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ALTERNATIVE GUIDELINE LIMITS FOR CHEMICALS WITHOUT ENVIRONMENTAL RESPONSE PLANNING GUIDELINES

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Emergency Response Planning Guideline (ERPG) values are the only well-documented exposure limits developed to date specifically for use in evaluating the health consequences of exposure of the general public to accidental releases of extremely hazardous chemicals. Because ERPG values have so far been developed for relatively few chemicals, there is a need for alternative guidelines to be used for other chemicals. The objective of this work was to provide consistent methodology for the selection of reasonable interim values for these chemicals until such time as official ERPGs are developed. Most of the commonly available published and documented concentration-limit parameters were considered. ERPG values should be used as the primary guidelines for chemical emergency planning. Alternatives are recommended for use when ERPGs are not available. The parameters are to be used in the order presented, based on availability for the chemical of interest. Though these concentration limits were developed for different purposes, and were intended specifically for occupational use, no other options were available. Nonoccupational populations include the young, the aged, and other hypersensitive individuals. For each chemical, the adoption of alternatives to ERPGs should be carefully evaluated.

This paper presents a recommended hierarchy of emergency exposure limits to be used for planning related to accidental chemical releases. Specifically, it presents the recommendations of a Chemical Exposures Working Group to the Subcommittee on Consequence Assessment and Protective Actions of the U.S. Department of Energy (DOE) Emergency Management Advisory Committee (EMAC) for alternative emergency exposure guidelines to be used for chemicals for which Emergency Response Planning Guideline (ERPG)[1] values have not been developed. This effort was deemed necessary because many chemicals in use in DOE facilities have no ERPG values.

The objective was to provide consistent methodology for the selection of reasonable interim values for these chemicals until official ERPG values are developed. The exposure limits considered are defined in the Appendix. ERPGs are the only well-documented parameters developed to date specifically for use in evaluating the health consequences of exposure of the general public to accidental releases of extremely hazardous chemicals.

METHODOLOGY

Current DOE Practice

The *DOE Emergency Management Guide (EMG) for Hazard Assessment*[2] presents guidelines for determination of the size of emergency planning zones for nonradiological releases in terms of "a peak concentration of the substance in air that equals or exceeds the ERPG-3 value for that substance . . . ."[2] Classification of the severity of emergencies is based on whether ERPG-2 equivalent concentrations can be exceeded at the site boundary, the facility boundary, or only locally. This EMG also

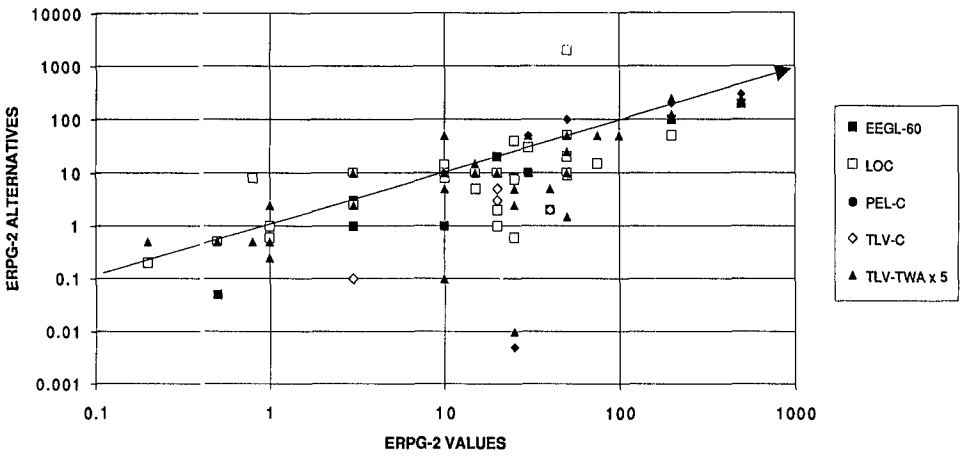

FIGURE 1. ERPG-2 alternatives versus ERPG-2 values

provides limited recommendations for parameters to use if ERPG-2 values are not available. These recommendations, which specifically invoke use of the emergency exposure guideline limits developed by the National Academy of Sciences' (NAS) Committee on Toxicology,[3] formed the starting point for the current work.

