Toxic Chemical HA = ARD Classification and Risk Acceptance Guidelines For Use in D.O.E. Facilities (U)

by
D. K. Craig
Westinghouse Savannah River Company
Savannah River Site
Aiken, South Carolina 29808

DOE Contract No. **DE-AC09-89SR18035**

DISCLAIMER

TOXIC CHEMICAL HAZARD CLASSIFICATION AND RISK ACCEPTANCE GUIDELINES FOR USE IN D.O.E. FACILITIES (U)

Recommendations of the Westinghouse M & O

Nuclear Facility Safety Committee

Subcommittee on

Nonradiological Risk Acceptance Guidelines Development

(March 24, 1995)

by

Douglas K. Craig (Chair)[1]
Janet S. Davis[2]
Larry G. Lee[3]
Pamela J. Lein (replaced on subcommittee by Jamie Prowse)[4]
and
Paul W. Hoffman[5].

1. WSRC, Aiken, SC
2. WHC, Richland, WA
3. WINCO (now LITCO), Idaho Falls, ID
4. W-WVNSC (Dames & Moore), West Valley, NY; and
5. WIID, Carlsbad, NM.

Westinghouse Savannah River Company
Savannah River Site
Aiken, South Carolina.

SRS

Savannah River Site

(This page intentionally left blank)

WSRC-MS-92-206, REV. 2

TOXIC CHEMICAL HAZARD CLASSIFICATION AND RISK ACCEPTANCE GUIDELINES FOR USE IN D.O.E. FACILITIES
(April 1993 Recommendations of the Westinghouse M & O Subcommittee on Nonradiological Risk Acceptance Guidelines Development)

Craig, D.K.[1], J.S. Davis[2], L.G. Lee[3], P.J. Lein[4], and Paul Hoffman[5].

1. WSRC, Aiken, SC; 2. WHC, Richland, WA; 3. WINCO, Idaho Falls, ID; 4. W-WVNSC (Dames & Moore), West Valley, NY; and 5. WIID, Carlsbad, NM.

INDEX:

TOXIC CHEMICAL HAZARD CLASSIFICATION AND RISK ACCEPTANCE GUIDELINES FOR USE IN D.O.E. FACILITIES

ABSTRACT

This document presents recommendations of a subcommittee of the Westinghouse Management and Operation (M & O) Nuclear Facility Safety Committee (NFSC) regarding chemical concentration-limit guidelines for use in the following applications: hazard classification of facilities per DOE Order 5481.1B (DOE 1991a), hazard categorization of facilities or operations according to DOE Order 5480.23 (DOE 1992a), and conduct of risk assessments or safety analyses associated with DOE facilities and operations.

The subcommittee recommends using the Emergency Response Planning Guideline (ERPG) values for hazard class, hazard category, and risk range. ERPGs are developed under the auspices of an American Industrial Hygiene Association technical committee for use in evaluating the effects of accidental chemical releases on the general public. ERPGs are estimates of concentration ranges for specific chemicals above which acute (< 1 hour) exposure would be expected to lead to adverse health effects of increasing severity for ERPG-1, -2, and -3. The subcommittee also recommends probability-based Incremental Cancer Risk (ICR) guidelines for analyses of risks from all known or suspected human carcinogens.

It is recommended that the peak 15-minute average chemical concentration be compared with the relevant concentration-limit guideline with no adjustment of the guideline value or the calculated concentration to account for differences between the recommended 15-minute exposure time and the exposure time implicit in the definition of the concentration-limit parameter. If the toxic effects of a chemical are known to be dose-dependent and not concentration-dependent (i.e., the toxic effects depend upon the total quantity of material taken up by the body), then for these chemicals only, the 1-hour average concentration may be used.

Since ERPGs are available for only a limited number of chemicals, the subcommittee has developed a hierarchy of concentration-limit parameters to be used on the basis of availability, in the order presented, until ERPGs are available for the chemicals of interest. This hierarchy was developed from an analysis of the parameters available for 88 chemicals. These chemicals include all those for which ERPGs were available or under active development in late 1992, the chemicals for which the National Academy of Sciences has developed Exposure Guidance Levels for military use, and other chemicals on the DOE Emergency Management Advisory Committee subcommittee on Consequence Assessment and Protective Actions (SCAPA) priority list for ERPG development.

1.0 Scope

The concentration-limit guidelines presented in this document apply to airborne releases of chemicals evaluated with respect to human health effects for the purposes of hazard classification and categorization, risk assessment and safety analysis. They apply to all DOE facilities and operations involving the use of potentially hazardous chemicals. The guidelines do not address other nonradiological hazards such as fire, pressure releases (including explosions), and chemical reactivity, but the guidelines are applicable to hazardous chemical releases resulting from these events.

