Descriptions of each are given below.

ERPGs intended for emergency planning and response operations have been developed by the AIHA. They are based on a weight-of-evidence evaluation and are reviewed at regular intervals as new information becomes available. Definitions of the three levels of ERPG values are:

- ERPG-1: The maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to 1 hour without experiencing more than mild, transient adverse health effects or without perceiving a clearly defined objectionable odor.
- ERPG-2: The maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to 1 hour without experiencing or developing

irreversible or other serious health effects or symptoms that could impair an individual's ability to take protective action.

- ERPG-3: The maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects.

The ERPGs are intended to protect most individuals in the general population but not particularly sensitive individuals (AIHA 1999). All populations have hyper-sensitive individuals who will show adverse effects at concentrations below these guidelines. For the development of the MAGs-S, ERPG values were applied to a typical deployment population. Therefore, the ERPG values were used above all other 1-hour values when available.

The AEGLs are intended to protect the general public, including sensitive sub-populations but not hypersensitive or hypersusceptible individuals (EPA 1997). They are derived for 30-minute, 1-hour, 4-hour, and 8-hour exposures. As with ERPGs, there are 3 levels:

- AEGL-1: The airborne concentration of a substance at or above which it is predicted that the general population (including "susceptible" but excluding "hyper-susceptible" individuals) could experience notable discomfort. Concentrations below AEGL-1 represent exposure levels that could produce mild odor, taste, or other sensory irritations.

- AEGL-2: The airborne concentration of a substance at or above which it is predicted that the general population (including "susceptible" but excluding "hyper-susceptible" individuals) could experience irreversible or other serious, long-lasting effects or impaired ability to escape.

- AEGL-3: The airborne concentration of a substance at or above which it is predicted that the general population (including "susceptible" but excluding "hyper-susceptible" individuals) could experience life-threatening effects or death.

The AEGL-1 values are protective of sensitive subpopulations and are derived using a weight-of-evidence method that commands a high degree of review. Since these values are currently draft values and may be more protective than required for a typical deployed population, AEGLs were selected when ERPG values were not available, yet they were selected over the following.

The DOE Subcommittee on Consequence Assessment and Protective Actions (SCAPA) has published TEELs for about 680 chemicals. They are based on the same levels set forth by AIHA and are designed to be interim ERPGs until final ERPG values can be established. TEELs are based on the correlation between acute data [e.g., lethal concentration, 50% (LC_{50}), lowest lethal

concentration (LC_{lo}), etc.] and existing values [e.g., Immediately Dangerous to Life and Health (IDLH)], Short-Term Exposure Limits (STELs), Threshold Limit Values (TLVs®) and the various levels of existing ERPGs (Craig et al. 1995, Craig and Lux 1998). These values were determined based on a hierarchy founded on the probability of these relationships (Craig et al. 1995). Therefore, TEELs were used when ERPGs or AEGLs were not available.

The three categories of risk addressed in TG 230A are consistent with the three categories presented by the AIHA/ERPG values. This provides the user with a range of concentrations from which to assess the severity of the situation.

Field Manual (FM) 100-14, *Risk Management*, lists four hazard severity levels: (1) negligible, (2) marginal, (3) critical, and (4) catastrophic. TG 230A's minimal effect level delineates to FM 100-14's negligible and marginal hazard severity effect levels in which concentrations below the minimal effect levels may be considered safe for most individuals. Individuals exposed to substance concentrations between TG 230A's minimal and significant effect levels correspond to FM 100-14's marginal hazard severity effect levels and may be considered to be in the marginal risk severity category where individuals may experience mild irritation or transient health effects. Individuals exposed to substance concentrations between TG 230A's significant effect levels and the severe effect levels may be considered to be in FM 100-14's critical risk hazard severity effect levels where individuals may experience irreversible health consequences that would impair their ability to take protective action. Likewise, individuals exposed to air concentrations exceeding TG 230A's severe effect levels are in the highest risk severity category of FM 100-14's catastrophic risk hazard severity level. Beyond this point, death may occur.

TLV® is a registered trademark of the American Conference of Governmental Industrial Hygienists, Cincinnati, Ohio. Use of the trademarked name does not imply endorsement by the U.S. Army but is intended only to assist in identification of a specific product.
Other available values that apply to specific levels are presented herein. The NRC/COT has developed EEGLs for emergency situations for deployed military personnel. One-hour and 24-hour EEGLs have been derived for many substances. The NRC/COT defines EEGLs as:

> A concentration of a substance in air that may be judged by DOD to be acceptable for the performance of specific tasks during rare emergency conditions.

The NRC/COT states that the EEGL is a peak level of exposure and should not be considered as "hygienic" or "safe" (NRC 1986a). The EEGLs were developed for rare emergency conditions and, therefore, represent levels that may cause more substantial effects than the primary levels cited by the preceding sources. This level of protection was equivalent to that of ERPG-2 and AEGL-2. It is for these reasons that EEGLs were considered as Level 2 values only when ERPG or AEGL values were not available since the latter are the more recent and considered the most current available toxicological data.

The SPEGLs are defined as "suitable concentrations for unpredicted, single, short-term, emergency exposure of the general public" (NRC 1986). Reproduction and developmental endpoints are considered. The SPEGL values were considered equivalent to minimal effect levels. Few SPEGLs applicable for TG 230A were found.

The IDLH values are published by the National Institute for Occupational Safety and Health (NIOSH). These represent 30-minute values that allow for a worker to escape injury or irreversible harm in the event of respiratory protection equipment failure. These values were revised in 1994. Not all of these values were revised based on new toxicity information. In the 1994 revision, NIOSH made an *a priori* determination not to publish values higher than the existing values. It is for this and other reasons that IDLH values were used only when ERPG-3 or AEGL-3 values were not available. The IDLH values are often equivalent to TEEL-3 values in most instances (Craig et al. 1995).

Therefore, the overall order of priority was: ERPGs > AEGLs > TEELs. The specific derivation including the criteria most important for value determination was evaluated for each substance. Special considerations were made for the specific selection of 1-hour values when conditions warranted (e.g., values based on dated toxicological information or reviews, unequal consideration of circumstances most applicable to military personnel, etc.). Some values were only applicable to a specific level of severity. For example, EEGLs were used to represent significant effect levels, and the SPEGLs were used to represent minimal effect levels, where appropriate. The TLV Ceiling values (ACGIH) were used to represent minimal effect levels considering the criteria and the logic for which they were based.
Further exceptions to the hierarchy were made for special chemicals such as chemical warfare agents and smokes and obscurants (various Army/DOD technical reports; Committee on Toxicology, *Toxicity of Military Smokes and Obscurants, Vol. 1*, 1997, etc.) and other situations where the published value was not consistent with the toxicological literature or with the levels set forth in this document. Other values that were available [e.g., OSHA Permissible Exposure Limits (PELs), NIOSH Recommended Exposure Limits (RELs), etc.] were not considered appropriate for inclusion based on the criteria presented above. The STELs were considered in the derivation of TEELs. However, STELs are presented for comparison purposes. Included in Appendix C are the present values selected, the source, the critical study or endpoints that were

considered most in value derivation, and any other pertinent notes. All other values applicable to the substance of concern are presented in the "Notes" column of Appendix C. Exceptions are also identified. See Section 3.3 for additional discussion of exceptions to the stated hierarchy. Minimal effect values were removed for substances that were less than the 1- to 14-day values. This occurred when either: 1) there were slight differences in the professional judgment used in the evaluation of these values, 2) The value was derived for detection purposes (e.g., "objectionable" odor), or 3) the value was based on studies involving sensitive individuals (e.g., asthmatics).

3.3 1- to 14-Day Values

These values were selected for continuous, 1- to 14-day exposures, consistent with a brief deployment or a brief exposure given specific information regarding source and ambient air dynamics. The potential variation in the properties and circumstances for both exposure and health effects for many substances can be significant in exposures of this duration (e.g., toxicological disposition, mode of action, environmental factors, etc.). The delineation of three levels of concern was not possible for exposures of 1 to 14 days. Consequently, these values represent exposures below which no significant adverse health effects are expected and above which the probability of adverse health effects are increased. The user is advised to review the 1-hour values to provide information of toxicity relating to concentration for a qualitative understanding of the potential slope of the dose-response curve for applications where concentrations exceed these 1- to 14-day values.

The NRC/COT has developed values for deployed military personnel for continuous exposures/deployments lasting up to 90 days (e.g., as in a submarine) (NRC 1986). In contrast to EEGLs, Continuous Exposure Guidance Levels (CEGLs) are not for use during emergencies but rather are intended to provide guidance for persistent exposures that should not cause serious or permanent effects. These values, when available, were the first selected.

The Agency for Toxic Substances and Disease Registry (ATSDR) has developed acute Minimal Risk Levels (MRLs) that are appropriate for continuous exposures from 1 to 14 days (ATSDR 1997). However, MRLs are derived using the no-observed adverse effect level (NOAEL) concentration and applying uncertainty factors (UFs) to extrapolate to the general population (including sensitive sub-populations but not hypersensitive individuals). The methodology used is consistent with that used by the EPA in the development of Reference Doses (RfDs). Since these values are based on a NOAEL, adverse effects may not occur as a result of exposures to concentrations that slightly exceed the MRL. It should be noted that carcinogenic endpoints were not considered in the development of MRLs. MRLs were used when CEGLs were not available.

The ACGIH has published TLVs that are effect based and consider the typical working population exposed 8 hrs/day, 5 days/week, 50 weeks/year for 30 years. ACGIH cautions against any other use. These TLVs are developed by the ACGIH Committee and are reviewed annually. Epidemiological data, as well as toxicological and toxicokinetic data, are used in the derivation of TLVs. Since occupational exposures can be chronic (i.e. exceeding 7 years), cancer is considered as an endpoint. Also considered is the 2/3 - (16-hour) daily break in exposure that may be important in the disposition of substances to which one is exposed in the workplace.

While there are published methods for mathematically extrapolating TLVs for variations in work schedules (Paustenbach 1994), none were found that addressed continuous (24-hour) exposures. Moreover, the mathematical extrapolation of values that are effects-based (i.e., a derivation of Haber's Law) may not be appropriate for strong irritants nor is this logic necessarily consistent with the determination of TLVs (i.e., toxicokinetic data are not always available, yet a threshold was determined). Therefore, as an interim measure, the following approach was used. The critical endpoints used by the ACGIH in deriving TLVs are paraphrased in Appendix D. Based on the predominant acute toxicological effects, these endpoints were categorized as "irritation-", "systemic-" or "mixed"-acting substances. A UF of 10 was applied to all TLVs that are systemic (or mixed) acting substances to account for differences in disposition between the 8-hour work schedule and a continuous exposure. This is consistent with the logic used by the COT in CEGL extrapolation (NRC 1986). Additional UFs were used for compounds that either have a steep dose response curve with some differences between doses that cause mild and serious effects (e.g., hydrogen cyanide) or for substances that may bioaccumulate given a constant rate of exposure, though it is recognized that ambient concentrations are unlikely to be consistent. If irritation can be significant and can occur at concentrations an order of magnitude lower than those which cause systemic effects, a UF was not necessarily applied. The UFs are 10 if not specifically indicated (see Appendix D). The TLVs for irritants were not adjusted and, as such, were assumed to be mostly concentration dependent. Other values, when available, are presented in Appendix D for comparison purposes. The order of priority for selection of 1- to 14-day values was CEGLs > MRLs > TLVs > Special Considerations.

Other values developed for occupational scenarios are available (e.g., OSHA PELs, and NIOSH RELs). Although these values serve regulatory purposes, TLVs were preferred given the methods used in their derivation, available documentation, and review that they undergo.

3.4 Special Chemicals

Concentration-dependent: Effects caused by some substances (e.g., irritants) are primarily concentration-dependent and should not be TWAs for short-term exposures. These substances often have Ceiling values (ACGIH). Since Ceiling values denote the threshold of irritant effects,

they were also considered as minimal effect values for 1-hour exposures. These Ceiling values may be presented as both 1-hour and 1- to 14-day MAGs-S where appropriate.

Absorbed through the skin: Some substances can be appreciably absorbed through the skin. These substances are noted with an "**s**" within Appendix D. Caution must be exercised when concentrations of these substances approach the MAGs-S since dermal absorption may contribute to the overall systemic dose and, as such, is not accounted for in these values. Specifically, airborne concentrations may be insufficient indicators of exposure because additional amounts of the chemicals can be introduced to the body via the skin.

Military-Unique Compounds. Guidelines for some military-unique chemicals were addressed in TG 230A. Specifically, guidelines were derived for chemical warfare agents and various smokes and obscurants. Existing values for military-unique substances were not available from the sources previously mentioned. However, comparable values were available through various military and NRC publications. The COT has reviewed the data for many military-unique substances (NRC 1997a, and NRC 1997b). Values such as SPEGLs and EEGLs were developed by the COT for some smokes and obscurants (NRC 1997a) and were included in TG 230A using the methods described above.