Selection of Alternative Concentration-Limit Guidelines

A detailed analysis of all the concentration-limit parameters that could be found for 86 extremely hazardous chemicals was performed. This list included all 35 chemicals for which ERPG values had been published prior to 1993, 13 chemicals for which DOE-sponsored draft ERPG values were available through 1992, all additional chemicals for which emergency exposure guidance levels (emergency exposure guidance levels [EEGLs], short-term public emergency guidance levels [SPEGLs], and continuous exposure guidance levels [CEGLs]) were developed by NAS,[3] and other chemicals that had been identified by DOE as requiring ERPG values. Most of the commonly available published and documented (United States) concentration-limit parameters were considered.[3-7] Preference was given to parameters specifically developed for emergency exposure conditions (e.g., EEGLs[3] and levels of concern [LOCs],[5]) but the extent to which specific exposure limits have been documented was also considered to be important.

Statistical Analyses of Primary and Alternative Parameters

Ratios of the concentration-limit parameters chosen as alternatives to each ERPG primary guideline versus the ERPG values were calculated. An example of these data (for ERPG-2s) is presented in Figure 1. The mean, coefficient of variation (CV = standard deviation as a percentage of the mean), and coefficient of determination (the square of the correlation coefficient [r]) of these ratios were calculated. Ratios judged to be outliers (in the sense that these outlier ratios are significantly different from the majority of ratios for those parameters) were excluded from the statistical analysis.

RESULTS

The hierarchy of alternative exposure-limit parameters presented in Table I is based on a detailed analysis of all the concentration-limit parameters that could be found for 86 extremely hazardous chemicals. The mean, coefficient of variation, and coefficient of determination of these ratios are summarized in Table II. Figure 2 presents the regression lines and coefficients of determination for the logarithms of each alternative parameter and the ERPG-2s. A summary of ERPG or ERPG-equivalent values for 30 chemicals, derived using the methodology described in this article, is presented in Table III.

DISCUSSION

Basis for Guideline Recommendations

ERPG values are recommended for use as the primary guidelines for chemical emergency planning because they are the only

TABLE I. Recommended Hierarchy of Alternative Concentration Guidelines

Primary Guideline	*Hierarchy of Alternative Guidelines*	*Source of Exposure-Limit Concentration*[A]
ERPG-3		AIHA
	EEGL (30-min)	NAS
	IDLH	NIOSH
ERPG-2		AIHA
	EEGL (60-min)	NAS
	LOC	EPA/FEMA/DOT
	PEL-C	OSHA
	TLV-C	ACGIH
	TLV-TWA × 5	ACGIH
ERPG-1		AIHA
	PEL-STEL	OSHA
	TLV-STEL	ACGIH
	TLV-TWA × 3	ACGIH

[A] AIHA = American Industrial Hygiene Association ERP Committee; NAS = National Academy of Sciences Committee on Toxicology; NIOSH = National Institute for Occupational Safety and Health; EPA = U.S. Environmental Protection Agency; FEMA = Federal Emergency Management Agency; DOT = U.S. Department of Transportation; OSHA = Occupational Safety and Health Administration; ACGIH = American Conference of Governmental Industrial Hygienists

TABLE II. Ratios of Selected Hierarchy Exposure-Limits (based on 1992 values)

Exposure-Limit Hierarchy	Abbreviation	Exposure-Limit Ratio				No. of Ratios	
		Ratio of	Mean	CV[A]	r^2[B]	N[C]	n[D]
ERPG-3	E3						
EEGL (30-min)	EEGL30	EEGL30:E3	0.55	100	0.646	6	4
IDLH	IDLH	IDLH:E3	2.48	85	0.828	34	32
ERPG-2	E2						
EEGL (60-min)	EEGL60	EEGL60:E2	0.99	89	0.918	13	10
LOC	LOC	LOC:E2	0.82	84	0.819	27	22
PEL-C	PEL-C	PEL-C:E2	1.09	60	0.789	9	6
TLV-C	TLV-C	TLV-C:E2	0.20	35	—	4	2
TLV-TWA × 5	5TLV	5TLV:E2	1.05	102	0.830	36	31
ERPG-1	E1						
PEL-STEL	PEL-STEL	PEL-STEL:E1	1.75	59	0.908	15	11
TLV-STEL	TLV-STEL	TLV-STEL:E1	1.90	48	0.935	16	13
TLV-TWA × 3	3TLV	3TLV:E1	2.54	60	0.855	29	22