2.0 Introduction

As prescribed by the United States Department of Energy (DOE) orders, all DOE contractors responsible for the design, construction and operation of DOE non-reactor nuclear facilities must perform hazard assessments and safety analyses for all onsite facilities and operations. It has become evident in fulfilling these requirements per DOE directives that there is a need for development of scientifically valid guidelines to be used in quantitative assessments of health risks associated with the accidental release of toxic chemicals. To address this need, the Westinghouse M & O Nuclear Facility Safety Committee formed the Subcommittee on Nonradiological Risk Acceptance Guidelines Development. The objectives of the subcommittee were to evaluate guidelines currently in use at Westinghouse M & O sites and to develop a uniform approach to the analysis of toxic chemical hazards.

This report presents the subcommittee's evaluation and recommendations regarding analyses of accidentally released toxic chemicals. The premise upon which these recommendations are based is that the mechanism of action of toxic chemicals is fundamentally different from that associated with radionuclides, with the exception of carcinogens. The recommendations reported herein are restricted to the airborne pathway because in an accident scenario this typically represents the most immediately significant route of public exposure. However, the subcommittee recognizes that exposure to chemicals through other pathways, in particular waterborne, can have significant impacts on human health and the environment. Although there are a number of chemicals for which absorption through the skin can contribute measurably to the total dose in chronic (e.g., occupational) exposure situations, this pathway has not been considered for the acute exposure scenarios considered in this report. Later studies will address these issues if it appears desirable.

The parameters against which the various chemical hazard indices and risk methodologies were judged include: 1) consistency with the intent of relevant DOE Orders (DOE 1990a and DOE 1992a); 2) scientific defensibility, i.e., are the proposed guidelines based on sound toxicological principles and research; 3) applicability to all Westinghouse M & O sites; 4) flexibility with respect to incorporation of appropriate site-specific data; and 5) ease of application.

2.1 Background:

2.1.1 Relevant DOE orders and guidelines.

DOE Order 5481.1B (DOE 1990a) defines hazard classification as follows:

Low	Those hazards which present minor onsite and negligible offsite impacts to people or the environment;
Moderate	Those hazards which present considerable potential for onsite impacts to people or the environment but, at most, only minor offsite impacts;
High	Those hazards with the potential for onsite or offsite impacts to large numbers of persons or for major impacts to the environment.

DOE Order 5480.23 (DOE 1992a), which supercedes DOE Order 5481.1B (DOE 1990a) for nuclear facilities, urges the use of probabilistic risk analysis, and provides for hazard classification for nuclear facilities and operations in accordance with three classification categories. "The consequences of unmitigated releases of radioactive and/or hazardous material are to be evaluated and classified by the following hazard categories" (p. 13):

Category 1 Hazard:	The hazard analysis shows the potential for significant offsite consequences.
Category 2 Hazard:	The hazard analysis shows the potential for significant onsite consequences.
Category 3 Hazard:	The hazard analysis shows the potential for only significant localized consequences.

The terms "offsite", "onsite", and "localized" are not defined in DOE Order 5480.23. There are definitions in the Emergency Management System order DOE 5500.1B (DOE 1992b), p. 6 of Attachment 2. For purposes of this report, receptors are defined and discussed in sections 4.4 and 5.2.4.

2.1.2 Summary of currently used guidelines and associated problems:

Because of a past lack of definitive guidance, there has been considerable site-to-site variability in both the quantitative interpretations of these definitions and in their application to

different facilities. Similar types of variances exist in the guidelines used to evaluate toxic chemical risk. DOE Order 5480.23 (DOE 1992a) supercedes DOE 5481.1B (DOE 1990a) for nuclear facilities and urges the use of probabilistic risk analyses. DOE Orders 5480.4 (DOE 1989b) and 5483.1A (DOE 1983) specify that DOE contractors and operators of DOE-owned facilities are subject to the provisions of various OSHA health and safety regulations concerning the handling of, and exposure to, nonradioactive hazardous materials.