Values for chemical warfare agents were recently evaluated (NRC 1997b) and presented as values to be used in military exposure events; these are presented in the Table, *Comparison and Justification for the Derivation of 1-hour Values for Chemical Warfare Agents*. Since the data used to develop these values were based on offensive effectiveness of agent in the field, significant values were not derived. Therefore, only minimal and severe values are presented. Various methods were used to derive these values (NRC 1997b). The 1-hour minimal effect levels are an extrapolation of existing data based on Haber's Law concentration times time (Ct). The severe effect levels were selected from existing Army IDLH values except for HD for which no existing IDLH exists. For HD, therefore, a severe effects concentration term cited by the NRC was extrapolated to a 1-hour period based on the Haber's Law linear Ct model. The 1- to 14-day MAGs-S for chemical warfare agents were derived from the Army 8-hour TWA by applying a UF of 10. For VX, the general population limit (GPL), (U.S. Department of Health and Human Services, Centers for Disease Control 1988), was selected for use since application of a UF of 10 to the 8-hour TWA resulted in a value even lower than the GPL. This value is deemed protective for a sensitive population with a daily lifetime exposure. The values for the 1 hour and 1- to 14-day MAGs-S for Lewisite are cited as Ceiling values. The chemical warfare agent values used in military exposure events is presented in the Table on page 11:

Agent	Minimal Effects* mg/m^3	Notes	Severe Effects mg/m^3	Notes
Tabun (GA)	**0.008** (NRC 1997b)	Ct Mild = 0.5 mg-min/m^3; differences in exposure scenarios may be significant.	**0.1** (IDLH; Mioduszewski et al. 1998)	Ct severe = 50 mg-min/m^3. GA = 0.5 GB (Ocular: 0.07 – 0.5 mg/m^3; Inhalation: 0.13 – 0.7 mg/m^3; USACHPPM 1999).
Sarin (GB)	**0.008** (NRC 1997b)	Ct Mild = 1.0 mg-min/m^3; differences in exposure scenarios may be significant.	**0.1** (IDLH; Mioduszewski et al. 1998)	Ct severe = 25 mg-min/m^3. (Ocular: 0.07 – 0.5 mg/m^3; Inhalation: 0.07 – 0.35mg/m^3; USACHPPM 1999).
Soman (GD)	**0.003** (NRC 1997b)	Ct Mild = 0.2 mg-min/m^3; yet differences in exposure scenarios may be significant. Ocular toxicity: GD = 2.5 GB.	**0.05** (IDLH; Mioduszewski et al. 1998)	Ct severe = 25 mg-min/m^3; Low confidence in LCt_{50}; value based on structure-activity relationships, UF = 10 (0.04 mg/m^3). (ocular: 0.03 – 0.2 mg/m^3; Inhalation: 0.07 – 0.35mg/m^3; USACHPPM 1999).
VX	**0.0015** (NRC 1997b)	Ct Mild = 0.09 mg-min/m^3; human data support estimate.	**0.02** (IDLH; DA-PAM 40-8)	Ct severe = 10 mg-min/m^3; Insufficient data.
Sulfur Mustard (HD)	**0.42** (NRC 1997b)	Ct Mild = 25 mg-min/m^3.	**1.7** (NRC 1997b)	Ct severe = 100 mg-min/m^3.

*** NOTE**:
The minimal effects level and the severe effects level for HD were derived from values evaluated in NRC (1997) using a linear extrapolation Ct model for one hour. The cited Cts were established for 2-10 minutes. All Ct severe concentration terms (established for 2-10 minutes) were cited in NRC (1997).

Table – Comparison and Justification for the Derivation of 1-hour Values for Chemical Warfare Agents.

3.5 Ambient Air Quality

Particulates and Other Criteria Pollutants: The EPA uses six "criteria pollutants" as indicators of air quality and has established for each of them a maximum concentration above which adverse effects on human health may occur. These threshold concentrations are called the National Ambient Air Quality Standards (NAAQS). The criteria pollutants are ozone (O_3), particulates [particulate matter (PM_{10}) and ($PM_{2.5}$)], carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2) and lead (Pb). For most of the criteria pollutants, an allowable 24-hour TWA exposure limit was established for most of the criteria pollutants, although some have only annual averages and O_3 has 1- and 8-hour standards. Measured concentrations of the various pollutants can be compared to their respective threshold and various levels above this threshold. This generates a descriptive category of air quality called the Pollution Standard Index (PSI). Once the PSI is determined, precautionary statements regarding health effects can be made.

Currently, sampling efforts during some deployment operations effectively monitor some of the criteria pollutants. The following information was considered in preparing guidance on how to evaluate such data and the associated hazards. This information and information from the EPA (EPA 1998) were summarized in Section 4.5 of TG 230A.

Ozone: Ozone is a photochemical oxidant and the major component of smog. While O_3 in the upper atmosphere is beneficial to life by shielding the earth from harmful ultraviolet radiation from the sun, high concentrations of O_3 at ground level are a major health and environmental concern. O_3 is not emitted directly in the air but is formed through complex chemical reactions between precursor emissions of volatile organic compounds (VOCs) and oxides of nitrogen (NOx) in the presence of sunlight. Sunlight and temperature stimulate these reactions so that peak O_3 levels occur typically during the warmer times of the year. Transportation and industrial sources emit both VOCs and NOx. VOCs are emitted from sources as diverse as autos, chemical manufacturing, dry cleaners, paint shops, and other sources using solvents. The reactivity of O_3 causes health problems because it damages lung tissue, reduces lung function, and sensitizes the lung to other irritants. Scientific evidence indicates that ambient levels of O_3 not only affect people with impaired respiratory systems such as asthmatics but healthy adults and children as well. Exposure to O_3 for several hours at relatively low concentrations has been found to significantly reduce lung function and induce respiratory inflammation in normal healthy people during exercise. Symptoms including chest pain, coughing, sneezing, and pulmonary congestion generally accompany this decrease in lung function. For this reason, in the past the EPA has set O_3 standards for 1-hour and 8-hour intervals. The EPA is transitioning to a more conservative 8-hour standard and revoking the 1-hour standard in those areas of the U.S. which are currently in attainment.

Particulate Matter: Air pollutants called PM include dust, dirt, soot, smoke, and liquid droplets directly emitted into the air by sources such as factories, power plants, cars, construction activity, fires, and natural windblown dust. Particles formed in the atmosphere by condensation or the transformation of emitted gases such as SO_2 and VOCs are also considered PM.

Based on studies of human populations exposed to high concentrations of particles and laboratory studies of animals and humans, there are major effects of concern for human health. These include effects on breathing and respiratory symptoms, aggravation of existing respiratory and cardiovascular disease, alterations in the body's defense systems against foreign materials, damage to lung tissue, carcinogenesis, and premature death. The major subgroups of the population that appear to be the most sensitive to the effects of PM include individuals with chronic obstructive pulmonary disease or cardiovascular disease, influenza and asthmatics, the elderly, and children.

Annual and 24-hour NAAQS for PM were first set in 1971. Total suspended particulate was the first indicator used to represent suspended particulates. Since 1 July 1987, however, the EPA has used the indicator PM_{10} that includes only those particles with an aerodynamic diameter smaller than 10 microns. These particles are small enough to reach the thoracic or lower regions of the respiratory tract. Currently, the EPA has transitioned into the use of $PM_{2.5}$ as research has supported that particles in this size range are responsible for most of the adverse health effects due to penetration into the lower regions of the respiratory tract.

Annual and 24-hour NAAQS are available for both PM_{10} and $PM_{2.5}$ at this time. An assessment of either level can be used to categorize air quality and define the PSI. It is important to note that particulates measured for ambient air quality are considered "generic" particles in that the concentration of particles is measured, but no assessment of source or composition is made. In sandy environments with high wind, particulate levels will reflect airborne sand particles, while in other settings, particulate levels might be more influenced by industrial emissions. It is also important to note that for various, specific industrial processes which generate particles, specific health-based standards may exist reflecting knowledge of the health effects of specific particles.

Carbon monoxide: CO is a colorless, odorless, and poisonous gas produced by incomplete burning of carbon in fuels. When CO enters the bloodstream, it reduces the delivery of oxygen to the body's organs and tissues. Health threats are most serious for those who suffer from cardiovascular disease, particularly those with angina or peripheral vascular disease. Exposure to elevated CO levels can cause impairment of visual perception, manual dexterity, learning ability, and the performance of complex tasks. Other major CO sources are wood-burning stoves, incinerators, and industrial sources. The CO standard is an 8-hour standard.

Sulfur dioxide: High concentrations of SO_2 affect breathing and may aggravate existing respiratory and cardiovascular disease. Sensitive populations include asthmatics, individuals with

bronchitis or emphysema, children, and the elderly. SO_2 is also a primary contributor to acid deposition or acid rain which causes acidification of lakes and streams and can damage trees, crops, and buildings. In addition, sulfur compounds in the air contribute to visibility impairment. Ambient SO_2 results largely from stationary sources such as coal and oil combustion, steel mills, refineries, pulp and paper mills and from nonferrous smelters.

There are two health-based NAAQS for sulfur dioxide. The first is an annual arithmetic mean of 0.03 parts per million (ppm) [80 micrograms per cubic meter ($\mu g/m^3$)]; the 24-hour level is 0.14 ppm (365 $\mu g/m^3$).

Nitrogen dioxide: NO_2 is a brownish, highly reactive gas that is present in all urban atmospheres. NO_2 can irritate the lungs, cause bronchitis and pneumonia, and lower resistance to respiratory infections. NO_x are an important precursor both to O_3 and acid rain and may affect both terrestrial and aquatic ecosystems. The major mechanism for the formation of NO_2 in the atmosphere is the oxidation of the primary air pollutant NO_2. NO_x, together with VOCs, play a major role in the atmospheric reactions that produce O_3. NO_x form when fuel is burned at high temperatures. The two major emission sources are transportation and stationary fuel combustion sources such as electric utility and industrial boilers. The NAAQS for NO_2 is an annual average. NO_2 can generate a PSI only if measured at levels above 0.65 ppm. A PSI over 200 ppm means a very unhealthy category.

SECTION 4 – MILITARY WATER GUIDELINES – SHORT TERM (MWGs-S)

4.1 Sources of Chemicals and Guidelines in TG 230A Appendix D

The chemicals included in Appendix D of TG 230A were primarily taken from two sources: EPA Drinking Water Regulations and Health Advisories (1996), and DOD Technical Bulletin, Medical (TB MED) 577 (1996). All the compounds with short-term water standards in TB MED 577 were included in the list as were all the compounds with short-term Health Advisories in the EPA document. [Note that compounds for which the EPA has developed Maximum Contaminant Levels (MCLs) but not Health Advisories do not appear in Appendix E]. Seven compounds were included in Appendix D of TG 230A that were considered to be medium or high priority (Stuempfle et al. 1998). Guidelines for compounds selected from the International Task Force (ITF)-25 list that did not have EPA Health Advisories or TB MED 577 standards were derived from the ATSDR acute oral MRLs.

4.2 Prioritization of Chemicals

Compounds in Appendix D of TG 230A were categorized according to the likelihood of being encountered overseas. Several sources were used for the categorization (see footnotes to Appendix E of this document). Sources were investigated which provided prevalence of chemicals in industrial effluents (the EPA Toxic Release Inventory) and in effluents from superfund sites (ATSDR). Pesticides used internationally were identified using sources such as the World Health Organization (WHO) and other United Nations agencies. ITF-25 list was used to identify widely used industrial chemicals. The data obtained from this endeavor are shown in Appendix E of this document.

Compounds were divided into four categories based on these findings: High Priority, Medium Priority, Low Priority, and Unknown. While prevalence was the major factor used in prioritizing compounds, some weight was given to the toxicity of the compounds. For example, the 5-day or 2-week MWGs-S that were less than 1 milligram per Liter (mg/L) were considered High Priority compounds. Additionally, with the exception of BZ and T-2 toxin, which were not believed to be a substantial threat, all of the compounds with standards in TB MED 577 were ranked as High Priority. High Priority compounds will vary from area to area depending on the prevalent industries and/or farm crops. Munitions and their by-products were ranked as Medium Priority because, for the most part, exposure to substantial levels of these compounds in water is likely to be confined to the environment surrounding munitions plants.

Compounds placed in the Unknown category were not identified as prevalent compounds in any of the sources used. This does not necessarily reflect the probability of their being encountered in water. For example, there are some pesticides and industrial compounds in this category that are widely used in the U.S. and are likely to be used in industrial and agricultural practices in other areas.

4.3 Derivation of Short-Term Water Guidelines

The majority of the MWGs-S were derived from the EPA 1-day and 10-day Health Advisories. The EPA derives Health Advisories by dividing the NOAEL [or the lowest-observed adverse effect level (LOAEL) when a NOAEL is not available] from an appropriate human or animal study by standard NAS/Office of Drinking Water UFs and multiplying by body weight over the daily drinking water consumption rate [NOAEL/UF x kilogram (kg) body weight/liters consumed]. The short-term EPA Health Advisories were derived for a 10 kg child consuming 1 Liter water/day. The MWGs-S were derived using the same NOAEL and UFs used by the EPA and a body weight of 70 kg with daily consumption rates of 5 Liters or 15 Liters water. Note that the original source documents for the EPA Health Advisories were used rather than values in

Drinking Water Standards and Health Advisories table because the latter values have been rounded up or down.

A few MWGs-S were derived from ATSDR acute oral MRLs (see Appendix E). These were adjusted for daily consumption rates in a similar fashion. Fourteen of the MWGs-S were taken from standards published in TB MED 577. No adjustments were required for these standards, and they were adopted unmodified.

4.4 The Military Adjustment Factor

The EPA Health Advisories were developed to protect the civilian population and incorporated UFs of 10 to protect the more sensitive constituents (e.g., children, the elderly, and the infirm) of the civilian population. While we had initially considered applying a "military adjustment factor" (MAF) of 10 to the EPA Health Advisories to account for the more homogeneous population represented by deployed military personnel, the SECWG decided to use a more conservative approach in adapting the Health Advisories to guidelines for the military population. Thus, the MAF was limited to 3 and was only applied in cases where it could be solidly justified. The rationale for using an MAF for each of the compounds to which it has been applied is discussed below.

Examples of when an MAF may (or may not) be applied are as follows:

- An MAF may be used when the EPA Health Advisory was derived from a NOAEL and the effects at the LOAEL are minimal.

- An MAF may be applied to reproductive and developmental toxicants if doing so would not introduce a risk to the developing fetus or to fertility (e.g., if developmental effects are observed only at doses toxic to the dam or at doses higher than the LOAEL of the critical study).

- An MAF may be applied if short-term Health Advisories were derived from minor effects observed at the LOAEL in subchronic and chronic studies.

- An MAF will not be applied to TB MED 577 standards, carcinogens, chemical warfare agents, or compounds with steep dose/response curves.