[A] CV = coefficient of variation (CV = SD/$\bar{X}$ × 100)

[B] r^2 = coefficient of determination of straight line fit to the logarithms of the values, i.e., for x = log X and y = log Y, y = mx + b; where X = ERPG-3, -2, or -1 values and Y = Alternative parameter values.

[C] N = total number of available comparisons, i.e., number of chemical compounds for which values for both parameters have been developed

[D] n = number of comparisons used to calculate means, standard deviations and coefficients of determination. Ratios excluded are considered to be outlier values because they differ from the mean by a factor of 10 or more

well-documented parameters developed to date specifically for emergencies. ERPG-1 values are not based exclusively on toxic effects, but sometimes on odor thresholds. For some chemicals for which ERPGs have been developed by the American Industrial Hygiene Association (AIHA) Emergency Response Planning Committee, no ERPG-1 value is listed, since its value would be equal to or greater than the ERPG-2 value.[1] Therefore it is recommended that short-term exposure limit values (permissible exposure limit, short-term exposure limit [PEL-STEL] or threshold limit value, short-term exposure limit [TLV-STEL]) be used as the primary guideline for chemicals whose odor threshold is particularly low (e.g., carbon disulfide, hydrogen sulfide, and trimethylamine, inter alia). Although their definitions are expressed in negative rather than positive terms, ERPG-2 values in effect represent the threshold for severe or irreversible toxic effects in exposed populations, while ERPG-3 values represent the threshold concentration for lethal effects.

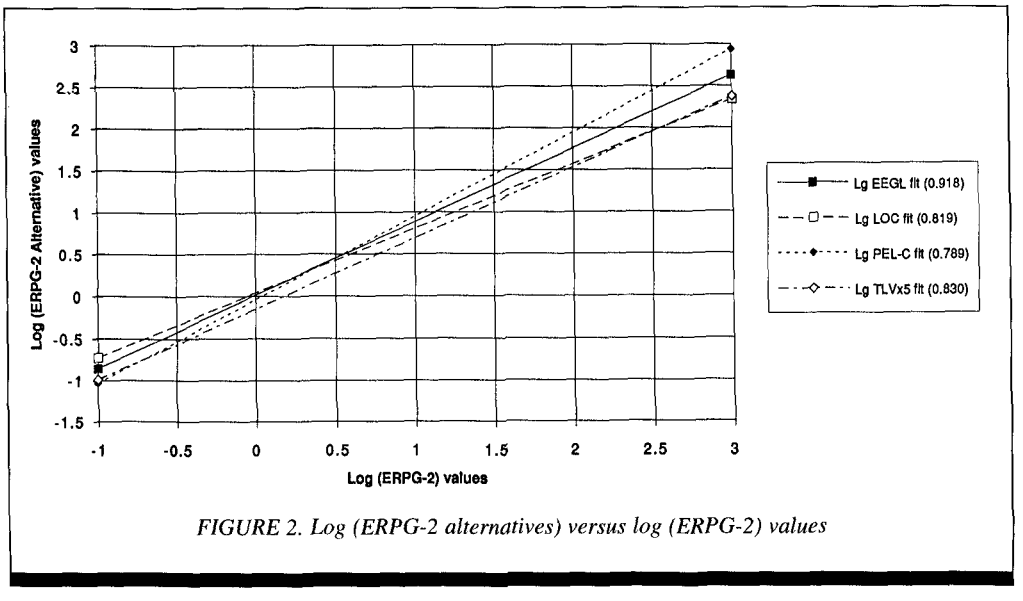

FIGURE 2. Log (ERPG-2 alternatives) versus log (ERPG-2) values

Concentration Versus Dose-Dependent Chemicals

Concentration-dependent chemicals are defined as fast-acting chemicals whose toxic effects are immediate, and correlate more closely to concentration than dose. Included in this category are sensory irritants and chemicals that are corrosive or vesicant in their action. Any chemical that has been assigned an Occupational Safety and Health Administration PEL-STEL or PEL-C (permissible exposure limit, ceiling), or an American Conference of Governmental Industrial Hygienists' (ACGIH) TLV-STEL or TLV-C (threshold limit value, ceiling) value must be considered to have concentration-dependent toxic effects.