Other problems associated with guidelines that have been used for hazard assessments and risk evaluations in the past have been the use of fractions and multiples of concentration-limit exposure parameters developed for specific purposes. This practice ignores the fact that the slope of the dose-response curve of individual chemicals varies considerably. For example, if the slope of the dose-response curve is very small (shallow or flat), exposure to multiples such as 0.1 or 5 times the concentration-limit (dose) may have a minimal impact on the observed response; however, if the slope is very large (steep), exposure to 0.1 or 5 times the concentration-limit may correspond to a significant change in the observed response. A second problem is the use of workplace exposure limits such as TLV values (ACGIH 1994) and IDLH values (NIOSH 1990) to evaluate consequences of an accidental release of a toxic chemical. These occupational parameters are based upon a very specific risk population and are not intended to be used for evaluating exposure to the general public, particularly to sensitive subgroups such as the young, aged and physiologically impaired.

These problems are offset to some extent by the following observations. First, for chemicals that do not have short-term exposure limit (STEL) or ceiling (C) values, the 1994-1995 Threshold Limit Values booklet states (ACGIH 1994, p. 5):

> "Excursions in worker exposure levels may exceed 3 times the TLV-TWA for no more than a total of 30 minutes during a work-day, and under no circumstances should they exceed 5 times the TLV-TWA, provided that the TLV-TWA is not exceeded."

In addition, TLV-TWA values were developed for assessing chronic occupational exposures over an 8-hour day, 40-hour work week and, therefore, their use as exposure limits in consequence analyses of acute exposure to accidental releases of toxic chemicals is conservative. IDLH values were established for acute (30 minute) accidental worker-exposure scenarios; however, their use as a guideline for evaluating accidental releases of chemical hazards is problematic since the

documentation of these values is very controversial (Alexeef 1989). As discussed in this reference, IDLH values represent inconsistent estimates of toxicity, varying up to 4 orders of magnitude in comparison to lethal or severe toxicity endpoints. Furthermore, many carcinogens pose a potentially significant carcinogenic risk at the IDLH exposure level and duration. Thus, this study and others (Crutchfield 1992) have concluded that the use of IDLH values as planning guides for accidental chemical releases is inappropriate.

3.0 Concentration-Limit Guidelines:

The primary nonradiological guidelines recommended for hazard classification and categorization are presented in Tables 1 and 2, and for risk assessment and safety analysis in Table 3. These are consistent with the definitions and risks provided in DOE Order 5481.1B and 5480.23, respectively. The subcommittee's recommendations address both acute toxic and latent carcinogenic effects. Alternative concentration-limit parameters recommended for use when values for the primary guidelines have not yet been published are provided in Table 4. Graphical representations of these hazard and risk classification guidelines are presented in Figures 1, 2, and 3, respectively.

Acute health effects associated with primary concentration guidelines are presented in Table 5. Acronyms used in this report are defined in Appendix 1.

4.0 Application of Guidelines:

The hazard classification and risk assessment guidelines should be applied as described below. A summary of this process is depicted in Figure 4.

4.1 Pathways:

The guidelines apply to the airborne pathway only, i.e., inhalation exposure. It should be noted that, for a number of compounds, absorption into the body through the skin is also a contributor to the total absorbed dose. This is not expected to be of significance for the acute exposures typically associated with accident scenarios.

4.2 Exposure time:

Concentrations for comparison with the guidelines must be calculated as the peak 15-minute average concentrations, which are then compared with the guideline concentration limits. This is applicable for all chemicals for which the toxic effect is immediate (i.e., concentration-dependent). If it is known that the toxic effects of a chemical are not concentration-dependent, but depend upon the total quantity of chemical taken up by the body (i.e., dose-dependent), then the peak 1-hour concentration may be used. 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 which are corrosive

or vesicant in their action. Any chemical which has been assigned an OSHA PEL-STEL or PEL-C, or an ACGIH TLV-STEL or TLV-C value must be considered concentration-dependent. In contrast, the effects of dose-dependent chemicals are a function of both concentration and duration of exposure. However, a chemical may elicit concentration-dependent effects at high levels and dose-dependent effects at lower concentrations. Dose (D) is equal to the product of concentration (C), inhalation rate (R), exposure time (T), and fraction absorbed by the body (f):

i.e., $D = C \times R \times T \times f$

It should be noted that Haber's Law ($K = C \times T$, where K is a constant), is not valid for any concentration-dependent chemical, nor for all dose-dependent chemicals. Thus, extrapolation to higher guideline levels for shorter exposure periods should not be attempted (8).

