Technically Speaking

Military Chemical Exposure Guidelines (MEGs) and LOC's

AristaTek has received a request from a PEAC customer that military Levels of Concern (LOCs) for toxic chemicals be incorporated into the PEAC tool. AristaTek listened, and the next PEAC revision will contain this information.

The military Levels of Concern comes from a Technical Guide document called "TG 230 Chemical Exposure Guidelines for Deployed Military Personnel". The reference document was published in January 2002, but updated addendums are also available. The document is published by the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM).

Let us look at these military chemical exposure guidelines and compare these numbers with LOCs from other data sources. TG 230 Chemical Exposure Guidelines for Deployed Military Personnel

A copy of this document and related documents including the May 2003 addendum can be obtained from the Internet at the USACHPPM site:

http://chppm-www.apgea.army.mil/desp/pages/samp_doc.htm

This document presents many categories of LOCs, for short term exposures, long term exposures, and for each category LOC by inhalation, drinking water, and soil contamination. The LOCs selected for incorporation into the PEAC tool are inhalation values. Even within the short-term exposure category are 1-hour, 8-hour, and 14-day military exposure guidelines; also 10-minute and 24-hour exposure guidelines for selected chemical warfare agents. Long-term inhalation exposure numbers are for continuous exposure for up to one year. For these different categories, LOC values are presented for three health levels, minimal, significant, and severe. Approximately 70 chemicals (about 20 more in the May 2003 addendum) are considered in the short-term category; several more chemicals are in the long-term (1-year exposure) category. Exposure symptoms and odor detection limits are listed for some of the chemicals.

All these different LOCs developed by the U.S. Army for various categories may seem confusing. Other organizations have stated LOC values intended for different purposes, and have used different language to describe the numbers. These numbers were developed by Occupational Safety and Health Administration (OSHA), U.S. National Institute for Occupational Safety and Health (NIOSH), American Council of Governmental Industrial Hygienists (ACGIH), U.S. Environmental Protection Agency, American Industrial Hygiene Association (AIHA), U.S. Department of Energy Subcommittee on Consequence Assessment and Protective Actions (SCAPA), and the National Research Council (NRC)/Committee on Toxicology (COT). Before we look at the numbers developed by the other organizations, let us examine the military exposure guidelines (MEGs) for Deployed Military Personnel.

As the name implies, the LOC numbers are for deployed military personnel, e.g. healthy young adults. Infants, children, the elderly, or people whose health is already impaired, or sensitive people are at additional risk. Some definitions for air LOCs are as follow:

Military Exposure Guidelines (MEGs)

1-hour duration, severe	The airborne concentration above which continuous exposure for 1 hour could begin to produce life-threatening or lethal effects in a small portion of individuals. Increasing concentrations and/or duration of exposure will increase incidence of lethality and severity of non-lethal severe effects.
1-hour duration, significant	The airborne concentration above which continuous exposure for 1 hour could begin to produce irreversible, permanent, or serious health effects that may result in performance degradation or incapacitate a small portion of individuals. Increasing concentrations and/or duration of exposure will increase incidence and severity of effects.
1-hour duration, minimal	The airborne concentration above which continuous exposure for 1 hour could begin to produce mild, non-disabling, transient, reversible effects, if any. Such effects should not impair performance. Increasing concentrations and/or duration of exposure could result in performance degradation, especially for tasks requiring specific mental/visual acuity or physical dexterity/strength.
8-hour and 24 hour	The airborne concentration above which continuous exposure for 8 or 24 hours could begin to produce mild, non-disabling, transient, reversible effects, if any. Such effects should not impair performance. Increasing concentrations and/or duration of exposure could result in performance degradation, especially for tasks requiring specific mental/visual acuity or physical dexterity/strength.
14-day	The airborne concentration for a continuous exposure for up to 14 days (24 hour/day basis) that should not impair performance and is considered protective against significant, non-cancer effects. Increasing concentrations and/or duration could result in performance degradation or increase the potential for inducing delayed/permanent disease (e.g. kidney disease or cancer).
1 year	The airborne concentration for a continuous exposure for up to 1 year (365 days, 24 hour/day basis) that is considered protective against health effects including chronic disease and increased risk to cancer (i.e., cancer risk greater than 1×10^{-4}). No performance degradation or long-term health consequences are expected with exposure at or below this level. Increasing concentrations and/or duration could result in performance degradation or increase the potential for delayed/permanent disease (e.g. kidney disease or cancer).