In contrast, the effects of dose-dependent chemicals are a function of both concentration and duration of exposure. Dose (D) is equal to the product of concentration (C), inhalation rate (R), exposure time (T), and the fraction of inhaled substance absorbed by the body (f): i.e.,

$$D = C \times R \times T \times f.$$

It should be noted that Haber's law (K = C × T, where K is a constant), is not valid for any

TABLE III. Examples of Chemical-Specific Primary or Hierarchy-Based ERPG-Equivalent Concentrations (Updated to 1993 Limits)

Chemical Name[A]	ERPG-Equivalent Exposure Guidelines			Units	Source of Values
	ERPG-1	ERPG-2	ERPG-3		
Acetone	1000	8500	20 000	ppm	This paper's methodology
Aluminum oxide	15[B]	15	25	mg/m^3	This paper's methodology
Ammonia	25	200	1000	ppm	ERP Committee values
Arsenic (inorganic as As) (Ca)[C]	0.03	1.4	100	mg/m^3	This paper's methodology
Benzene (Ca)	5	50	3000	ppm	This paper's methodology
Beryllium (Ca)[D]	0.005[B]	0.005	10	mg/m^3	This paper's methodology
Cadmium (& compounds as Cd)	0.03	1.4	50	mg/m^3	This paper's methodology
Carbon disulfide	1	50	500	ppm	ERP Committee values
Chlorine	1	3	20	ppm	ERP Committee values
Dichlorofluoromethane (FC21)	30	100	50 000	ppm	This paper's methodology
Ethylene glycol	20[E]	40	60[E]	ppm	This paper's methodology
Fluorine	2	7.5	10	ppm	This paper's methodology
Formic acid	10	20[F]	30	ppm	This paper's methodology
Hydrazine (Ca)[D]	0.03	8	80	ppm	This paper's methodology
Hydrogen chloride	3	20	100	ppm	ERP Committee values
Hydrogen sulfide	15[G]	30	100	ppm	ERP Committee values
Isopropyl alcohol	400[B]	400	12 000	ppm	This paper's methodology
Mercury vapor (as Hg)	0.075	0.1	28	mg/m^3	This paper's methodology
Methyl hydrazine (Ca)	0.5[B]	0.5	50	ppm	This paper's methodology
Nitric acid[D]	4	10	100	ppm	This paper's methodology
Oxalic acid	2	5[H]	500	mg/m^3	This paper's methodology
Ozone	0.3	1	10	ppm	This paper's methodology
Phosphoric acid	3	5	10 000	mg/m^3	This paper's methodology
Sodium hydroxide[D]	2	2	2	mg/m^3	This paper's methodology
Sodium tetraborate	3[I]	5[I]	500[J]	mg/m^3	This paper's methodology
Sulfuric acid (oleum, sulftriox.)	2	10	30	mg/m^3	ERP Committee values
Toluene	150	200	2000	ppm	This paper's methodology
Tributyl phosphate	7[I]	11[I]	1360	mg/m^3	This paper's methodology
Tricholoroethylene (Ca)[D]	200	200	1000	ppm	This paper's methodology
Uranium, hexafluoride	5	15	30	mg/m^3	ERP Committee values

[A] Bolded entries are ERP Committee-adopted ERPG values.

[B] Values are adjusted downwards to next higher range value. For example, the PEL-STEL for isopropyl alcohol is 500 ppm, whereas the EEGL-60 is 400 ppm. Therefore, the ERPG-1-equivalent value is adjusted downwards to 400 ppm.

[C] Chemicals marked "(Ca)" are confirmed or suspected human carcinogens.