4.3 Carcinogens: For known or suspected human carcinogens, identified in the EPA data base (EPA 1993), the Pocket Guide to Chemical Hazards (NIOSH 1990), the International Agency for Cancer Research publications (e.g., IARC 1982a, and IARC 1982b), or other sources, the incremental cancer risk (ICR) is calculated using the IRIS database (see Appendix 2) values for the chemical-specific slope factor [q_1^* in $(mg/kg/d)^{-1}$ or $(mg/m^3)^{-1}$]. Adjustments between units are made assuming that a person weighing 70 kg breathes 20 m^3 a day (FR 51, 1986b). The calculated concentration (in mg/m^3) for the scenario of concern is averaged over a lifetime of 70 years, then adjusted upward by a factor of 5 (see Appendix 5) to account for the additional risk from acute exposures. Both acute toxic and cancer risk guidelines must be met for known or suspected human carcinogens.

4.4 Receptor distance:

4.4.1 Onsite receptor: In the absence of explicit DOE or contractor management guidance, the onsite receptor is assumed to be in the sector with the highest ground-level concentration (a) at the facility boundary or 100 meters for ground-level releases, or (b) at or beyond (where the plume touches the ground) the facility boundary or 100 meters for elevated releases. If the highest ground-level concentration from an elevated release is beyond the site boundary, the onsite receptor should be located at the site boundary.

4.4.2 Offsite receptor: The offsite receptor is assumed to be in the sector with the highest ground-level concentration at (a) the site boundary for ground-level releases, or (b) the site boundary or beyond (see 4.4.1) for elevated releases.

4.4.3 Local receptor (applicable only to hazard categorization analysis): "Localized" is interpreted to mean the area immediately surrounding the facility and/or operation to which only workers involved in and knowledgeable about the facility and/or operation have access. This area could be defined by a separate facility fence, with controlled entrance points. These workers would come under the applicable OSHA regulations and guidelines, and would have received all appropriate orientation and training associated with the facility and/or operation.

4.5 Dispersion models: When choosing the level of conservatism in the dispersion modeling, consideration should be given to the relationship between the hazard classification and risk assessment results: risk assessment results that are higher than unmitigated release hazard classification results should be reexamined to ascertain that the difference is not due solely to the dispersion assumptions. In the absence of explicit DOE Guidance, the subcommittee recommends the following:

4.5.1 Hazard classification and categorization: An unmitigated release at a uniform rate over a time period of 15 minutes is assumed. The physicochemical properties of the chemical of interest may be used to establish a release fraction. The straight-line Gaussian dispersion model should be used, assuming class D wind stability and 4.5 m/s wind speed (or 50% site-specific sector meteorology), taking no credit for plume meander or building wake effects. Where class D stability and a 4.5 m/s windspeed are obviously not conservative for the scenario being analyzed, more appropriate and conservative assumptions should be made.

4.5.2 Risk assessment: Atmospheric models appropriate to the site and/or accident scenario being evaluated should be chosen (e.g., dense gas model, buoyant plume model, straight-line Gaussian plume model, etc.) so that a conservative risk assessment results. The release time should also be determined by the accident scenario being analyzed. Building wake effects may be considered, but plume meander should not be considered.

4.6 Identification and prescreening of chemicals: The evaluation of any given facility often involves the consideration of numerous chemicals. It is typically the case that the safety analysis can be simplified with negligible loss in scientific integrity by including only those chemicals which constitute the most significant safety concerns. The types of factors that determine the degree of hazard any given chemical represents include: (a) physicochemical properties that contribute to the chemical's

dispersibility, reactivity, and incompatibility with other chemicals; (b) a chemical's inherent toxicity; and (c) the conditions under which the chemical is stored and/or used (including the quantity involved).

A list of specific questions which can be used in deciding which chemicals to include is presented below. It should be emphasized that this list is not all-inclusive and that it is possible that the situation may warrant that a chemical be evaluated even though it is not hazardous according to the following guidelines. However, a chemical should be considered if the answer to any one of the questions is positive.

* Is the chemical listed on any of the following:
  1) EPA's list (EPA 1987) of extremely hazardous substances having levels of concern (LOCs);
  2) EPA's list of extremely hazardous substances and their threshold planning quantities (TPQs) (FR 52, 1987);
  3) EPA's list of hazardous substances and reportable quantities (RQs) (CFR 40:302); or
  4) OSHA's list of highly hazardous chemicals, toxics and reactives (TQs) and DOE's addendum to this list (CFR 29:1910.119) ?

* Have short-term exposure limits been derived for the chemical, e.g. emergency response planning guideline (ERPG) values (AIHA 1993), OSHA PEL-STEL or PEL-C values (CFR 29: 1910.1000), ACGIH TLV-STEL or TLV-C values (ACGIH 1994)?

* Is there any indication that the chemical exhibits significant toxic properties (Sax 1991) (NIOSH 1987)?

* Is the chemical extremely reactive or flammable (Bretherick 1991)?