Deployed military personnel are assumed to consist of relatively healthy and fit male and non-pregnant female adults between the ages of 18 to 55 years, and an average weight of 70 kilograms (154 pounds). Predisposing factors such as illness (e.g. asthma) or stress or

life-style choices (e.g. smoking or alcohol use) may alter susceptibility to the toxicant.
Comparison of 1-hour MEGs with ERPGs

The American Industrial Hygiene Association has published Emergency Response Planning Guidelines (ERPGs) representing airborne concentrations of toxic chemicals for use by emergency responders in case of a chemical spill. Three LOCs are published for 1-hour exposure, designated ERPG-1, ERPG-2, and ERPG-3. These LOCs have been published for 110 chemicals as of 2004, and about 7 new chemicals are added each year. A list of chemicals current as of 2002 is at http://www.bnl.gov/scapa/scapawl.htm. The 2004 edition can be ordered from the American Industrial Hygiene Association at a cost of $20 at https://www.aiha.org/webapps/commerce/product.aspx?id=AEAH04-559&cat=Books&subcat=NewTitles. Definitions of ERPG-1, ERPG-2, and ERPG-3 are as follows:

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

ERPG-2: The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action.

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

Table 1. Comparison of ERPG and MEG for 1-hour Exposure, Units: mg/m^3.

Chemical	ERPG-1	ERPG-2	ERPG-3	MEG-minimal	MEG-significant	MEG-severe
Acrolein	0.23	1.145	6.87	ND	ND	25
Ammonia	17	105	525	17	77	766
Arsine	NA	1.6	4.8	NA	0.54	1.6
Boron trifluoride	2	30	100	0.6	16	39
Bromine	0.65	3.27	32.7	0.16	1.6	56
Carbon disulfide	3	156	1557	3	156	1557
Carbon monoxide	230	403	575	NA	95	330
Carbon tetrachloride	126	629	4718	75	352	1070
Diborane	NA	1.13	3.4	0.34	1.13	4.2
Ethylene oxide	NA	90	900	14	81	360
Fluorine	0.775	7.8	31	2.6	7.8	20.2
Formaldehyde	1.2	12.3	31	1.2	12.3	31
Hexachlorobutadiene	32	107	320	32	107	320
Hydrazine	0.66	6.55	39.3	0.13	17	46
Hydrogen chloride	NA	30	234	2.7	33	149
Hydrogen cyanide	NA	11	27.5	2.2	7.8	16.6
Hydrogen fluoride	1.64	16.4	41	0.82	19.7	36

Hydrogen sulfide	0.14	58.8	140	0.71	38	70
Methyl bromide	NA	195	778	58.3	195	777
Methylene chloride	695	2600	13880	695	2600	13880
Methyl mercaptan	0.01	49	197	1	9.7	45
Nitric acid	2.6	15.5	201	1.3	10	57
Phosgene	NA <="" td="">	0.8	4	0.4	1.2	3
Phosphine	NA	0.7	7	NA	0.42	1.5
Sulfur dioxide	0.8	8	39	ND	8	39
Sulfuric acid	2	10	30	2	10	30
Toluene	189	1131	3770	754	1923	10933

ND = not determined

NA = not available, data insignificant

If the LOC numbers are compared, sometimes the MEGs are the same as ERPGs as in the case of methylene chloride and sometimes they are different. The ERPG numbers for many chemicals had been published when the military put together their MEG document in 2002 (revised May 2003) so it is not surprising that they adopted the same numbers for some of the chemicals. If the numbers are different, sometimes the MEGs are higher and sometimes they are lower than the corresponding ERPGs.

The U.S. Army (USACHPPM) used many of the LOC numbers developed by the U.S. Environmental Protection Agency (EPA), called Acute Exposure Guideline Levels (AEGL), when forming the MEG list. The EPA AEGL list is not the same as the AIHA ERPG list. Therefore some of the MEG numbers are different.