[D] The DOE-sponsored draft ERPG values for these chemicals are not included in this table, since their documentation was not available.

[E] EEGL values were developed for 24 hours, 8 hours, 60 minutes, and 10 minutes. In the absence of other alternatives, the 24-hour value is recommended as the ERPG-1 alternative, and the 10 minute value as the ERPG-3 alternative.

[F] Interpolated value, based on very limited inhalation toxicology data

[G] For certain chemicals, ERPG-1 values that are odor-based have been adjusted upwards (for H_2S, ERPG-1 = 0.1 ppm, and the PEL-TWA = 10 ppm). The higher PEL-STEL is used because the ERPG-1 value is based on perception rather than health effects.

[H] Based on 5 × TLV-TWA. Although this is a departure from guidelines (there are STEL values), 5 ppm is much less than the NIOSH IDLH value of 500 ppm.

[I] ERPG-1-equivalent = 3 × TLV-TWA; ERPG-2-equivalent = 5 × TLV-TWA

[J] Based on the maximum likely concentration of respirable dust

concentration-dependent chemical, nor for all dose-dependent chemicals. Thus extrapolation to higher guideline levels for shorter exposure periods should not be attempted.[1] Also, the fact that a chemical exhibits concentration-dependent effects does not preclude dose-dependent effects at much lower levels.

Exposure Time

In practice, observed atmospheric concentrations of chemicals downwind of a source, whether instantaneous or continuous, vary widely about the mean concentration measured over any period of time. Unless information to the contrary is available, published exposure-limit parameters or guidelines should be treated as ceiling or peak values. The concentration of interest, therefore, is the instantaneous value at the point of interest. For practical purposes the peak 15-minute average concentration may be treated as the instantaneous concentration. This peak concentration value is used for comparison with the primary concentration guidelines, or the alternative hierarchy guidelines (Table I), without regard to the length of time for which any particular exposure-limit parameter was

developed. An exception is made for those chemicals whose toxic effects are known to be dose-dependent. For these chemicals only, the peak 1-hour average concentration may be used for comparison to the guideline value.

It is of interest to note that the Environmental Protection Agency does not specify an exposure time for its levels of concern (LOC), stating only that they are concentrations in air above which there may be serious irreversible health effects or death as a result of a single exposure for a relatively short period of time.[5] However, one-quarter of the approximately 400 published LOC values are one-tenth of the IDLH (immediately dangerous to life or health) values, which are based on a 30-minute exposure time.[7]

Use of the peak 15-minute average concentration introduces a measure of conservatism in using these exposure-limit parameters. Additional reasons for using a 15-minute averaging time include the lack of toxic effects data for shorter time periods, physiological equilibration in relation to the breathing rate of humans, and better matching with hypothetical centerline plume concentrations than would be the case over a longer time period. Finally, ACGIH states[6] that "in conventional industrial hygiene practice if instantaneous monitoring is not feasible, then the TLV-C can be assessed over a 15-minute period except for those substances that may cause immediate irritation when exposures are short." A draft DOE document prepared by EMAC subcommittee members[8] recommended use of a 5-minute peak concentration based mainly on meteorological considerations. This recommendation was not accepted by DOE, but elements of this document were incorporated in several DOE emergency preparedness documents.[2,9-12]

Hierarchy of Alternative Exposure-Limit Concentration Guidelines

The primary ERPG concentration-limit guidelines should be used if values for the chemicals of interest have been published. If the primary ERPG guidelines are not available, then use of the Table I hierarchy of alternative concentration-limit parameters in the order presented, on the basis of availability of parameters for the chemicals of interest, is recommended.