* Is the chemical in close physical proximity (e.g., storage tanks co-located) to other, incompatible chemicals (Sax 1991) (Bretherick 1991), which could result in the release of toxic reaction products in an accident (see MSDSs)?

* What quantity of material is involved? Does the quantity exceed its TPQ (FR 52, 1987), RQ (CFR 40:302), or TQ (CFR 29:1910.119) value?

* Is the material readily volatilized (i.e., does it have a substantial vapor pressure at ambient temperatures) ?

* Does chemical generate toxic combustion products (Sax 1991)?

4.7 Alternative parameter hierarchy for concentration guidelines: The primary concentration-limit guidelines should be used if values for the chemicals of interest have been published. If the primary guidelines are not available, then the Table 4 hierarchy of alternative concentration-limit parameters is to be used, in the order presented, on the basis of availability of parameters for the chemicals of interest (see Appendix 3). Note that even though the concentration-limit parameters used as guidelines are associated with various averaging times (such as up to 1 hour for the ERPGs (AIHA 1993), 15 minutes for the PEL- and TLV-STELs, and 8 hours for the PEL- and TLV-TWAs (CFR 29: 1910.1000), (ACGIH 1994)), the concentrations initially calculated for comparison with the guideline concentration should be the peak 15-minute average concentration and not the average concentration for the time period associated with the guideline. However, if this leads to unduly restrictive results for chemicals for which the toxic effects are known to be dose-dependent rather than concentration-dependent, then the concentration may be averaged over not more than 1 hour.

Application of the primary guidelines presented in Tables 1, 2, and 3, or the alternative parameter hierarchy (Table 4) values, to the 88 chemicals for which detailed values are given in Appendix 3, is presented in Table 6.

4.8 Special situations: If no concentration-limit parameter or ICR information is available for a given chemical, a knowledgeable individual may be requested to (a) determine whether the chemical needs to be evaluated, (b) develop appropriate values, or (c) perform a case-specific examination that provides suitable justification for the conclusion. This person's recommendations should, when possible, be reviewed by a second "knowledgeable" individual. See Appendix 4 for further guidance.

A primary guideline may be developed by a knowledgeable individual if the value has not been published for the chemical of interest, even if values for the alternative guidelines have been published. This option is provided for those who may be willing to pay for guidelines development if the results would be less restrictive than an alternative limit. See Appendix 4 for further guidance.

When conclusions based on calculated concentrations and incremental cancer risk fall in different risk acceptance or hazard classification categories, the more conservative categorization should be selected.

If the guideline value for a specific hazard classification, hazard category, or risk category range is higher than that for the next higher category, this higher guideline value (e.g., ERPG-1-equivalent) should be adjusted downwards to match the concentration for the next higher category guideline value. This adjustment should be made whenever the hierarchy-derived guideline concentration for a given range is greater than the hierarchy-derived concentration for the next higher range (e.g., ERPG-2-equivalent), (e.g., see chloropicrin in Tables 6 and A3-2).

If there is no guideline value for a specific hazard category for a chemical of interest, another alternative would be to use the guideline value for the next more restrictive category. For example, there are no ERPG-3-equivalents for several chemicals, so the ERPG-2-equivalent value was used (e.g., methane and vinylidene chloride).

When conservative analyses along the lines described in this section yield concentrations that are well below the lowest risk guidelines, further analysis is not required. However, when the calculated concentration is close to the relevant concentration limit, consideration should be given to the conduct of a more detailed safety analysis.

5.0 Technical Basis

5.1 Guideline recommendations:

5.1.1 Primary: Primary concentration guidelines are presented in Tables 1 and 2 (for hazard classification and categorization) and 3 (for risk assessment). Emergency Response Planning Guideline (ERPG) values 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 (EPA 1987) (AIHA 1989) (see Appendix 1 for definitions). In effect, ERPG-3 values represent the threshold concentration for lethal effects, while ERPG-2 values represent the threshold for severe or irreversible toxic effects in exposed populations. The DOE Emergency Management Guide for "Hazard Assessment" (DOE 1992c) defines guidelines for early, severe health effects (ESHE). For radiological releases, the threshold for ESHEs is "a dose equivalent of about 100 rem from external, penetrating radiation or uniformly distributed internal emitters ...", and for nonradiological releases, the threshold for ESHEs is "a peak concentration of the

substance in air that equals or exceeds the ERPG-3 value for that substance ...". This definition is under active review. Since ERPG-1 values are not based exclusively on toxic effects, but sometimes on odor thresholds, the subcommittee initially considered not recommending their use as a primary concentration guideline. In some instances, the ERPG-1 value would be equal to or greater than the ERPG-2 value for a chemical so no ERPG-1 value is listed by the AIHA ERPG technical committee (AIHA 1991). However, the subcommittee decided to recommend use of ERPG-1 values for consistency, but to recommend that Short-Term Exposure Limit values (PEL-or TLV-STEL) be used as the primary guideline for particularly odiferous chemicals. (See Appendix 3 for further details).