Ammonium Sulfamate: An MAF is recommended for ammonium sulfamate because the short-term Health Advisory was based on a 90-day rat study in which only minimal effects were observed at the LOAEL (500 mg/kg/day). The only significant effect observed at the LOAEL was weight loss with no changes in organ to body weight ratios. (Slight fatty degeneration of the liver was observed in one rat at the LOAEL).

Supporting data: Two other oral rat studies showed no effects at doses equal to or greater than the LOAEL of the critical study. (In the first study, no effects were seen at 500 mg/kg/day after 19 months of exposure; in the second study, no effects were seen after 105 days of exposure to 10 g/kg/day.)

No data were available for mutagenicity, carcinogenicity, or developmental or reproductive effects.

An MAF of 3 was applied to the short-term Health Advisories for ammonium sulfamate because the short-term Health Advisory was based on a 90-day rat feeding study in which only mild effects were observed at the LOAEL.

The 1-day and 10-day Health Advisories of 75 mg/L were adjusted to 50 and 15 Liter consumption rates to yield MWGs-S of 30 and 10, respectively. The values were then multiplied by the MAF of 3 to produce final values of 90 and 30 mg/L for 5 and 15 Liter consumption rates, respectively. MAFs were applied in the same fashion to the Health Advisories for other chemicals discussed below.

Hexazinone: An MAF was applied because the short-term Health Advisory was based on a 90-day rat feeding study in which only mild effects were observed at the LOAEL.

- NOAEL = 25 mg/kg/day
- LOAEL = 125 mg/kg/day

Effects observed at the LOAEL: Weight loss, slightly elevated liver weight, increased alkaline phosphatase, decreased albumin/globulin ratio.

Supporting data: A NOAEL of 375 mg/kg/day was identified in an 8-week rat study (increased absolute and relative liver weights were the only effects observed at the LOAEL of 1500 mg/kg/day).

- Developmental effects (rat): NOAEL = 50 mg/kg/day; LOAEL = 250 mg/kg/day (effects observed: lower pup weight, no malformations).

- Developmental effects (rabbit): NOAEL (highest dose tested) = 125 mg/kg/day.

Diisopropyl methylphosphonate (DIMP) : The longer-term (1-year) Health Advisory for a 10 kg child was used by the EPA for the 1-day and 10-day Health Advisories. The critical study was a 90-day feeding study in dogs at doses of 0, 150, 1500, or 3000 ppm DIMP in the diet

(equivalent to 0, 3.75, 37.5, or 75 mg/kg/day). No effects were seen at the highest dose (75 mg/kg/day), which was considered to be the NOAEL.

Supporting data: NOAELs of 150 and 315 mg/kg/day, the highest doses tested, were observed in 90-day feeding studies conducted in rats and mice, respectively.

A NOAEL of 135 mg/kg/day (highest dose tested) was observed in a three-generation rat feeding study.

No developmental effects were observed in offspring of rats fed 0, 5, 15, or 150 mg/kg/day on days 6 through 15 of gestation.

An MAF of 3 was applied to account for the shorter exposure duration associated with the MWG-S. Even with this MAF, the MWG-S for DIMP is highly conservative.

Isopropyl methylphosphonate (IMP): The longer-term (1-year) Health Advisory for a 10 kg child was used for the 1-day and 10-day Health Advisories. The critical study was a 90-day rat-drinking water study at doses of 300, 1000, or 3000 ppm IMP in water. No effects were seen at the highest dose (3,000 ppm) which was considered to be the NOAEL.

An MAF of 3 was applied to account for the shorter exposure duration associated with the SWG-S.

No data were available for carcinogenicity or developmental or reproductive effects. Mutagenicity assays have been negative.

APPENDIX A

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APPENDIX B

ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygienists
AEGLs	Acute Exposure Guidelines Levels
AIHA	American Industrial Hygiene Association
ATSDR	Agency for Toxic Substances and Disease Registry
CEGLs	Continuous Exposure Guidance Levels
CNS	Central Nervous System
CO	Carbon monoxide
COT	Committee on Toxicology
Ct	Concentration times time
DIMP	Diisopropyl methyl phosphonate
DOD	Department of Defense
DOE	Department of Energy
EEGLs	Emergency Exposure Guidance Levels
EPA	Environmental Protection Agency
ERPGs	Emergency Response Planning Guidelines
FM	Field Manual
g	gram
GPL	General Population Limit
IDLH	Immediately Dangerous to Life and Health
IMP	Isopropyl methyl phosphonate
ITF	International Task Force
kg	kilogram
LC_{50}	Lethal Concentration, 50%

LC_{lo}	Lowest Lethal Concentration
LOAEL	Lowest-Observed Adverse Effect Level
MAF	Military Adjustment Factor
MAGs-S	Military Air Guidelines – Short Term
MCLGs	Maximum Contaminant Level Goals
MCLs	Maximum Contaminant Levels
MEDCOM	Medical Command
µ	micro
µg/m^3	micrograms per cubic meter
µm	micrometer
mg	milligram
mg/kg	milligram per kilogram
mg/kg/day	milligram per kilogram per day
mg/L	milligrams per Liter
mg/m^3	milligrams per cubic meter
MRLs	Minimum Risk Levels
MTD	Maximum Tolerated Dose
MWGs-S	Military Water Guidelines – Short Term
NAAQS	National Ambient Air Quality Standards
NAS	National Academy of Sciences
NIOSH	National Institute of Occupational Safety and Health
NOAEL	No-Observed Adverse Effect Level
NO_x	Oxides of nitrogen

NO_2	Nitrogen dioxide
NRC	National Research Council
O_3	Ozone
OSHA	Occupational Safety and Health Agency
PELs	Permissible Exposure Levels
PM	Particulate Matter
ppm	Parts per million
PSI	Pollution Standard Index
RfD	Reference Dose
SECWG	Soldier Exposure Criteria Workgroup
SCAPA	Subcommittee on Consequence Assessment and Protective Actions
SME	Subject Matter Expert
SO_2	Sulfur dioxide
SPEGLs	Short-term Public Emergency Guidance Levels
STELs	Short-term Exposure Limits
TB MED	Technical Bulletin, Medical
TEELs	Temporary Emergency Exposure Limits
TG	Technical Guide
TLV	Threshold Limit Value
TWA	Time-Weighted Average
UF	Uncertainty Factor
USACHPPM	U.S. Army Center for Health Promotion and Preventive Medicine
VOC	Volatile Organic Compound

APPENDIX C

MILITARY AIR GUIDELINES – SHORT TERM (MAGs-S) (1-HOUR VALUES) TABLE

Compound	1-Hour MAGs-S ppm (mg/m^3)			Notes	Other Values
	Minimal effects level	**Significant effects level**	**Severe effects level**		
Acetone cyanohydrin 75-86-5	**4.7**[C] (16.4)	**ND**	**ND**	Dermal exposures can contribute to systemic dose. Ceiling value derived as CN.	Only acute value available.
Acrolein 107-02-8	**0.1** (0.23) (ERPG-1)	**0.5** (1.15) (ERPG-2)	**3** (6.9) (ERPG-3)	Concentrations of 0.06 ppm for 5 min caused irritation in humans.	EEGL – 0.05 ppm; Ceiling value – 0.1 ppm, IDLH – 2 ppm.
Acrylonitrile 107-13-1	**10** (22) (ERPG-1)	**35** (76) (ERPG-2)	**75** (163) (ERPG-3)	Lethality was observed in dogs after exposure to 65 ppm for 4 hrs.	IDLH – 85 ppm.
Aldrin 309-00-2	**ND**	**ND**	(25) (IDLH)	Based on oral data; 18 mg/m^3/day caused no effects in man; ingestion of 25.6 mg/kg caused convulsions in 20 min (extrapolated: 1200 mg/m^3 for 30 min) (NIOSH 1994).	No other acute values available.
Allyl alcohol 107-18-6	**4** (9.5) (TEEL-1)	**15** (36) (TEEL-2)	**20** (48) (TEEL-3)	NIOSH (1994) notes that inferences from animal experiments suggest that single 1-hour exposures of 150 ppm may be fatal, yet exposures to 100 ppm would probably allow survival.	STEL - 4 ppm; IDLH - 20 ppm.
Ammonia 7664-41-7	**25** (17) (ERPG-1)	**200** (139) (ERPG-2)	**1000** (696) (ERPG-3)	Minimal effect levels based on eye and respiratory irritation; significant to severe irritation in subjects exposed to 500 ppm for 0.5 hrs (NIOSH 1994).	STEL - 35 ppm; EEGL – 100 ppm; IDLH – 300 ppm.
Arsine 7784-42-1	**NA**	**0.5** (1.6) (ERPG-2)	**1.5** (4.8) (ERPG-3)	Levels based on methemoglobin synthesis and hemolysis (and subsequent renal effects); NIOSH (1994) states that 6 – 30 ppm is maximum concentration for 1 hr without serious consequences.	EEGL – 1 ppm; IDLH – 3 ppm.

* Notes for table on page C-14

Compound	1-Hour MAGs-S ppm (mg/m^3)			Notes	Other Values
	Minimal effects level	**Significant effects level**	**Severe effects level**		
Benzene 71-43-2	**50** (160) (ERPG-1)	**150** (479) (ERPG-2)	**1000** (3195) (ERPG-3)	Exposure at 1500 ppm for 1 hr induces serious symptoms; exposure at 500 ppm for 1 hr leads to symptoms of illness; exposure at 150 ppm for 5 hrs produces headache, lassitude, and weakness (NIOSH 1994).	STEL - 2.5 ppm; EEGL – 50 ppm; IDLH – 500 ppm.
Boron tribromide 10294-33-4	**1**[C] (10)	**ND**	**ND**	Considered primary irritant (see Appendix D). Minimal effect levels based on NOAEL in rats; rats exposed for 6 hrs/day, 5 days/wk for 3 months produced transient signs of irritation; rounded up to be consistent with the 1-14 day value.	Ceiling value – 10 mg/m^3.
Boron trifluoride 7637-07-2	**1** (20) (ERPG-1)	**11** (30) (ERPG-2)	**36** (100) (ERPG-3)	Considered primary irritant (see Appendix D).	No other acute values available.
Bromine 7726-95-6	**0.2** (1.3) (ERPG-1)	**1** (6.5) (ERPG-2)	**5** (33) (ERPG-3)	Concentrations above 10 ppm cause severe upper respiratory irritation; 1.7 – 3.5 ppm produces severe choking; 30 ppm would be fatal in a short duration (NIOSH 1994).	STEL - 0.2 ppm; IDLH – 3 ppm.
Butyl isocyanate (n-) 111-36-4	**0.01** (0.04) (ERPG-1)	**0.05** (0.2) (ERPG-2)	**1** (4.1) (ERPG-3)	A 4-hr LC_{01} for rats was 6.8 ppm. Concentrations of 0.1 – 1 ppm produce irritation to the respiratory tract and mucous membranes (AIHA 1999).	No other acute values available.
Carbon disulfide 75-15-0	**1** (3.1) (ERPG-1)	**50** (156) (ERPG-2)	**500** (1557) (ERPG-3)	Exposures to 4800 ppm for 30 min cause coma and is fatal; severe symptoms and unconsciousness may occur within 30 min at 1100 ppm; 760 ppm causes an immediate headache that lasts for hrs (NIOSH 1994).	EEGL – 50 ppm; IDLH – 500 ppm.

Compound	1-Hour MAGs-S ppm (mg/m^3)			Notes	Other Values
	Minimal effects level	Significant effects level	Severe effects level		
Carbon monoxide 630-08-0	**200** (229) (ERPG-1)	**350** (286) (ERPG-2)	**500** (572) (ERPG-3)	1-hr exposures to 1000 – 1200 ppm will cause unpleasant but no dangerous symptoms; 1500 – 2000 may be dangerous after 1 hr.	IDLH – 1200 ppm; EEGL – 400 ppm.
Carbon tetrachloride 56-23-5	**20** (126) (ERPG-1)	**100** (629) (ERPG-2)	**750** (4719) (ERPG-3)	Exposures to 1000 – 2000 ppm for 0.5 – 1.0 hrs have caused human fatalities and kidney damage; 30-min exposure to 300 ppm causes symptoms of intoxication (NIOSH 94).	Above odor threshold; STEL – 10 ppm; IDLH – 200 ppm.
Chlorine 7782-50-5	**1** (2.9) (ERPG-1)	**3** (8.7) (ERPG-2)	**20** (58) (ERPG-3)	Exposures of 30 min cause intense coughing fits; a concentration of 34 – 51 ppm has been reported to be fatal in 1 – 1.5 hrs.	STEL – 1 ppm; EEGL – 3 ppm; IDLH – 10 ppm
Chlorine trifluoride 7790-91-2	**0.1** (0.4) (ERPG-1)	**1** (3.8) (ERPG-2)	**10** (38) (ERPG-3)	Exposures of 50 ppm for 0.5 – 2 hrs may be fatal.	EEGL – 1 ppm; Ceiling value – 0.1 ppm; IDLH – 20 ppm.
Chloroacetaldehyde 107-20-0	**1**[C] (3.2)	**22** (71) (TEEL-2)	**45** (144) (TEEL-3)	Volunteers found that concentrations of 45 ppm were very disagreeable, and conjuctival irritation was noted (NIOSH 1994).	IDLH – 45 ppm.
Chloroacetone 78-95-5	**1**[C] (3.8)	**ND**	**ND**	Concentration of 605 ppm is lethal after a 10-min exposure and 26 ppm is intolerable after a 1-min exposure (ACGIH 1991).	No other acute values available.
Chloroacetophenone [CN] 532-27-4	**ND**	**ND**	(15) IDLH	Concentration of 31 mg/m^3 is intolerable after 3 min (NIOSH 1994).	IDLH – 15 mg/m^3.
Chloroacetyl chloride 79-04-9	**0.1** (0.46) (ERPG-1)	**1** (4.6) (ERPG-2)	**10** (46) (ERPG-3)	Exposures exceeding 0.14 ppm may cause slight eye irritation and respiratory irritation.	STEL – 0.15 ppm.
Chlorobenzylidene malonitrile o- [CS] 2698-41-1	**0.05**[C] (0.39)	**ND**	**0.26** (2) (IDLH)	Incapacitating concentration range from 12 – 20 mg/m^3 after 20 seconds of exposure (NIOSH 1994).	No other acute values available.