Following the recommendation of the chair of the AIHA Emergency Response Planning Committee, multiples of TLV-TWA values were added to the alternative criteria for ERPG-1 and ERPG-2 for chemicals that do not have STEL or ceiling (C) values. Although there are exceptions, for the present purposes it is assumed that the toxic effects of chemicals that have STEL and/or C values are immediate (i.e., concentration-dependent), while the toxic effects of chemicals that do not are cumulative (i.e., dose-dependent). Although it is generally recommended that multiples of exposure parameters not be used, the justification for these recommendations is provided in the *ACGIH 1993–1994 Threshold Limit Values* booklet, which states:[6]

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

An equally important justification for this recommendation is that it greatly increases the number of chemicals for which at least some alternative hierarchy concentration-limit values are available. This consideration was also important in the decision to use LOC values[5] as the second alternative parameter (after EEGL 60-minute values) for ERPG-2 equivalents. Even though published documentation of LOCs is lacking, they compare quite favorably with ERPG-2 values. A multiple of the TLV-TWA should only be used after an examination of the documentation; this approach should not be used for irritants. DOE's *Hazard Assessment Guidance* cited SPEGLs as the first alternative to ERPG-2s,[2] even though values were developed for only five chemicals. The 60-minute SPEGL values are all much less than the corresponding values for the chemical (hydrogen chloride) having an ERPG-2, and the two chemicals (hydrazine and nitrogen dioxide) for which there are DOE-sponsored draft ERPG values.

Exclusion of a few ratio values from the statistics is done solely for the purpose of identifying the predominant trends in the comparison of primary to alternative criteria. Their exclusion does not mean that the concentration limits from which they were derived are not valid; only that their inclusion distorts the trend of the mean and standard deviations for the particular parameter comparisons. For example, exclusion of just 5 out of 27 LOC to ERPG-2 ratios reduces the mean ratio from 2.53 to 0.82 and the CV from 306 to 84. Exclusion of just 5 of 36 (5 × TLV-TWA) to ERPG-2 ratios changes the mean ratio from 0.91 to 1.05, and the CV from 116 to 102, but the coefficient of determination changes from 0.460 to 0.830. The arbitrarily chosen criterion for values to be considered outliers was that they differed from the primary guideline value by a factor of 10 or more.

Nearly all the IDLH[7] values are significantly greater, while most TLV-STEL values are significantly lower, than the ERPG-2 values for the same compound. For these reasons, the Chemical Exposures Working Group did not agree with the use of SPEGL, TLV-STEL, or IDLH values as alternatives for ERPG-2 values. Some examples of chemical-specific primary, or hierarchy-based ERPG-equivalent concentration values using the recommended methodology, are presented in Table III.

It is recognized that these exposure limits were developed for different purposes, and some were intended specifically for occupational use. However, a measure of conservatism is introduced in that they are to be applied to the peak 15-minute average concentration at the point of interest. This is in contrast to the "up to 1 hour" duration in the ERPG definitions.

It is recommended that concentrations for comparison with the guidelines be calculated as peak 15-minute average concentrations, which are then compared with the guideline concentration limits. This is applicable to all chemicals for which the toxic effect is immediate (i.e., concentration-dependent, e.g., irritants, corrosives, and any chemical that has a PEL-STEL, PEL-C, TLV-STEL, and/or TLV-C value). If it is known that the toxic effects of a chemical are not concentration-dependent, but depend on the total quantity of chemical taken up by the body, then it is recommended that the peak 1-hour concentration be used. Multiples of TLV-TWA may only be used for these dose-dependent chemicals.

CONCLUSIONS

ERPG values should be used as the primary guidelines for chemical emergency planning. When ERPG values are not available, it is recommended that the alternative exposure-limit parameter hierarchy (Table I) be followed. The objective here is to recommend alternative exposure limits that can be used until further ERPGs are developed. It must be emphasized that no alternatives are equivalent in origin to ERPGs, and that their use is not without their own limitations.

Except for LOCs and SPEGLs, all of the proposed alternatives to ERPGs were derived for use with healthy occupational populations (essentially, ages 18 to 65 years). Nonoccupational populations include the young, the aged, and other hypersensitive individuals[13] and certainly include individuals who are not as healthy as workers.

For each chemical, the adoption of alternatives to ERPGs should be carefully and separately evaluated. This document presents general guidelines for choosing appropriate concentration limits that, on consideration for any specific chemical, may prove to be invalid. Where possible, values selected for individual chemicals should be reviewed for appropriateness by a qualified individual (e.g., a toxicologist).