Although the OSHA permissible exposure limits (PEL-TWA) and ACGIH threshold limit values (TLV-TWA) were developed as permissible workplace exposure limits (applicable to persons working 8 hours a day, 5 days a week), the subcommittee recommends the use of the more conservative of these as the primary offsite concentration guideline for the highest "event frequency" category ($\geq 10^{-2}$ to < 1) and for facilities or processes not requiring a hazard classification. Few other low-concentration limit parameters are available, and it seems logical to use adequately documented values that have been developed for a large number of chemicals. The fact that they were developed for workers (ages 18 to 65) is partially offset by their use in the present context for short-term exposures only. This should provide an adequate margin of safety for the population at large.

5.1.2 Carcinogenic risk: Following the guidance of the United States Environmental Protection Agency (FR 51, 1986b), chemical compounds that have been identified as confirmed or suspected human carcinogens are treated differently from those compounds eliciting only toxic effects. The dose-response curves for non-carcinogenic chemicals are characterized by the existence of threshold exposure levels below which no toxic effects will be observed (i.e., the absorbed dose is not sufficient to elicit an adverse effect in the exposed population). Due to a fundamental difference in the mechanism of action, the dose-response curves for carcinogens are considered to be linear, with no threshold below which there will be no increased incidence of cancer following exposure.

It is the Department of Energy's goal in Nuclear Safety Policy SEN-35-91 (DOE 1991d) to limit the public's cancer

risk from nuclear operations to 0.1% of that from all other causes:

> "The risk to the population in the area of a DOE nuclear facility for cancer fatalities that might result from operations should not exceed one-tenth of one percent (0.1%) of the sum of all cancer fatality risks resulting from all other causes".

It makes sense to apply the same goal to incremental cancer risks from chemical carcinogens. The annual cancer fatality risk of approximately 2×10^{-3}, is derived from the mean cancer death rate of 196 per 100,000 people in 1987 (NSC 1990). One-tenth of one percent of this is 2×10^{-6}, or 2E-06. Therefore, the chemical incremental cancer risk (ICR) guidelines are based on limiting offsite (public) exposures to yield an ICR of no more than 2E-6 per year. This is accomplished in the risk guidelines by assigning ICR values such that the product of the offsite ICR value and the upper limit for each event frequency range is equal to 2E-06. The onsite ICR values are set at 100 times the offsite values. This is reasonable in that it results in onsite ICR values that will yield no more than 10% of the annual cancer fatality risk from all other causes.

The ICR hazard classification and hazard categorization guidelines were assigned in accordance with the correlation of ERPG and ICR values in the risk guidelines (i.e., an ERPG-1 concentration corresponds to 2E-4 ICR, an ERPG-2 concentration corresponds to 2E-2 ICR, and an ERPG-3 concentration corresponds to 2E 0 ICR).

An additional measure of conservatism is built into the ICR guidelines because the IRIS database (on which determination of the incremental cancer risk is based), is based on cancer incidence, and not cancer fatalities. Since cancer incidence includes both fatal and nonfatal cancers, the calculated ICR consequence will be conservative with respect to the guidelines, which specifically address fatal cancers.

5.1.3 Hierarchy: The hierarchy of alternative concentration-limit parameters presented in Table 4 is based upon a detailed analysis of all the concentration-limit parameters that could be found for 88 extremely hazardous chemicals. This list included all 35 chemicals for which ERPG values had been published (late 1992), all additional chemicals for which Emergency Exposure Guidance Levels (EEGLs, SPEGLs, and CEGLs) were developed by NAS (NAS 1985), all

chemicals for which ERPG values were in the process of development by DOE, and other chemicals which had been identified by DOE as requiring ERPG values (mainly from the Priority 1 list drawn up by a subcommittee of the predecessor of EMAC, DOE's Emergency Management Advisory Committee). Details are presented in Appendix 3. Preference was given to parameters specifically developed for emergency exposure conditions, but the extent to which specific parameters have been documented is also considered to be important.