Compound	1-Hour MAGs-S ppm (mg/m^3)			Notes	Other Values
	Minimal effects level	Significant effects level	Severe effects level		
Chloroform 67-66-3	**NA**	**50** (244) (ERPG-2)	**5000** (24,400) (ERPG-3)	Disorientation occurs at concentrations exceeding 1000 ppm (NIOSH 1994).	REL 1 – 0.74 ppm; EEGL – 1000 ppm; IDLH 500 ppm.
Crotonaldehyde 4170-30-3	**2** (5.7) (ERPG-1)	**10** (28.6) (ERPG-2)	**50** (143) (ERPG-3)	Exposure to 4.1 ppm for 15 min was reported to be highly irritating to the nose and upper respiratory tract (NIOSH 1994).	IDLH – 50 ppm.
Cyanogen 460-19-5	**30** (64) (TEEL-1)	**50** (107) (TEEL-2)	**50** (107) (TEEL-3)		No other acute values available.
Diborane 19287-45-7	**0.3** (0.34) (TEEL-1)	**1** (1.13) (ERPG-2)	**3** (3.4) (ERPG-3)	Dogs experienced minor irritation at 1 ppm for 1 hr (AIHA 1999). AIHA determined odor threshold insufficient to derive a minimal effect levels.	IDLH – 15 ppm.
Dichloroethane (1,1-) 75-34-3	**ND**	**ND**	**3000** (12,144) (IDLH)	Rats survived 4-hr exposures of 4000 ppm but not 16000 ppm; may cause narcosis at lower concentrations (NIOSH 1994).	No other acute values available.
Dieldrin 75-34-3	(0.75) (TEEL-1)	(1.25) (TEEL-2)	(50) (IDLH)	Lethal oral dose = 5 g (equivalent to 3300 mg/m^3 for 30 min); (NIOSH 1994).	No other acute values available.
Diesel fuel smoke	(8) (SPEGL)	(80) (EEGL)	**ND**	No irritant effects in humans; pulmonary inflammation in rats (NRC[a]).	No other acute values available.
Diketene 674-82-8	**1** (3.4) (ERPG 1)	**5** (17) (ERPG 2)	**50** (172) (ERPG 3)	Serious signs of toxicity observed in rats at 250 ppm surviving a 1-hr exposure (AIHA 1999).	No other acute values available.
Dimethyl sulfate 77-78-1	**0.3** (1.5) (TEEL-1)	**1** (5.2) (TEEL-2)	**7** (36) (IDLH)	20-min exposures to 13 ppm caused severe symptoms in monkeys; death (LC_{50}) in guinea pigs at 75 ppm (NIOSH 1994).	No other acute values available.

Compound	1-Hour MAGs-S ppm (mg/m^3)			Notes	Other Values
	Minimal effects level	**Significant effects level**	**Severe effects level**		
Endrin 72-20-8	(0.3) (TEEL-1)	(2) (TEEL-2)	(2) (IDLH)	Oral dose of 171 mg/kg is lethal; 0.2 mg/kg may cause convulsions (equivalent to 8000 ppm and 9 ppm, respectively); (NIOSH 1994).	No other acute values available.
Ethyl benzene 100-41-4	**125** (542) (TEEL-1)	**125** (542) (TEEL-2)	**800** (3474) (IDLH)	Dizziness may occur after 5 min of exposure to 2000 ppm (NIOSH 1994). IDLH based on $1/10^{th}$ lower explosive limit.	STEL – 125 ppm; no other acute values available.
Ethylenimine 151-56-4	**1.5** (2.64) (TEEL-1)	**23** (4.0) (TEEL-2)	**100** (176) (IDLH)	Powerful lacrimator and emetic; exposures exceeding 100 ppm have caused respirator irritation and inflammation, yet symptoms may be delayed several hours (NIOSH 1994).	No other acute values available.
Ethylene oxide 75-21-8	**7.5** (14) (TEEL-1)	**50** (90) (ERPG-2)	**500** (900) (ERPG-3)	Exposures above 2000 ppm have caused headache, nausea, vomiting, dyspnea, and respiratory irritation; concentrations > 1 hr at 2000 ppm may be fatal (NIOSH 1994). AIHA determined insufficient data to derive a minimal effect level.	IDLH – 800 ppm.
Fluorine 7782-41-4	♦	**5** (7.8) (ERPG-2)	**20** (31) (ERPG-3)	Concentrations of 25 ppm have been tolerated briefly, yet both volunteers developed sore throats and chest pains that lasted 6 hrs; 50 ppm could not be tolerated (NIOSH 1994). Minimal effect levels based on objectionable odor threshold, yet repeated exposures to workers of 10 ppm has been reported to be well tolerated (AIHA 1999).	EEGL – 7.5 ppm; STEL – 2 ppm; IDLH – 25 ppm; ERPG-1 – 0.5 ppm.
Fog oil smoke	(9) (SPEGL)	(90) (EEGL)	**ND**	Based on Shoshkes, et al. (1950). Haber's law applied based on the similarity of fog-oil and diesel-fuel smokes (*in* NRC[a]).	No other acute values available.

Compound	1-Hour MAGs-S ppm (mg/m^3)			Notes	Other Values
	Minimal effects level	**Significant effects level**	**Severe effects level**		
Formaldehyde 50-00-0	**1** (1.2) (ERPG-1)	**10** (12.3) (ERPG-2)	**25** (31) (ERPG-3)	5 to 10 min exposures to 50 – 100 ppm may cause serious injury to the lower respiratory tract; many volunteers could not tolerate prolonged exposures to 4 - 5 ppm (NIOSH 1994).	ACGIH ceiling – 0.3 ppm; IDLH – 20 ppm.
GA **(Tabun)** 77-81-6	(0.01)	**ND**	(0.1)	Based on acetyl cholinesterase activity determined through miosis. Ct for one hour extrapolated from a 10-min exposure (see text for more information); (NRC[b]).	No other acute values available.
GB **(Sarin)** 107-44-8	(0.008)	**NA**	(0.1)	Minimal effect levels based on acetyl cholinesterase activity determined through miosis. Ct for 1 hr extrapolated from a 10-min exposures. Severe effect levels based on IDLH (see text for more information); (NRC[b]).	No other acute values available.
GD **(Soman)** 96-64-0	(0.003)	**NA**	(0.05)	Based on acetyl cholinesterase activity determined through miosis. Ct for 1 hr extrapolated from a 10-min exposure. Severe effect levels based on IDLH (see text for more information); (NRC[b]).	No other acute values available.
Hexachlorobutadiene 87-68-3	**3** (32) (ERPG-1)	**10** (107) (ERPG-2)	**30** (320) (ERPG-3)	Less than odor threshold; concentrations of 23 ppm (245 mg/m^3) produced strong odors; 1 ppm (10 mg/m^3), faint.	No other acute values available.
Hexachlorocyclopentadiene 77-47-4	**0.02** (0.22) (TEEL-1)	**0.02** (0.22) (TEEL-2)	**0.02** (0.22) (TEEL-3)	TEEL 1 – 3 values identical based on limited data.	No other acute values available.

Compound	1-Hour MAGs-S ppm (mg/m^3)			Notes	Other Values
	Minimal effects level	Significant effects level	Severe effects level		
Hexachloroethane smoke 67-72-1	(0.3) (SPEGL)	(3) (EEGL)	**ND**	Based on reports from acute human inhalation exposures (NRC[a]).	IDLH – 300 ppm (based on oral toxicity); deemed not appropriate for use.
Hexane 110-54-3	**150** (528) (TEEL-1)	**250** (880) (TEEL-2)	**1100** (3872) (TEEL-3)	Exposures of 10 min to 5000 ppm caused dizziness and a feeling of giddiness (NIOSH 1994).	IDLH – 1100 ppm; STEL – 1000 ppm.
Hydrazine 302-01-2	**0.3** (0.4) (TEEL-1)	**0.8** (1) (TEEL-2)	**10** (13) (TEEL-3)	Exposures of 4 hr to 80 – 300 ppm was lethal to rats (NIOSH 1994).	IDLH – 50 ppm; SPEGL – 0.12 ppm.
Hydrogen bromide 10035-10-6	**3** (9.9 (TEEL-1)	**3** (9.9) (TEEL-2)	**30** (99) (TEEL-3)	Exposures of 1300 – 2000 ppm may be lethal in exposures lasting a few minutes; 2 – 6 ppm has been reported to cause nose and throat irritation (NIOSH 1994).	IDLH – 30 ppm; ACGIH Ceiling – 3 ppm.
Hydrogen chloride 1333-74-0	♦	**20** (30) (ERPG-2)	**150** (223) (ERPG-3)	Concentrations of 35 ppm caused throat irritation; 50 – 100 ppm are barely tolerable (NIOSH 1994). Concentrations exceeding 3 ppm may produce discomfort in asthmatics.	IDLH - 50 ppm; ACGIH Ceiling – 5 ppm; EEGL – 20 ppm; ERPG-1 – 3 ppm.
Hydrogen cyanide 74-90-8	**4.7** (5.2) (TEEL-1)	**10** (11) (ERPG-2)	**25** (27) (ERPG-3)	Concentrations of 45 – 54 ppm may be tolerable for 0.5 – 1.0 hr; 110 – 135 ppm may be fatal after 0.5 – 1.0 hr or later (NIOSH 1994).	IDLH – 50 ppm; ACGIH Ceiling – 4.7 ppm.
Hydrogen fluoride 7664-39-3	♦	**20** (16.4) (ERPG-2)	**50** (41) (ERPG-3)	Concentrations of 50 ppm for 30 – 60 min may be fatal; volunteers tolerated 4.7 ppm for 6 hrs/day for 10 – 50 days (NIOSH 1994).	IDLH – 30 ppm; ACGIH Ceiling – 3 ppm; EEL – 8 ppm; ERPG-1 – 0.1 ppm.
Hydrogen selenide 7783-07-5	**ND**	**ND**	**1** (3.3) (IDLH)	IDLH based on Se; human data used.	No other acute values available.

Compound	1-Hour MAGs-S ppm (mg/m^3)			Notes	Other Values
	Minimal effects level	Significant effects level	Severe effects level		
Hydrogen sulfide 7783-06-4	♦	**30** (42) (ERPG-2)	**100** (140) (ERPG-3)	Concentrations of 170 to 300 ppm are the maximum tolerated concentrations for 1-hr without serious consequences; olfactory fatigue occurs at 100 ppm (NIOSH 1994). Minimal effect levels based on objectionable odor at 0.3 ppm.	IDLH – 100 ppm; STEL – 15 ppm, EEGL (10 min) – 50 ppm; ERPG-1 – 0.1 ppm.
Lewisite 541-25-3	(0.003^C)	**ND**	**ND**	Irritation: eye and mucous membrane.	No other acute values available.
Lindane 58-89-9	(1.5) (TEEL-1)	(50) (TEEL-2)	(50) (IDLH)	IDLH value based on acute oral data; oral doses of 150 mg/kg have been associated with grand-mal seizures (equivalent to 7000 mg/m^3 for 30 min) (NIOSH 1994).	No other acute values available.
Methyl bromide 74-83-9	**15** (58.3) (TEEL-1)	**50** (195) (ERPG-2)	**200** (777) (ERPG-3)	AIHA determined ERPG-1 was NA based on the lack of detectable odor at low concentrations (poor warning properties). NIOSH (1994) reports that concentrations of 200 ppm may be endured for several hours without serious effects; data mixed.	IDLH – 250 ppm.
Methylene chloride 75-09-2	**200** (695) (ERPG-1)	**750** (2600) (ERPG-2)	**4000** (13,880) (ERPG-3)	Data variable: vertigo, dizziness, nausea may occur at concentrations above 2300 ppm (NIOSH 1994).	IDLH – 2300 ppm.
Methyl isocyanate 624-83-9	**0.025** (0.06) (ERPG-1)	**0.5** (1.17) (ERPG-2)	**5** (11.7) (ERPG-3)	Mild, transient eye irritation possible above Minimal effects level. Eye irritation and lacrimation at 5 ppm in less than 50 seconds; unbearable at 21 ppm (NIOSH 1994).	IDLH – 3 ppm.

Compound	1-Hour MAGs-S ppm (mg/m^3)			Notes	Other Values
	Minimal effects level	**Significant effects level**	**Severe effects level**		
Methyl mercaptan 74-93-1	**0.005** (0.01) (ERPG-1)	**25** (49) (ERPG-2)	**100** (197) (ERPG-3)	Exposures to 4 ppm for several hours have caused headaches and nausea (NIOSH 1994). Minimal effect levels based on low odor threshold that may be perceived as objectionable. ERPG-1 based on low odor threshold.	IDLH – 150 ppm; ERPG-1 – 0.005 ppm.
Nitric acid 7697-37-2	**0.5** (1.3) (AEGL-1)	**4** (10) (AEGL-2)	**13** (34) (AEGL-3)	Animals exhibited no adverse effects to concentrations of 24 ppm; maximum allowable workplace value proposed – 10 ppm (NIOSH 1994).	IDLH – 25 ppm; STEL – 4 ppm.
Nitric oxide 10102-43-9	**25** (31) (TEEL-1)	**25** (31) (TEEL-2)	**100** (123) (IDLH)	Oxides dangerous for exposures between 100 and 150 ppm from 30 – 60 min (NIOSH 1994).	No other acute values available.
Nitrogen dioxide 10102-44-0	♦	**15** (28) (TEEL-2)	**20** (38) (IDLH)	TEELs most appropriate and consistent with other values. Exposure to 10 – 20 ppm mildly irritating; exposure > 150 ppm can cause death from pulmonary edema (NIOSH 1994).	EEL – 10 ppm; SPEGL – 1 ppm; STEL – 5 ppm; TEEL-1 – 2 ppm.
Paraquat 4685-14-7	(0.15) (TEEL-1)	(0.15) (TEEL-2)	(1) (IDLH)	Toxicity: particle size dependant (< 5 μ, 5-6x more toxic; under spraying conditions particle sizes are nonrespirable) (NIOSH 1994).	No other acute values available.
Parathion 56-38-2	(0.3) (TEEL-1)	(2) (TEEL-2)	(10) (IDLH)	Workers regularly exposed to 2 to 15 mg/m^3 exhibited only a 25% decrease in cholinesterase; 69 mg/m^3 (extrapolated from an oral dose) may be lethal (NIOSH 1994).	No other acute values available.