The limited number of ERPGs, coupled with the unsuitability of their alternatives for use in emergency response planning (e.g., those developed for the occupational environment), makes it imperative that AIHA and DOE continue to support the development and approval of ERPGs.

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APPENDIX

Definitions of Concentration-Limit Parameters Used

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

ERPG-2 (Emergency Response Planning Guideline 2): The maximum airborne concentration below which it is believed that 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 their abilities to take protective action.

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

EEGL (Emergency Exposure Guidance Level): A concentration of a substance in air (as a gas, vapor, or aerosol) that may be judged by DOD to be acceptable for the performance of specific tasks during rare emergency conditions lasting for periods of 1–24 hours. Exposure at an EEGL might produce reversible effects that do not impair judgment and do not interfere with proper responses to the emergency. The EEGL is a ceiling guidance level for a single emergency exposure, usually lasting from 1 h to 24 h—an occurrence expected to be infrequent in the lifetime of a person.

CEGL (Continuous Exposure Guidance Level): Ceiling concentrations designed to avoid adverse health effects, either immediate or delayed, of more prolonged exposures and to avoid degradation in crew performance that might endanger the objectives of a particular mission as a consequence of continuous exposure for up to 90 days.

SPEGL (Short-Term Public Emergency Guidance Level): Defined as a suitable concentration for unpredicted, single, short-term, emergency exposure of the general public. In contrast to

the EEGL, the SPEGL takes into account the wide range of susceptibility of the general public. This includes sensitive populations such as children, the aged, and persons with serious debilitating diseases.

PEL (Permissible Exposure Limit): Although the term PEL is not used in the "Final Rule Limits Columns" of Table Z-1-A and Table Z-2 (29 *CFR* 1910.1000, July 1, 1990), it was used in the "Transitional Limits." It is also used in the compound-specific rules for various substances, e.g., #1910.1018 (inorganic arsenic), #1910.1028 (benzene), #1910.1045 (acrylonitrile), #1910.1047 (ethylene oxide), etc.

PEL–TWA (time-weighted average): The employee's average airborne exposure in any 8-hour work shift of a 40-hour work week which shall not be exceeded. This is to be computed from the equation:

$$E = (C_aT_a + C_bT_b + \cdots C_nT_n)/8$$

where C is the concentration during any period of time T (in hours) where the concentration remains constant.

PEL-STEL (short-term exposure limit): The employee's 15-minute time-weighted average exposure, which shall not be exceeded at any time during a work day unless another time limit is specified.

PEL-C (ceiling): The employee's exposure that shall not be exceeded during any part of the work day. If necessary from a monitoring point of view, C may be assessed as a 15-minute time weighted average.

LOC (level of concern): The concentration of an extremely hazardous substance in air above which there may be serious irreversible health effects or death as a result of a single exposure for a relatively short period of time. (Also used by the Federal Emergency Management Administration and U.S. Department of Transportation.)

TLV-TWA (threshold limit value-time weighted average): The time-weighted average concentration for a normal 8-hour workday and a 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.

TLV-STEL (threshold limit value-short term exposure limit): The concentration to which workers can be exposed continuously for a short period of time without suffering from (1) irritation, (2) chronic or irreversible tissue damage, or (3) narcosis of sufficient degree to increase the likelihood of accidental injury, impair self-rescue, or materially reduce work efficiency, and provided that the daily TLV-TWA is not exceeded. A TLV-STEL is a 15-minute TWA exposure which should not be exceeded at any time during a workday even if the 8-hour TWA is within the TLV-TWA. Exposures above the TLV-TWA up to the STEL should not be longer than 15 minutes and should not occur more than four times per day. There should be at least 60 minutes between successive exposures in this range.

TLV-C (threshold limit value-ceiling): The concentration that should not be exceeded during any part of the working exposure . . . If instantaneous monitoring is not feasible, then the TLV-C can be assessed by sampling over a 15-minute period except for those substances that may cause immediate irritation when exposures are short.

IDLH (immediately dangerous to life or health): The maximum concentration from which, in the event of respirator failure, one could escape within 30 minutes without a respirator and without experiencing escape-impairing (e.g., severe eye irritation) or irreversible health effects.