For chemicals that do not have short-term exposure limit (STEL) or ceiling (C) values and whose toxic response is not otherwise known to be concentration-dependent, the subcommittee is recommending use of TLV-TWA x 3 for chemicals lacking ERPG-1 or other hierarchy values, and TLV-TWA x 5 for chemicals lacking ERPG-2 or other hierarchy values. Although it is generally recommended that multiples of exposure parameters not be used, the justification for these recommendations is provided in the ACGIH 1992-1993 Threshold Limit Values booklet, which states (ACGIH 1992, p. 5):

> "Excursions in worker exposure levels may exceed 3 times the TLV-TWA for no more than a total of 30 minutes during a work-day, and under no circumstances should they exceed 5 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 ERPG-1 and ERPG-2 hierarchy concentration-limit values are available.

Values for the concentration-limit parameters chosen as alternatives to each primary guideline are plotted against these primary guidelines values in Figures 5, 6, 7, and 8, respectively. In Figure 9, the values of concentration-limit parameters suggested by others as alternatives to ERPG-2 values are plotted against ERPG-2 values. These include IDLHs (Kim 1990), TLV-STELs (SuperChems™, 1992), and SPEGL-60 (DOE 1991c). This figure shows that, where there are values for both parameters, nearly all IDLH values are significantly greater than the corresponding ERPG-2s, while TLV-STEL values are significantly less than the corresponding ERPG-2s. The 3 SPEGL-60 values are all much less than the corresponding ERPG-2 values (hydrazine, hydrogen chloride, and nitrogen dioxide).

Accordingly, IDLH, TLV-STEL, and SPEGL-60 values are not recommended as alternatives for ERPG-2 values.

Chemical-specific concentration limits corresponding to the primary guidelines (or alternative guidelines if the primary guidelines do not exist) for the 88 chemicals evaluated for hierarchy determination purposes, are presented in Table 6.

5.1.4 Step function versus smooth curve: Implementation of the guidelines as step functions rather than as smooth curves (see Figures 1 and 2) is recommended because the limit parameters used as primary guidelines represent incremental effect thresholds rather than a continuum of toxic effects of increasing severity. For example, nearly all individuals could be exposed to a given chemical for up to one hour to concentrations below the ERPG-3 value without experiencing or developing life-threatening effects. Even though carcinogenic effects are considered to increase monotonically with dose (i.e., incidence increases as dose increases), carcinogenic effects are treated in the same way as other toxic effects (i.e., as a step function) for both hazard classification, hazard categorization, and risk evaluation.

5.1.5 Reasons for differences from radiological guidelines: Reasons for differences in the approaches between radiological and nonradiological hazardous materials are discussed in the document "Guidance for Hazards Assessment Methodology" (DOE EPG 5500.1, 1991). This states:

> "The consequence guidelines to be used in the calculations are the dose (for radioactive materials) and concentration (for toxicological materials) associated with early severe health effects and the levels of the consequence guidelines which should trigger protective actions, such as Protective Action Guides (PAG), for radioactive materials, and Emergency Response Planning Guidelines (ERPG), for toxicological materials" (p 11).

A draft EMAC subcommittee document on "Toxic Procedures" (DOE 1990c), listed a number of ways in which toxic chemicals differ from radiological materials, and therefore, require special considerations that are different from typical planning for nuclear incidents.

> "These differences include the physical and temporal characteristics of the release, the atmospheric

characteristics of the plume, and the nature of the health and environmental effects."

The differences in the mass concentrations in air mean that dense gas effects, causing airborne plumes whose density is greater than that of the surrounding air to remain near the ground, flow downhill, and diffuse slowly, are not usually a consideration in radioactive material releases. In addition, chemical reactions in contact with air and upon exposure to sunlight can alter the toxicity of the plume by changing its composition (e.g., by the formation of more toxic compounds such as NO_2 or H_2SO_4).

Toxic chemicals also differ from radioactive materials in that the adverse health effects induced by the former are typically associated with a threshold dose. In other words, a dose (or concentration) can be defined for most toxic chemicals below which no adverse effects are observed. In contrast, the effects elicited by radioactive materials are assumed to occur over a dose continuum. It should be noted, however, that the effects of carcinogenic chemicals, like those of radioactive materials, are considered to be non-threshold events. That is, all levels of exposure, no matter how low, are assumed to pose some risk.

These differences between toxic chemicals and radioactive materials are punctuated by the observations that severe acute adverse health effects have been observed in offsite populations following chemical releases (e.g. at Bhopal, India, where more than 2000 people died following the accidental release of methylisocyanate from a pesticide factory). In contrast, similar acute lethalities are extremely unlikely from any but the most catastrophic radioactive material releases such as the Chernobyl incident in the Soviet Union in 1986.