Compound	1-Hour MAGs-S ppm (mg/m^3)			Notes	Other Values
	Minimal effects level	Significant effects level	Severe effects level		
Perchloroethylene (Tetrachloroethylene) 127-18-4	**100** (678) (ERPG-1)	**200** (1356) (ERPG-2)	**1000** (6781) (ERPG-3)	95-min exposures exceeding 1000 ppm produces slight drunkenness, yet no narcosis; 30 min exposures to > 206 ppm may cause dizziness and irritation.	IDLH – 150 ppm; STEL – 100 ppm.
Perchloromethyl mercaptan 594-42-3	**ND**	**ND**	**10** (1.3) (IDLH)	Data show exposures to 25 ppm may be appropriate (NIOSH 1994).	No other acute values available.
Phosgene 75-44-5	**0.1** (0.4) (TEEL-1)	**0.2** (0.81) (ERPG-2)	**1** (4) (ERPG-3)	Lethal dose to humans for a 30-min exposure was calculated to about 17 ppm; lethality may be evident at lower (5 ppm) concentrations due to pulmonary edema (NIOSH 1994).	IDLH – 2 ppm; EEGL – 0.2 ppm.
Phosphine 7803-51-2	**NA**	**0.5** (0.7) (ERPG-2)	**5** (7) (ERPG-3)	Concentrations up to 35 ppm have caused diarrhea, nausea, vomiting, cough, headache, and dizziness; 100 – 200 ppm may be maximum for a duration of 0.5 – 1.0 hrs (NIOSH 1994).	STEL – 1 ppm; IDLH – 50 ppm.
Phosphorus (yellow) 7723-14-0	(0.3) (TEEL-1)	(3) (TEEL-2)	(5) (IDLH)	Single lethal oral doses of 1 mg/kg have been reported; severe symptoms have been reported following a single 15 mg dose (equivalent to 10 mg/m^3 for 30 min); (NIOSH 1994).	No other acute values available.
Phosphorus trichloride 7719-12-2	**ND**	**ND**	**25** (140) (IDLH)	Concentrations of 1.8 – 27 ppm have been reported to produce burning of the eyes and throat, and mild bronchitis within 2 – 6 hours after exposure (NIOSH 1994).	STEL – 0.5 ppm.
Red phosphorus smoke	(1) (SPEGL)	(10) (EEGL)	(1000) (NRC[a])	Lethality, respiratory distress and irritation, pulmonary lesions; severe effects value based on "intolerable" concentration (Mitchell and Burrows 1990); (NRC[a]).	No other acute values available.

Compound	1-Hour MAGs-S ppm (mg/m^3)			Notes	Other Values
	Minimal effects level	**Significant effects level**	**Severe effects level**		
Selenium hexafluoride 7783-79-1	**0.15** (1.2) (TEEL-1)	**0.25** (2) (TEEL-2)	**2** (16) (IDLH)	Rabbits, mice, rats, and guinea pigs exposed to 5 ppm for 4 hrs developed pulmonary edema of which all survived (NIOSH 1994).	No other acute values available.
Stibine 7803-52-3	**ND**	**0.5** (2.6) (ERPG-2)	**1.5** (7.7) (ERPG-3)	Exposures to 40 – 45 ppm for 1 hr in dogs and cats have been reported to be dangerous (NIOSH 1994).	IDLH – 5 ppm.
Sulfur dioxide 7446-09-5	♦	**3** (8) (ERPG-2)	**15** (39) (ERPG-3)	Maximum concentration for 0.5 – 1.0 hrs was reported to be 50 to 100 ppm (NIOSH, 1994). Minimal effect levels based on increased airway resistance in asthmatics exposed to concentrations above 0.4 ppm.	IDLH – 100 ppm; EEGL – 10 ppm; ERPG-1 – 0.3 ppm.
Sulfur mustard [HD] 505-60-2	(0.42)	**NA**	(1.7)	Irritation: eyes, mucous membranes; potent alkylating agent; mutagenic. Based on determination of review from NRC (1997), (see text for more information); (NRC[b]).	No other acute values available.
Sulfuric acid 7664-93-9	(2) (ERPG-1)	(10) (ERPG-2)	(30) (ERPG-3)	Variable human responses; 5- to 15-min exposures of 5 mg/m^3 reported to be very objectionable (NIOSH 1994).	IDLH – 15 mg/m^3; STEL – 3 mg/m^3; EEGL – 1 mg/m^3.
Sulfuryl fluoride 2699-79-8	**ND**	**ND**	**200** (835) (IDLH)	Based on animal data. Less than 5% mortality resulted from 3-hr exposures of 1000 ppm in animals (NIOSH 1998).	STEL – 10 ppm.
Tellurium hexafluoride 7783-80-4	**0.06** (0.6) (TEEL-1)	**1** (10) (TEEL-2)	**1** (10) (IDLH)	IDLH = TEEL-2 value; in animals, 1 ppm for 4 hrs caused increased rate of breathing but no mortality (NIOSH 1994).	No other acute values available.
Tetrachloroethane (1,1,2,2-) 79-34-5	**3** (20.6) (TEEL-1)	**5** (3.4) (TEEL-2)	**100** (686) (IDLH)	A 30-min exposure to 146 ppm has caused vertigo, irritation, fatigue, head pressure; same effects were noted after a 10-minute exposure to 335 ppm (NIOSH 1994).	No other acute values available.

Compound	1-Hour MAGs-S ppm (mg/m^3)			Notes	Other Values
	Minimal effects level	Significant effects level	Severe effects level		
Tetraethyl lead 78-00-2	(0.13) (TEEL-1)	(0.75) (TEEL-2)	(40) (IDLH)	NIOSH reports that a value of 100 mg/m^3 would have been appropriate for IDLH but not being currently reviewed.	IDLH – 40 mg/m^3.
Tetramethyl lead 75-74-1	**ND**	**ND**	(40) (IDLH)	NIOSH reports a value of 150 mg Pb/m^3 may be appropriate.	No other acute values available.
Titanium tetrachloride 7550-45-0	(5) (ERPG-1)	(20) (ERPG-2)	(100) (ERPG-3)	At higher concentrations irritation of the respiratory tract and exposed tissue may result. Based on theoretical extrapolation of hydrochloric acid release (AIHA 1999).	No other acute values available.
Toluene 108-88-3	**50** (188) (ERPG-1)	**300** (1131) (ERPG-2)	**1000** (3769) (ERPG-3)	Eye and respiratory irritation and symptoms of dizziness, fatigue, drowsiness, headache, and feelings of intoxication at the minimal effects level; loss of consciousness to humans at concentrations > 5000 ppm within minutes.	IDLH – 500 ppm; EEGL – 200 ppm.
Toluene 2,4-diisocyanate 584-84-9	**0.02** (0.14) (TEEL-1)	**1** (7.1) (TEEL-2)	**2.5** (18) (IDLH)	Strong sensitizer; repeated exposures may lower concentration at which effects are experienced.	STEL – 0.02 ppm.
Trichloroethylene 79-01-6	**100** (537) (ERPG-1)	**500** (2687) (ERPG-2)	**5000** (26,870) (ERPG-3	Exposures of 1000 ppm for 2 hrs caused decrements in perception and motor skills (NIOSH 1994).	IDLH – 1000 ppm; STEL – 100 ppm.
Trichloropropane (1,2,3-) 96-18-4	**30** (181) (TEEL-1)	**50** (302) (TEEL-2)	**100** (603) (IDLH)	Exposures exceeding 100 ppm causes objectionable ocular and mucosal irritation after 15 min.	No other acute values available.

Compound	1-Hour MAGs-S ppm (mg/m^3)			Notes	Other Values
	Minimal effects level	**Significant effects level**	**Severe effects level**		
VX 50782-69-9	(0.0015)	**NA**	(0.02)	Based on acetyl cholinesterase activity determined through miosis. Concentration times time for one hour extrapolated from a 10-min exposure. Severe effects value based on derived IDLH (see text for more information); (NRC[b]).	No other acute values available.
Xylene (mixed) 1330-20-7	**150** (650) (TEEL-1)	**200** (868) (EEGL)	**900** (3906) (IDLH)	Exposures of 1000 ppm for 5 min may allow for self-rescue; reaction time not affected in 23 volunteers exposed to 100 or 200 ppm from 3 to 7 hrs (NIOSH 1994).	STEL – 150 ppm.

Notes:

CAW – Chemical Agent Warfare Technical Report: *Information for Combat Developers on Performance Effects from Exposure to Chemical Warfare Agents*, March 1999.

NRC[a] – National Research Council. 1997. *Toxicity of Military Smokes and Obscurants, Vol. 1*. Committee on Toxicology, National Academy Press, Washington, DC.

NRC[b]– National Research Council. 1997. *Review of Acute Human-Toxicity Estimates for Selected Chemical-Warfare Agents*. Committee on Toxicology. National Academy Press, Washington, D.C.

AIHA – American Industrial Hygiene Association. 1999, *Emergency Response Planning Guidelines*, AIHA Press, Fairfax, VA.

EPA – Environmental Protection Agency. 1997, *National Advisory Committee for Acute Exposure Guidelines Levels for Hazardous Substances (DRAFT)*; Federal Register, Thursday, 30 October.

ACGIH – American Conference of Governmental Industrial Hygienists. 1998, *Threshold Limit Values for Chemical Substances and Physical Agents*, ACGIH Press, OH.

♦ - Indicates values less than 1-14 day value, based on objectionable odor, differences in professional judgment between organizations in value derivation, or derived based on applications to sensitive subpopulations (e.g., asthmatics).

c – Ceiling value.

NA – Not applicable; value determined not appropriate.

ND – Not determined; data not yet evaluated.

Mitchell, W. R., Burows, E. P. 1990. *Assessment of Red Phosphorus in the Environment*. AD-A221704. U.S. Army Biomedical Research & Development Laboratory, Fort Detrick, Frederick, MD 21701-5010.

Shoshkes, M., Banfield, Jr., W.G., and Rosenbaum, S.J. 1950. "Distribution, effect, and fate of oil aerosol particles retained in the lungs of mice." Arch. Ind. Hyg. Occup. Med. 1:20-35 (*in* NRC, 1997a).

APPENDIX D

MILITARY AIR GUIDELINES – SHORT TERM (MAGs-S) (1- TO 14-DAY VALUES) TABLE

Compound	1-14 Day MAGs-S ppm (mg/m^3)	Source	Critical Study Endpoint	Notes
Acetone cyanohydrin 75-86-5	**4.7[C]** (16.4)	**ATSDR**	CNS effects, anoxia.	
Acrolein 107-02-8	**0.01** (0.023)	**NRC[1]**	Irritant; dermal and eye irritation in humans.	ATSDR/MRL - 0.00011 mg/m^3; ACGIH/TLV[CS] – 0.23 mg/m^3.
Acrylonitrile 75-05-8	**0.10** (0.22)	**ATSDR**	Based on human NOAEL.	ACGIH/TLV – 4.3 mg/m^3.
Aldrin 309-00-2	(0.25[S])	**ACGIH**	Based on an exposure designed to prevent liver effects (limited data).	CNS and liver effects may be possible during prolonged exposures; dermal exposure may contribute to overall dose; deposits in subcutaneous fat; UF applied; carcinogen.
Allyl alcohol 107-18-6	**2[S]** (0.48)	**ACGIH**	Mixed; eye irritation, corneal necrosis, lacrimation; visceral congestion, hematuria, nephritis.	UF applied; dermal exposures may contribute to overall dose.
Ammonia 7664-41-7	**0.13** (0.35)	**ATSDR**	No effect on pulmonary function.	Based on chronic occupational exposures. ACGIH/TLV – 1.7 mg/m^3.
Arsenic trichloride 7784-34-1	(0.01)	**ACGIH**	Irritation of mucous membranes, dermatitis, perforation of nasal septum, pharyngitis and conjunctivitis; value based on industrial concentrations where no effects were found.	Based on arsenic as an inorganic compound; soluble arsenic acutely toxic form; chlorides may induce irritation effects at lower concentrations; data to substantiate this is lacking; carcinogen.
Arsine 7784-42-1	**0.005** (0.016)	**ACGIH**	Red blood cell and kidney effects.	UF applied; carcinogen.
Benzene 71-43-2	**0.05** (0.16)	**ATSDR**	Based on lymphocyte apoptosis in mice.	TLV: Based on chronic studies where cancer was primary endpoint; TLV approaches odds for those not exposed in the development of cancer (ACGIH/TLV - 3.2E+01 mg/m^3).

*Notes for table on page D-12.