Usually the LOC estimates are good to roughly only one significant figure or even only one order of magnitude. Calculations and conversion factors artificially increase the apparent number of significant figures. For example, the ERPG-1, ERPG-2, and ERPG-3 for methylene chloride are 200, 750, and 4000 parts per million (ppm) respectively. The conversion factor for ppm to mg/m^3 is 3.47. This converts to 695, 3600, and 13880 mg/m^3 respectively, which are the numbers published by the U.S. Army. For toluene, the corresponding ERPG numbers are 50, 300, and 1000 ppm which convert to 189, 1131, and 3770 mg/m^3.

Why not express everything in parts per million (ppm)? The units of ppm do not apply to solid particulates, dusts, and some acid gases; airborne concentrations must be expressed in "mass per unit volume", e.g. mg/m^3 [milligrams per cubic meter of air under standard conditions]. Gases and liquid vapors in air can be expressed in units of ppm or mg/m^3 .

Acute Exposure Guideline Levels (U.S. Environmental Protection Agency) and Temporary Emergency Exposure Limits (U.S. Department of Energy).

Two additional lists that were consulted when USACHPPM developed their MEGs were (1) the Acute Exposure Guideline Levels (AEGLs) developed by the Environmental Protection Agency (EPA) and (2) Temporary Emergency Exposure Limits (TEELs) developed by the Department of Energy Subcommittee on Consequence Assessment and Protective Actions

(SCAPA). The AEGLs were developed for 10-minute, 30-minute, 1-hour, 4-hour, and 8-hour exposures. The EPA defines three exposure levels, as follows:

AEGL-1: The airborne concentration of a substance at or above which it is predicted that the general population, including "susceptible" individuals, could experience notable discomfort, irritation, or certain asymptomatic, non-sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.

AEGL-2: The airborne concentration of a substance above which it is predicted that the general population, including "susceptible" individuals could experience irreversible or other serious, long-lasting health 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" individuals could experience life-threatening health effects or death.

"Susceptible" individuals may include persons in the 40 to 65 age bracket, smokers, or people who use alcohol; but not hyper-susceptible or hypersensitive individuals.

The AEGL-1 and AEGL-2 levels are also evaluated to ensure that the chemicals do not pose a greater than 0.0001 increased risk for cancer.

The AEGL numbers are peer-reviewed and published in the U.S. Federal Register. They are also available at the EPA website at

http://www.epa.gov/opptintr/aegl/chemlist.htm.

The DOE SCAPA list of TEELs are a temporary list designed to serve as interim ERPGs until the final, peer-reviewed numbers are developed by AIHA. As of 2004, AIHA has developed ERPGs for 110 chemicals but the DOE SCAPA has developed numbers for approximately 2000 chemicals. The DOE SCAPA list can be obtained at the website,

http://www.bnl.gov/scapa/teels.htm.

Table 2. Comparison of AEGL and MEG for 1-hour Exposure, Units: mg/m^3.