Compound	1-14 Day MAGs-S ppm (mg/m^3)	Source	Critical Study Endpoint	Notes
Boron tribromide 10294-33-4	**1**[C] (10)	**ACGIH**	Irritation; primary irritant with no known chronic effects.	
Boron trifluoride 7637-07-2	**1**[C] (2.8)	**ACGIH**	Irritation; pulmonary irritant leading to pneumonia after repeated exposure; no pathological changes in rats exposed to 6 ppm for 6 hrs/day, 5 day/wk, for 13 wks.	
Bromine 7726-95-6	**0.1** (0.65)	**ACGIH**	Irritant; respiratory passage irritation and lung injury.	
Bromine pentafluoride 7789-30-2	**0.1** (0.72)	**ACGIH**	Irritant; irritation to upper respiratory passages and eyes.	
Carbon disulfide 75-15-0	**1**[S] (3.1)	**ACGIH**	Systemic; headaches.	UF applied; dermal exposures may contribute to overall dose; carcinogen.
Carbon monoxide 630-08-0	**2.5** (2.9)	**ACGIH**	Systemic; based on blood carboxyhemoglobin levels < 3.5%.	UF applied; may not be protective of sensitive individuals under conditions of heavy labor, high temperatures, or in elevation >5,000ft.
Carbon tetrachloride 56-23-5	**0.2** (1.3)	**ATSDR**	Systemic; liver toxicity; alcohol potentiation may occur.	ACGIH/TLV - 3.1+01 mg/m^3; carcinogen.
Carbonyl fluoride 353-50-4	**0.2** (0.54)	**ACGIH**	Mixed; pulmonary edema; kidney injury; fluorosis.	UF applied.
Chlorine 7782-50-5	**0.1** (0.29)	**NRC**[1]	Irritation; eyes and mucous membrane irritation.	ACGIH/TLV – 1.5 mg/m^3.

Compound	1-14 Day MAGs-S ppm (mg/m^3)	Source	Critical Study Endpoint	Notes
Chlorine trifluoride 7790-91-2	**0.1**[C] (0.4)	**ACGIH**	Irritant; lung and mucous membrane injury.	
Chloroacetaldehyde 107-20-0	**1**[C] (3.2)	**ACGIH**	Irritant; pneumonitis, bronchitis; tumor initiator.	Carcinogen.
Chloroacetone 78-95-5	**1**[C] (3.8)	**ACGIH**	Irritation; lacrimation, upper respiratory tract, skin effects.	
Chloroacetophenone [CN] 532-27-4	**0.05** (0.32)	**ACGIH**	Irritation, eyes, respiratory tract.	
Chloroacetyl chloride 79-04-9	**0.05**[S] (0.23)	**ACGIH**	Irritant; eye and respiratory passage irritation.	Dermal exposures may contribute to overall dose.
Chlorobenzylidene malonitrile (o-) [CS] 2698-41-1	**0.05**[C] (0.39)	**ACGIH**	Irritation, eye, conjuctiva, nose and throat.	Potential sensitizer.
Chloroform 67-66-3	**0.1** (0.5)	**ATSDR**	Systemic; liver effects; embryotoxic.	ACGIH/TLV - 4.9E+01 mg/m^3; carcinogen.
Crotonaldehyde 4170-30-3	**0.3**[CS] (0.86)	**ACGIH**	Irritation; eyes and respiratory passages, lacrimation.	Dermal exposures may contribute to overall dose.
Cyanogen 460-19-5	**1** (2.1)	**ACGIH**	Mixed; by analogy with hydrogen cyanide to prevent irritation and systemic effects.	UF applied.
Diborane 19287-45-7	**0.01** (0.01)	**ACGIH**	Mixed; neurological effects, respiratory irritant; pulmonary function.	UF applied.

Compound	1-14 Day MAGs-S ppm (mg/m^3)	Source	Critical Study Endpoint	Notes
Dichloroethane (1,1-) 75-34-3	**41** (10)	**ACGIH**	Systemic; liver toxicity.	UF applied.
Dieldrin 60-57-1	(0.025^S)	**ACGIH**	Based on systemic toxicity; liver effects.	Dermal exposures may contribute to overall dose; ACGIH suggests that the greatest pathway for exposure in an industrial exposure is through the skin; toxic metabolite of aldrin; UF applied.
Diesel fuel smoke	(5)	**NRC[a]**	Weight losses and reduced weight gain in rats, focal pneumonitis in rats.	Value based on two 8-hour exposures per week. Critical study endpoint data obtained from Lock et al. (1984) and Dalbey et al. (1982) (*in* NRC[a]).
Dimethyl sulfate 77-78-1	**0.01^S** (0.01)	**ACGIH**	Mixed; irritation of eyes and skin; liver and CNS effects.	UF applied; dermal exposures may contribute to overall dose.
Endrin 72-20-8	(0.01^S)	**ACGIH**	Based on extrapolation of acute animal data and limited evidence in humans.	Stereoisomer of dieldrin; UF applied; dermal exposures may contribute to overall dose.
Ethyl benzene 100-41-4	**10** (43)	**ACGIH**	Mixed effects; hepatic, renal, pulmonary, cardiac, and neurological toxicity; narcosis and respiratory irritation; skin notation.	UF applied.
Ethylenimine 151-56-4	**0.05^S** (0.09)	**ACGIH**	Mixed; CNS effects; liver and kidney effects; respiratory irritation, eye and nose irritation, skin notation.	UF applied; dermal exposures may contribute to overall dose.
Ethylene oxide 75-21-8	**0.1** (0.18)	**ACGIH**	Systemic; mutagen, neurotoxin; liver, kidney and blood effects.	UF applied; carcinogen.
Fluorine 7782-41-4	**1** (1.6)	**ACGIH**	Irritant; eye, mucous membrane, and skin irritation.	

Compound	1-14 Day MAGs-S ppm (mg/m^3)	Source	Critical Study Endpoint	Notes
Fog oil smoke	(5)	**NRC[a]**	Discomfort threshold.	Based on Hendricks et al. (1962) (*in* NRC[a]).
Formaldehyde 50-00-0	**0.3[C]** (0.37)	**ACGIH**	Irritation; eye, nose, throat, and upper respiratory tract irritation; dermatitis; rhinitis; conjunctivitis, and asthma.	Carcinogen.
GA (Tabun) 77-81-6	(0.00001)	**DA-PAM 50-6**	Acetyl cholinesterase endpoint; miosis.	Based on worker TWA; UF applied.
GB (Sarin) 107-44-8	(0.00001)	**DA-PAM 50-6**	Acetyl cholinesterase endpoint; miosis.	Based on worker TWA; UF applied.
GD (Soman) 96-64-0	(0.000003)	**DA-PAM 50-6**	Acetyl cholinesterase; miosis.	Based on worker TWA; UF applied.
Hexachlorobutadiene 87-68-3	**0.002[S]** (0.02)	**ACGIH**	Systemic; kidney effects; no human data; based on a NOEL of 0.2 mg/kg/day after continuous ingestion by rats for 2 yrs.	UF applied; dermal exposures may contribute to overall dose; carcinogen.
Hexachlorocyclopentadiene 77-47-4	**0.01** (0.11)	**ACGIH**	Irritant; skin and mucous membrane irritation, lacrimation, sneezing, and salivation; higher concentrations cause pulmonary hyperemia and edema.	
Hexachloroethane smoke 67-72-1	(0.2)	**NRC[a]**	In mice; respiratory distress, edema of the lungs, destructive alveolitis, and macrophage infiltration, followed by development of fibrosis.	Based on data for $ZnCl_2$, Marrs et al. (1988) (*in* NRC[a]).

Compound	1-14 Day MAGs-S ppm (mg/m^3)	Source	Critical Study Endpoint	Notes
Hexane 110-54-3	**5**[S] (18)	**ACGIH**	Systemic; polyneuropathy; based on the conclusion that solvents contain 50% to 70% n-hexane.	UF applied; dermal exposures may contribute to overall dose.
Hydrazine 302-01-2	**0.01**[S] (0.013)	**ACGIH**	Based on a slightly higher incidence of nasal tumors in rats exposed to 0.05 ppm.	Given the application of the given exposure period (equivalent to $1/70^{th}$ of the exposure period); no UF was applied.
Hydrogen bromide 10035-10-6	**3** [C] (9.9)	**ACGIH**	Irritant; nose, throat, and eye irritation.	
Hydrogen chloride 1333-74-0	**5**[C] (7.5)	**ACGIH**	Irritant; eye, mucous membrane, and skin irritation.	
Hydrogen cyanide 74-90-8	**0.05**[S] (0.05)	**ACGIH**	Mixed; CNS, headache, tachycardia, nausea; nasal irritation.	Given the possibility of bioaccumulation from continuous exposures and the magnitude of effect, a UF (100) was applied; ceiling value = 4.7 ppm; dermal exposures may contribute to overall dose.
Hydrogen fluoride 7664-39-3	**3** [C] (2.4)	**ACGIH**	Irritant; respiratory irritation; in solution, burns to the skin and eyes.	
Hydrogen selenide 7783-07-5	**0.05** (0.16)	**ACGIH**	Irritation; eye and mucous membrane.	
Hydrogen sulfide 7783-06-4	**1** (1.4)	**ACGIH**	Mixed; eye irritation; neuroasthenic symptoms such as headache, dizziness, and irritability; CNS effects.	UF applied.
Iron pentacarbonyl 13462-40-6	**0.01** (0.08)	**ACGIH**	Mixed; respiratory distress, cyanosis, tremors, and paralysis of the extremities in animals.	UF applied.

Compound	1-14 Day MAGs-S ppm (mg/m^3)	Source	Critical Study Endpoint	Notes
Lewisite **541-25-3**	(0.003^{C})	**DA PAM 50-6**	Irritation: eye and mucous membrane.	Value represents a technologically feasible "real-time" detection limits. Based on inference from available toxicity information.
Lindane 58-89-9	(0.05^{S})	**ACGIH**	Based on a LOAEL of 0.19 – 0.7 mg/m^3 for CNS effects.	UF applied; dermal exposures may contribute to overall dose.
Methyl bromide 74-83-9	**0.1^{S}** (0.38)	**ACGIH**	Systemic; pulmonary edema, neurotoxic effects.	UF applied; dermal exposures may contribute to overall dose; carcinogen.
Methylene chloride 75-09-02	**0.4** (1.4)	**ASTDR**	Based on human behavioral data.	ACGIH/TLV - 1.7E+02 mg/m^3; carcinogen.
Methyl hydrazine 60-34-4	**0.001^{S}** (0.002)	**ACGIH**	Systemic; hemolytic anemia.	UF applied; dermal exposures may contribute to overall dose; carcinogen.
Methyl isocyanate 624-83-9	**0.02^{S}** (0.05)	**ACGIH**	Irritant; corrosive and irritating to the mucous membranes; sensitization of the pulmonary tract.	Dermal exposures may contribute to overall dose.
Methyl mercaptan 74-93-1	**0.05** (0.1)	**ACGIH**	Mixed; eye and mucous membrane irritation; CNS depression.	UF applied.
Nitric acid 7697-37-2	**2** (5.2)	**ACGIH**	Irritant; eye and mucous membrane irritant, corrosion of the teeth and skin; pulmonary edema.	
Nitric oxide 10102-43-9	**2.5** (3.1)	**ACGIH**	Systemic; methemoglobinemia, CNS effects.	UF applied.
Nitrogen dioxide 10102-44-0	**3** (5.6)	**ACGIH**	Irritant; mildly irritating to the eyes, nose, and upper respiratory tract; bronchitis and emphysema.	

Compound	1-14 Day MAGs-S ppm (mg/m^3)	Source	Critical Study Endpoint	Notes
Paraquat 4685-14-7	(0.01)	**ACGIH**	Based on systemic toxicity of respirable fraction (<5 µm) TLV = 0.5 mg/m^3.	UF applied; toxicity dependant on particle size, particles <5 µm; TLV = 0.5 mg/m^3.
Parathion 56-38-2	(0.01^S)	**ACGIH**	Systemic; anticholinesterase activity.	UF applied; dermal exposures may contribute to overall dose.
Perchloroethylene (Tetrachloroethylene) 127-18-4	**2.5** (17)	**ACGIH**	Systemic; liver injury.	UF applied.
Perchloromethyl mercaptan 594-42-3	**0.1** (0.76)	**ACGIH**	Irritant; eye, nose, and throat irritation; at higher concentrations may cause coughing, dyspnea, lacrimation, pallor, vomiting, tachycardia, cyanosis.	
Phosgene 75-44-5	**0.01** (0.04)	**NRC[1]**	Mixed; pulmonary edema, anoxia.	ACGIH/TLV – 0.10 ppm.
Phosphine 7803-51-2	**0.03** (0.04)	**ACGIH**	Mixed; severe respiratory irritant; gastrointestinal, respiratory, and CNS effects noted at concentrations < 10 ppm (14 mg/m^3).	UF applied; does not account for chronic phosphorus poisoning.
Phosphorus (yellow) 7723-14-0	(0.01)	**ACGIH**	Acute effects; respiratory irritation, nausea, hepatic and renal necrosis.	UF applied; severe symptoms in man at relatively low, single doses (15 mg); chronic effects not well characterized.
Phosphorus oxychloride 10025-87-3	**0.007** (0.06)	**ACGIH**	Mixed; eyes, mucous membrane, and skin irritation; kidney effects.	UF applied.
Phosphorus trichloride 7719-12-2	**0.2** (1.1)	**ACGIH**	Irritant; severe irritation of the eyes, mucous membranes, and skin.	

Compound	1-14 Day MAGs-S ppm (mg/m^3)	Source	Critical Study Endpoint	Notes
Red phosphorus smoke	(1)	**NRC[a]**	Eye and skin irritation, pulmonary effects.	Based on the ACGIH TLV-TWA for phosphoric acid, the main combustion product of concern.
Selenium hexafluoride 7783-79-1	**0.05** (0.4)	**ACGIH**	Irritation; based on acute toxicity, pulmonary edema.	
Stibine 7803-52-3	**0.1** (0.51)	**ACGIH**	Irritant; pulmonary irritation; kidney and liver damage at higher concentrations.	
Sulfur dioxide 7446-09-5	**1** (2.6)	**NRC[1]**	Irritant; mild respiratory irritation and human bronchoconstriction.	ACGIH/TLV – 5.2 mg/m^3.
Sulfur mustard [HD] 505-60-2	**0.003[C]**	**DA-PAM 50-6**	Irritation of skin, mucous membranes, lungs; carcinogenic endpoints.	Carcinogen.
Sulfuric acid 7664-93-9	(1)	**ACGIH**	Irritant; pulmonary irritation.	Carcinogen.
Sulfuryl fluoride 2699-79-8	**0.5** (2.1)	**ACGIH**	CNS depressant and pulmonary irritant in animals.	UF applied.
Tellurium hexafluoride 7783-80-4	**0.02** (0.2)	**ACGIH**	Irritant; pulmonary irritation in animals; in humans, respiratory tract irritation and intoxication.	
Tetrachloroethane (1,1,2,2-) 79-34-5	**0.1[S]** (0.7)	**ACGIH**	Systemic; nervous, hepatic, and gastrointestinal effects.	UF applied; dermal exposures may contribute to overall dose.
Tetraethyl lead 78-00-2	(0.01[S])	**ACGIH**	Tinnitus, ataxia, tremors, insomnia, psychosis, mania, and convulsions.	Dermal exposures may contribute to overall dose.

Compound	1-14 Day MAGs-S ppm (mg/m^3)	Source	Critical Study Endpoint	Notes
Tetramethyl lead 75-74-1	(0.02)	**ACGIH**	Headache, nausea, and convulsions.	UF applied.
Toluene 108-88-3	**3** (11)	**ATSDR**	Mixed; skin irritation and CNS effects.	ACGIH/TLV - 1.9E+02 mg/m^3.
Toluene 2,4-diisocyanate 584-84-9	**0.005** (0.036)	**ACGIH**	Irritant; cough, phlegm production, breathlessness, and wheezing, bronchitis.	Potential sensitizer.
Trichloroethylene 79-01-5	**5** (27)	**ACGIH**	Headache, fatigue, and irritability.	UF applied.
Trichloropropane (1,2,3-) 96-18-4	**1**[S] (6)	**ACGIH**	Systemic; hepatic and renal injury.	UF applied; dermal exposures may contribute to overall dose; carcinogen.
Tungsten hexafluoride	(0.1)	**ACGIH**	Mixed; anorexia, colic, incoordination of movement, trembling, and dyspnea (CNS).	UF applied, TLV based on soluble tungsten.
VX 50782-69-9	**0.000003**	**DA-PAM 50-6**	Cholinesterase inhibition.	Equivalent to GPL (72 hrs); (see text for more information).
Xylene (mixed) 1330-20-7	**10** (43)	**ACGIH**	Mixed; eye, skin, and mucous membrane irritation; hepatic and renal; neurological impairments.	UF applied.

Compound	1-14 Day MAGs-S ppm (mg/m^3)	Source	Critical Study Endpoint	Notes

Notes:

ACGIH – American Conference of Governmental Industrial Hygienists. 1996. *Threshold Limit Values for Chemical Substances and Physical Agents*, Cincinnati, OH.

NRC[a]– National Research Council. 1997. *Toxicity of Military Smokes and Obscurants, Vol. 1*. Committee on Toxicology, National Academy Press, Washington, DC.

NRC[1] – National Research Council. 1984. *Emergency and Continuous Exposure Limits for Selected Airborne Contaminants*, National Academy of Sciences. AD-A142-133, Vols. 1-3.

ATSDR – Agency for Toxic Substances and Disease Registry. *Acute Minimal Risk Levels (MRLs).* Toxicological Profiles. U.S. Public Health Service.

Department of Army Pamphlet (DA PAM) 40-8, *Occupational Health Guidelines for the Evaluation and Control of Occupational Exposure to Nerve Agents, GA, GB, GD, and VX*. 4 December 1990.

DA PAM 50-6, *Update, Chemical Agent Incident Response and Assistance (CAIRA) Operations*. 17 May 1991.

c– Ceiling value (ACGIH, 1998).

s – Skin notation; dermal exposures have the potential for significant contribution to overall dose.

CNS – Central Nervous System.

Lock, S., Dalber, W., Schmoyer, R., and Griesemer, R. 1984. *Chemical Characterization and Toxicological Evaluation of Airborne Mixtures. Inhalation Toxicology of Diesel Fuel Obscurant Aerosol in Sprague-Dawley Rats, Final Report, Phase 3, Subchronic Exposures*. ORNL/TM-9403. AD-A150 100. Oak Ridge National Laboratory, Oak Ridge, TN (*in* NRC 1997a).

Dalbey, W., Lock, S., and Schmoyer, R. 1982. *Chemical Characterization and Toxicological Evaluation of Airborne Mixtures. Inhalation of Toxicology of Diesel Fuel Obscurant Aerosol in Sprague-Dawley Rats, Final Report, Phase 2, Repeated Exposures*. ORNL/TM-9196. AD-A142 540. Oak Ridge National Laboratory, Oak Ridge, TN (*in* NRC 1997a).

Hendricks, N.V., Collings, G.H., Dooley, A.E., Garrett, J.T., and Rather, Jr., J.B. 1962. "A review of exposures to oil mist." Arch. Environ. Health 4:139-145 (in NRC 1997a).

Marrs, T.C., Colgrave, H.F., Edington, J.A.G., Brown, R.F.R., and Cross, N.L. 1988. "The repeated dose toxicity of a zinc oxide/hexachloroethane smoke." Arch. Toxicol. 62:123-132 (*in* NRC 1997a).

APPENDIX E

CATEGORIZATION OF COMPOUNDS ACCORDING TO PROBABILITY OF ENCOUNTERING AS A WATER CONTAMINANT AND TOXICITY

High Priority

Compound	ITF 25	TB MED	EPA/ Army	TRI	PIC	POP	LL	WHO	ATSDR gw/sw	MWG-S (mg/L)
Alachlor 15972-60-8								X		**0.14**
Aldrin 309-00-2				**Low**	**X**	**X**		**X**	**8/2**	**0.0004**
Benzene 71-43-2				**Top 75**					**115/41**	**0.1**
Carbofuran 1553-66-2							**X**	**X**		**0.07**
Carbon disulfide 75-15-0	**X**			**Top 75**				**X**		**0.14****
Chlordane 57-74-9				**Low**	**X**	**X**		**X**		**0.09**
Chloride	**As chlorine**	**X**		**Top 21 as chlorine**						**600**
Chloromethane [Methyl chloride)] 74-87-3				**Top 34**						**0.5**
Chromium (total) 7440-47-3				**Top 21 as Cr cpds**					**93/55**	**2**
Cyanide 21725-46-2	**As HCN**	**X**		**Top 34**					**13/9**	**6**
2,4-D 94-75-7								**X**		**0.4**
Diazinon 333-41-5										**0.03**

Compound	ITF 25	TB MED	EPA/ Army	TRI	PIC	POP	LL	WHO	ATSDR gw/sw	MWG-S (mg/L)
Dibromochloropropane 96-12-8								**X**		**0.28**
Dieldrin 60-57-1					**X**	**X**		**X**	**8/2**	**0.007**
Dinitrobenzene (1,3-) 99-65-0			**X**	**Top 34**						**0.06**
Dinoseb 88-85-7					**X**					**0.42**
Dioxane (1,4-) 123-91-1				**Top 21**						**0.56**
Disulfoton 298-04-4								**X**		**0.014**
Ethylene dibromide 106-93-4					**X**			**X**		**0.01**
Endrin 72-20-8						**X**		**X**		**0.02**
Fenamiphos 22224-92-6								**X**		**0.013**
Fonofos 944-22-9								**X**		**0.03**
GA [Tabun[77-81-6		**X**								**0.14***
GB [Sarin[107-44-8		**X**								**0.028***

Compound	ITF 25	TB MED	EPA/ Army	TRI	PIC	POP	LL	WHO	ATSDR gw/sw	MWG-S (mg/L)
GD [Soman[96-64-0		**X**								**0.012***
Heptachlor 76-44-8				**Low**	**X**	**X**		**X**	**2/0**	**0.014**
Heptachlor epoxide 1024-57-3						**X**			**2/0**	**0.014***
Hexachlorobenzene 118-74-1				**Top 145**	**X**			**X**		**0.08**
Lewisite 542-25-3		**X**			**X**					**0.027***
Lindane 58-89-9		**X**		**None**				**X**		**0.6**
Magnesium 7439-95-4		**X**								**100**
Malathion 121-75-5										**0.3**
Methylparathion 298-00-0								**X**		**0.4**
Molybdenum trioxide 7439-98-7				**Top 34**						**0.03**
Oxamyl [Vydate] 23135-22-0										**0.35**
Paraquat 1910-42-5								**X**		**0.14**

Compound	ITF 25	TB MED	EPA/ Army	TRI	PIC	POP	LL	WHO	ATSDR gw/sw	MWG-S (mg/L)
Simazine 122-34-9								**X**		**0.03**
Sulfate	**As H_2SO_4**	**X**		**Top 21 as H_2SO_4**						**300**
Sulfur mustard [HD] 505-60-2		**X**								**0.14***
TCDD (2,3,7,8-) 1746-01-6						**X**			**5/3**	**1**
Terbufos 13071-79-9								**X**		**0.007**
Trifluralin 1582-09-8								**X**		**0.1**
VX 50782-69-9		**X**								**0.015***

Medium Priority

Compound	ITF 25	TB MED	EPA/ Army	TRI	PIC	POP	LL	WHO	ATSDR gw/sw	MWG-S (mg/L)
Acrylonitrile 107-13-1	X			Top 145						1.4**
Cadmium 7440-43-9				Low					72/49	0.06
Carbaryl 63-25-2							X	X		1.4
Chloroform 67-66-3				Top 21					61/20	6
Dichlorobenzene p- 106-46-7				Low			X		6/10	5
Dichloroethane (1,2-) 107-06-2								X		1.0
Dichloromethane [Methyl chloride] 75-09-2				Top 75					61/21	2.8
Dinitrotoluene (2,4-) 121-14-2			X	Low						0.6
Dinitrotoluene (2,6-) 606-20-2			X	Low						0.6
Diphenylamine 122-39-4			X	Low						1.6
Dithiane (1,4-) 505-29-3			X							0.5

Compound	ITF 25	TB MED	EPA/ Army	TRI	PIC	POP	LL	WHO	ATSDR gw/sw	MWG-S (mg/L)
Nickel 7440-02-2				**Top 34 as Ni cpds**					**30/24**	**1**
Pentachlorophenol 87-86-5					**X**			**X**		**1.4**
RDX 121-82-4			**X**							**0.14**
2,4,5-T [Trichlorophenoxy acetic acid] 93-76-5					**X**					**1**
Tetrachloroethylene 127-18-4				**Top 145**					**116/28**	**2.8**
Toluene 108-88-3				**Top 34**					**78/26**	**3**
Trinitroglycerol 55-63-0			**X**							**0.007**
Trinitrotoluene (2,4,6-) 118-96-7			**X**							**0.025**

Low Priority

Compound	ITF 25	TB MED	EPA/ Army	TRI	PIC	POP	LL	WHO	ATSDR gw/sw	MWG-S (mg/L)
Ammonia 7664-41-7	X			Top 6						3.4
Beryllium, 7440-41-7				Low					2/3	36
BZ (Quinuclidinyl Benzilate) 6581-06-2		X								0.023
Di(2-ethylhexyl) phthalate 177-81-7				Low						14**
Diisopropylmethyl-phosphonate [DIMP] 1445-75-6			X							10.5
Dimethyl methyl-phosphonate 756-79-6			X							2.5
Ethyl benzene 100-41-4							X	X		4.5
Ethylene glycol 107-21-1				Top 21						8
Formaldehyde 50-00-0	X			Top 21						8
Glyphosate 1071-83-6								X		25

Compound	ITF 25	TB MED	EPA/ Army	TRI	PIC	POP	LL	WHO	ATSDR gw/sw	MWG-S (mg/L)
Hexachloroethane 67-72-1			**X**	**Top 145**						**7**
HMX 2691-41-0			**X**							**7**
Isopropyl methyl-phosphonate			**X**							**40**
Maleic hydrazide 123-33-1								**X**		**14**
Methyl tert-butyl ether 1634-04-4				**Top 34**						**33.6**
Nitroguanidine 556-88-7			**X**							**15**
Phenol 108-95-2										**8**
Picloram 1918-02-1								**X**		**28**
T-2 Toxin 21259-20-1		**X**								**0.0087**
Trichloroethylene 79-01-6				**Top 145**					**236/88**	**7****
Vinyl chloride 75-01-4				**Low**					**80/16**	**3.6**
Zinc chloride 7646-85-7			**X**	**Top 6; as Zn cpds**						**8**

Compound	ITF 25	TB MED	EPA/ Army	TRI	PIC	POP	LL	WHO	ATSDR gw/sw	MWG-S (mg/L)

Notes:

ITF-25: International Task Force that prioritized toxic industrial chemicals according to production figures and toxicity. All compounds in the ITF-25 list that have EPA Health Advisories or Acute Oral MRLs are included in Appendix D.

EPA/Army: Health Advisories developed for military-unique compounds.

TB MED: All compounds in the TB MED 577 list were given high priority with the exception of BZ and T2-toxin which are not thought to be used.

POP: Persistent Organic Pollutant – United Nations Program efforts involve information dissemination on "banned or severely restricted" chemicals. All compounds on the POP list that have EPA Health Advisories were given high priority.

PIC: Prior Informed Consent – Part of a program developed in 1987 by the United Nations Environment Program to help control imports of unwanted chemicals that have been banned or severely restricted. PIC "helps participating countries learn more about the characteristics of potentially hazardous chemicals that may be shipped to them, initiates a decision-making process on the future import of these chemicals by the countries themselves, and facilitates the dissemination of this decision to other countries. The aim is to promote a shared responsibility between exporting and importing countries in protecting human health and the environment from the harmful effects of certain hazardous chemicals being traded internationally."