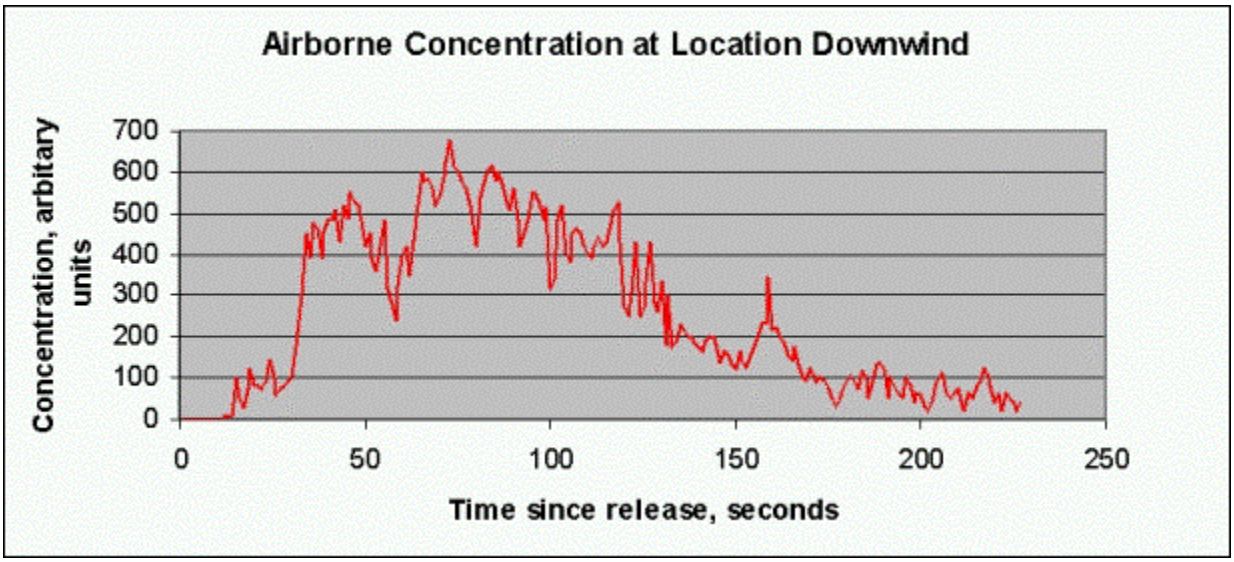
Chemical	AEGL-1	AEGL-2	AEGL-3	MEG-minimal	MEG-significant	MEG-severe
Acrolein	0.069	0.23	3.2	ND	ND	25
Ammonia	21	77	770	17	77	766
Agent GB (sarin)	0.0028	0.035	0.13	0.0028	0.035	0.13
Agent VX	0.00017	0.0029	0.010	0.0017	0.0029	0.010
Arsine	NR	0.54	1.6	NA	0.54	1.6
Boron trifluoride	0.33	8.6	39	0.6	16	39
Bromine	0.16	1.6	56	0.16	1.6	56
Carbon disulfide	12.4	498	1493	3	156	1557
Carbon monoxide	NR	95	380	NA	95	330
Carbon tetrachloride	75	352	1070	75	352	1070
Diborane	NR	1.13	4.2	0.34	1.13	4.2

Ethylene oxide	NR	81	360	14	81	360
Fluorine	2.6	7.8	20.2	2.6	7.8	20.2
Formaldehyde	1.1	17.2	69	1.2	12.3	31
Hydrazine	0.13	17	46	0.13	17	46
Hydrogen chloride	2.7	33	131	2.7	33	149
Hydrogen cyanide	2.2	7.8	16.5	2.2	7.8	16.6
Hydrogen fluoride	0.82	19.7	36	0.82	19.7	36
Hydrogen sulfide	0.71	38	70	0.71	38	70
Methyl mercaptan	NR	92.6	134	1	9.7	45
Nitric acid	1.4	62	237	1.3	10	57
Phosgene	NR	1.2	3	0.4	1.2	3
Phosphine	NR	2.8	5	NA	0.42	1.5
Sulfur dioxide	0.66	2.6	71	ND	8	39
Toluene	754	1923	10933	754	1923	10933

NR = Not Recommended (EPA note)

As seen in table 2, the U.S. Army adopted EPA's AEGL Levels Of Concern for many chemicals when formulating the MEGs. But there are also many differences. In Event of a Chemical Release Airborne Concentrations Vary

In the real world of a chemical release, concentrations in the air will vary by orders of magnitude as time progresses because of the chemical mixing with air. Emergency Responders should use these numbers (MEGs or ERPGs or AEGLs) as rough guidelines and not as a sharp cutoff for "safe" and "dangerous" conditions.



Even if a toxic chemical is released at a constant rate, a sensor measuring the concentration at a point downwind will see the concentrations vary with time, typically as shown above. AristaTek, Inc., has performed many tests at the HazMat Spill Center near Mercury, Nevada, where a toxic chemical surrogate was released under different conditions, and concentrations measured using sensors at various locations downwind. As the chemical cloud passed over the sensors, data similar to that plotted in the above graph was recorded.

Responders to releases must keep in mind that real-world conditions do not produce constant concentrations out in the field. Differences between listed MEG and ERPG or AEGL Levels of Concern even by a factor of 2 do not have a great deal of practical significance in an outdoor situation.