ATSDR: These values come from measurements of selected hazardous substances at 951 NPL sites; gw/sw = number of sites at which the compound was found in ground water or surface water.

TRI: Toxic Release Inventory – Data compiled for about 500 chemicals nationwide in 1995. Values shown represent pounds of compound discharges into surface water as follows: Top 6, 21, 34, 75, and 145 compounds were discharged into surface water in quantities greater than 106, 105, 50,000, 10,000 and 1,000 pounds, respectively. "Low" means that less than 1,000 pounds were discharged into water and "None" means that none of the compound was discharged into water.

LL: List of high priority chemicals gleaned from the Lawrence Livermore report, Evaluation of Field Water Quality, (Daniels 1990).

WHO: Compounds were taken from *WHO Recommended Classification of Pesticides by Hazard and Guidelines to Classification 1996-1997*.

MWG-S: The guidelines shown in this column are the MWG-S for an exposure period of 2 weeks at 5L/day.

***MWG-S:** A 2-week guideline was not available so the 5-day guidelines derived from the EPA 1-day health advisory or the 7-day TB MED 577 standards are shown instead.

****MWG-S:** The MWG-S was derived from the acute oral MRL which is a 2-week guideline.

Unknown Priority: The compounds in Appendix D of TG 230A that were not found in any of the resources examined are categorized as "Unknown Priority" and are not shown in this Table.

APPENDIX F

EXPLANATION OF TECHNICAL REVIEW COMMENTS

BACKGROUND

During the development process of TG 230A, several reviews were performed. These reviews included DOD and non-DOD individuals representing a wide range of expertise. This included the military operational community as well as technical experts from the toxicological, medical and preventive medicine communities. The last review resulted in significant changes to the presentation of TG 230A. In addition, some reviewers requested additional input on various issues that were considered outside the scope of TG 230A. A listing of some of these issues along with suggested points of contacts/sources of additional information is provided on the inside of the back cover of this document.

GENERAL ISSUES

The following issues include some of the major comments that were addressed in the last rewrite of TG 230A. In summary, due to the conceptual/major concerns identified below, the U.S. Army Medical Command (MEDCOM) and the U.S. Army Chemical School non-concurred with the September 1998 Draft of TG 230A. In addition, the Office of the Assistant Secretary of Defense (Investigation and Analysis), while commending the overall effort, suggested expanding various areas of discussion and links to other documents/doctrine. Other substantial concerns were presented by the U.S. Navy as well as the U.S. Air Force (Bowling Green). Technical errors were corrected within TG 230A, as now revised (May 1999 version). Specific individual responses may be acquired through contacting USACHPPM. General conceptual concerns that were addressed are discussed below:

Field Operational Risk Management

The U.S. Army MEDCOM non-concurred with September 1998 Draft version of TG 230A citing the following rationale:

> **"**Non-concur with the publication of TG 230A as it is currently written. The guidance provided in the document is inconsistent with the current North Atlantic Treaty Organization and U.S. approach to chemical hazards by failing to give commanders a range of risk levels from which they can operate…. As currently structured, the TG is too complicated for use in the field. The data need to be compressed into something like "Black, Red, Amber, Green" for each of the major types of deployments – peacekeeping, combat, etc….. Develop guidelines that are similar to the radiation Operational Exposure Guidance that places the risks in terms a field commander can understand…. Recommend including the dose required for a fatal exposure or an exposure that would cause all of the symptoms present in the toxic symptoms section. Otherwise, the soldier will conclude that these actions will occur when the standards are exceeded. Adding this type of information will also give a good feel for what a dangerous exposure is…" (COL Eric Daxon, MEDCOM, 210-221-6612)

As others had pointed out similar concerns, USACHPPM agreed with the added usefulness of expanding the available information in the document to demarcate estimated levels at which more serious effects may begin to occur. As described in TG 230A, the recently published FM 100-14, *Risk Management*, describes the framework for which deployed military personnel should assess overall risk on the basis of probability/frequency and severity of identified hazards. Based on the MEDCOM request, USACHPPM expanded the information to facilitate the categorization of severity of risk from a chemical concentration. The available data allowed for a range of values for exposures that occur up to 1 hour in duration by route of inhalation. The projected range begins at the MAGs (1-hour air guidelines) listed in the September 1998 Draft of TG 230A. These minimal effect levels would be classified as a negligible to marginal severe risk. Additional data provided significant and severe effect levels for 1-hour duration. The air guidelines for 1 to 14 days remain a singular value - due to limited data. Expanded example scenarios will provide suggestions as to how one might categorize concentrations for these continued exposures. Certain data constraints did not permit establishing additional MWGs; however, the MWGs are provided for different consumption rates, and additional information on severe or fatal doses is provided where available.

Military-Unique Chemicals and Future Scientific Advances

The U.S. Army Chemical School indicated concern regarding the inclusion of chemical warfare agents in TG 230A. Given current public attention and misunderstandings regarding the low-levels effects of agents, it was suggested that these specific chemical hazards should be dealt with through separate mechanisms and documents. (Charles E. Kirkwood, U.S. Army Chemical School).

While USACHPPM agrees that chemical agents are generally perceived as unique battlefield hazards (and in certain respects there is good reason), this concept of uniqueness greatly hinders the Army's ability to defend assessments of potential exposures below levels that cause obvious signs and symptoms. At a certain point (low-level concentration), the health risks caused by chemical warfare agents may be of lesser concern than those posed by other commercial chemicals. TG 230A proposes a systematic, scientific approach to delineate environmental concentrations of chemicals above which there may be health effects and below which there should be none. The success of this approach is limited by the available data and limitations in existing methodology. This approach addresses the entire new "Nuclear, Biological, Chemical - Environmental" concept of chemical hazards - both agents and those commercially generated. Its scientific "limitations" (e.g., application of Haber's Law) reflect current areas of scientific review, but there are problems that impact agents and commercial chemicals alike. TG 230A is also a first step in answering recently documented concerns by the General Accounting Office and Congress "that the DOD has not addressed effects of multiple chemicals" (chemical warfare agents as well as commercial-based compounds). USACHPPM is fully aware of ongoing analysis and research associated with the chemical agents. The information currently in TG 230A is based on the most recently available sources, but this document will require updates as new information becomes

available. Other reviewers, such as the Office of Special Assistant for Gulf War Illness (DOD) and the Navy remarked about the utility of the values for the chemical warfare agents, not only as a tool for assessing "real-time" exposures but also to assist in strategic planning and to assess past events. As the Gulf War saga has demonstrated, attempting to deal with the chemical warfare agent issue separately and when the need arises offline cannot be easily handled. The DOD has learned much from the Gulf War Illness with respect to gaps not only in policy and doctrine, and training but also in the technical information and guidance. The DOD has also been directed to establish a chemical warfare agent strategy on low-level concentrations and to ensure that monitoring equipment/alarms and medical and environmental surveillance are adequate. TG 230A, in particular the inclusion of the chemical warfare agents, is a critical component of the strategy and demonstrates the DOD's efforts to address the issues raised. For these reasons, chemical warfare agents will continue to be listed in TG 230A. As future scientific advances in the research data evolve, TG 230A will be updated accordingly.

Carcinogenicity

The approach to addressing carcinogenicity was not clearly understood by some reviewers. The process and rationale by which carcinogenicity was considered in establishing the guidelines are described below.

For most non-cancer health effects, the toxicological evaluation of a substance is determined by collecting data from human epidemiologic and experimental animal studies. These studies attempt to define the NOAEL of exposure or the lowest exposure associated with an adverse health effect. This concept assumes that there is a threshold concentration or dose below which a chemical will cause no adverse health effects. These reference values of exposure (the no-effect level or the lowest-effect level) are often modified (i.e., reduced) to produce exposure guidelines by application of a numerical factor that address the relative uncertainty in this estimate. However, the approach for cancer is quite different. The current state of knowledge concerning the mechanisms of cancer cannot prove or discount that a single mutagenic event is sufficient to cause cancer. Moreover, evidence from epidemiological studies has failed to define a threshold below which no increased incidences of cancer occurred due to lack of precise exposure information and the lack of information on confounding variables. In addition, animal studies have not provided support for the presence of a threshold level for most carcinogens.
The current risk assessment approach as applied to carcinogens includes a number of default assumptions intended to err on the side of protection rather than to underestimate risk. It is thought that these assumptions reflect an appropriate concern for public health when data to the contrary are not widely available. Therefore, it is assumed that every exposure to a carcinogen is associated with some risk which can be calculated (i.e., a single mutagenic event is capable of producing a neoplasm, and as such a single molecule is capable of creating such an event). This is known as the "No-threshold" concept. Unless other evidence is available, this assumption is necessary to be protective since toxicologists are restrained statistically by the number of animals necessary for the determination of a 10^{-4} increased risk of developing cancer.

In most cancer studies, the animals have traditionally been exposed over their lifetime to the maximum tolerated dose (MTD) and to ½ the MTD. (The MTD is the highest dose that can be administered repeatedly without shortening the animal's natural life span). This provides information on the development of cancer at very high constant doses but provides little information about the development of cancer at lower doses or for shorter periods of time. Thus, the observable range of exposure doses associated with outcomes is generally small, and the number of animals used in the studies limits the ability to detect differences in outcome between the exposed and unexposed animals to about 1 percent. Therefore, optimally, 1 incidence of cancer in 100 animals may be determined. For public policy, however, the maximum excess cancer risk which is considered "acceptable" is 1 in 10,000 (reflecting a probability that 1 out of 10,000 persons will develop cancer from an exposure to a specified chemical. This is often cited as 10^{-4} cancer risk. At this end of the dose-response curve, information is typically unavailable due to the statistical limitations.

Since there is always a presumed level of risk associated with carcinogenic compounds, and since carcinogenic compounds are ubiquitous in today's society, public policy has established nationally accepted models for calculating cancer risk levels as well as Federal guidelines for what is deemed to be "acceptable risk". Specifically, the risk of developing cancer from exposure to a chemical is calculated as a probability, such as risk equals the probability of 1 out of 10,000 persons developing cancer from exposure to that chemical. In general, a maximum cancer risk level of 1 in 10,000 (10E-4) is considered acceptable for the general public. For certain occupational guidelines, cancer risk levels of up to 1 in 1,000 (10E-3) are accepted (Graham 1993). Furthermore, documentation cites acceptable risk to military personnel as 10^{-4} (NRC 1986a). However, U.S. guidelines/standards that are based on these acceptable levels of risk reflect chemical exposures that will occur continuously over a significant duration (years) of time, generally representing a lifetime.

Mathematically, a relative cancer risk can be calculated for brief periods of exposure such as 1 hour or up to 14 days (the exposure periods of concern for TG 230A). In fact, these calculations are performed and considered in the derivation of certain existing U.S. guideline levels discussed in TG 230A (see Section 4) (i.e., the resulting cancer–based concentrations, while calculated to be adequately protective against cancer, are not deemed protective of non-cancer effects). However, insufficient evidence exists that various acute exposures at different ages are equivalent, a fundamental assumption of this model. It is for these reasons, and acknowledging the variation in repair mechanisms and detoxification that can be operative in the low-dose ranges, that the guidelines in TG 230A for short-term exposures are <u>not</u> based on cancer risk associated with brief exposures. TG 230 B will directly address cancer risk and will incorporate carcinogenic potency into the development of the long-term guidelines.

Expansion of Topics Covered

Some reviewers requested additional information relating to the application of TG 230A. Such topics included sampling methods/equipment, modeling applications, protective measures, related policies and doctrine, and water treatment capabilities. While USACHPPM considered these issues to be outside the scope of TG 230A (although additional information regarding the capabilities of the Army's Reverse Osmosis Water Purification Unit is now included in Appendix F of TG 230A), a listing of some of these issues along with suggested points of contacts/sources of additional information is provided on the inside of the back cover of this document.

TG 230A AREAS OF RELATED INTEREST

The following information is provided to further assist users of TG 230A.

Sampling Methodologies/Equipment Detection Limits

Deployment Environmental Surveillance Program (DESP), USACHPPM – (410) 436-6096
Theater Area Medical Lab (520th TAML) – (410) 436-3647

Modeling of Known or Potential Chemical Releases/Environmental Conditions:

Deployment Environmental Surveillance Program (DESP), USACHPPM – (410) 436-6096

Sources of Chemical Hazards During Deployments

USACHPPM TG 231(underdevelopment): Operational Exposures and Sources
Occupational and Environmental Medicine Program, USACHPPM – (410) 436-2714

USACHPPM TG 217, *Hazardous Material/Hazardous Waste Management Guidance for Maneuver Brigades During Field and Contingency Operations.* June 1996. Hazardous and Medical Waste Program, USACHPPM – (410) 436-3651

Defense Intelligence Report, DI-1816-8-99, *Medical Intelligence Assessment of Deployment Health Risks),* Defense Intelligence Agency, January 1999. Armed Forces Medical Intelligence Center - (301) 619-7574/DSN 343-7574 x2409 (Unclassified Fax), x2649 (Classified Fax).

Key Doctrine and Policy on Chemical Hazards (USA/AF/USN/Joint)

Allied Command Europe Directive 80-64, *ACE Policy for Defensive Measures Against Toxic Industrial Chemical Hazards During Military Operations,* 20 December 1996

Sources of Nuclear, Biological, Chemical, Risk Management Training for Deployment

NBC-E Training by request: DCSOPS, USACHPPM – (410) 436-2488

U.S. Army Medical Department Center and School, NBC Branch – (210) 221-7448

U.S. Army Chemical School
ATTN: ATZN-CMR-A; Ft. Leonard Wood, MO 65473 – DSN 865-5331

Medical Treatment and Antidotes

Pamphlet for Receiving and Handling Chemical and/or Radiological Casualties from Industrial Sources, USACHPPM-Europe, May 1999. [POC: LTC GUM/Dr. Coleen Weese – (410) 436-2714]

Water Treatment Capabilities

Water Supply Management Program, USACHPPM – (410) 436-3919