5.2 Justification of application assumptions

5.2.1 Pathways: The subcommittee has restricted its work to guidelines used in assessing health consequences of airborne chemicals, since in the event of an accidental chemical release, the most immediately significant route of exposure both onsite and offsite, is atmospheric.

5.2.2 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 limit

parameters or guidelines must be treated as ceiling values. The concentration of interest, therefore, is the instantaneous value at the point of interest. For practical purposes, the peak 15-minute average concentration is treated as the instantaneous concentration. It is recommended that this concentration value be used for comparison with the primary concentration guidelines (Tables 1, 2, and 3), or the alternative hierarchy parameters (Table 4), without regard to the length of time for which any particular 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. Dose-dependent chemicals are defined as chemicals whose effects are a function of concentration and duration of exposure (time). If a chemical has been assigned a short-term exposure limit or a ceiling value, it cannot be treated as a dose-dependent chemical, although it is possible that a chemical with concentration-dependent effects at high levels can cause dose-dependent effects at lower levels.

It is of interest to note that the EPA 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 (EPA 1987). However, one-quarter of the published LOC values are one-tenth of the IDLH values, which are based upon a 30-minute exposure time (NIOSH 1990).

Use of the peak 15-minute average concentration introduces a measure of conservatism in using these 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 centerline plume concentrations than would be the case over a longer time period. Finally, ACGIH states (ACGIH 1994, p. 3) 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 (DOE 1990b), recommended use of a 5-minute peak concentration based mainly upon meteorological considerations, but this recommendation has not been

accepted by DOE. However, elements of this document have been incorporated in several DOE emergency preparedness documents (DOE 1991a, DOE 1991b, DOE 1991c, DOE 1992b, and DOE 1992c).

5.2.3 Carcinogen concentration calculations: Assumptions and guidelines for the assessment of carcinogenic chemical hazards have been published by the United States Environmental Protection Agency (EPA) in the Federal Register (FR 51, 1986b). The EPA Guidance states that:

> "Unless there is evidence to the contrary, the cumulative dose received over a lifetime, expressed as average daily exposure prorated over a lifetime, is recommended as an appropriate measure of exposure to a carcinogen. That is, it is assumed that a high dose of a carcinogen received over a short period of time is equivalent to a corresponding low dose spread over a lifetime" (p. 33998, B. Exposure Assessment).

This statement is followed by a caveat to the effect that

> "Problems arise as the exposures become shorter and more intense, especially if the chemical in question has displayed dose-rate effects".

In considering less than lifetime exposure, the EPA Carcinogen Assessment Group assumed that, if exposure to a carcinogen ceases (which is usually the case for accidental exposures), the cancer risk will continue to accrue. Furthermore, they assumed that, for less than lifetime exposure, the earlier in life that the exposure occurs, the greater the ultimate risk, since there will be a longer time available for the cancer to be expressed (Beck et al 1989). For the purpose of incremental cancer risk calculation, the "lifetime" is taken to be 70 years (FR 51, 1986b), and shorter-term exposures are averaged over this time. Since lifetime appears in the denominator in the calculation of dose, the greater the lifetime, the lower the ICR, which conflicts with the assumptions.

Therefore, for chemicals that are confirmed or suspected human carcinogens, adjustments need to be made to the above average lifetime concentration to more accurately reflect the true, long-term risk following an acute exposure. This problem was addressed by Crump and Howe (Crump 1984), and is also discussed by the Committee on Toxicology of the National Academy of Sciences (NAS

1986). They concluded that, in calculating the acceptable short-term dose for a carcinogen, an additional adjustment of the lifetime dose by a factor of 2.8 would be conservative. They add that

> "the assumption that the carcinogenic response is directly proportional to the total dose is likely not to hold for all materials and all tissues that these materials affect."

The important point to be made here is that the dose obtained using the procedure described in the Risk Assessment Guidelines of 1986 (EPA 1987), can be used for exposures as short or shorter than 2 hours only if the calculated mean dose is appropriately adjusted upward.

The subcommittee recommends that a factor of 5, which should err on the conservative side, be adopted (see Appendix 5).

5.2.4 Receptors:

5.2.4.1 Hazard classification and categorization Receptors: Hazard classification and hazard categorization releases are assumed to occur at ground level because DOE Order 5480.23 requires that no mitigation be considered. Since airborne concentrations from ground-level releases are inversely proportional to distance, the closer the receptor, the higher the consequence.

Onsite: A distance of 100 meters for the onsite receptor is considered to be conservative because (a) the shortest distance at which atmospheric dispersion calculations can be performed for releases from facilities is generally accepted to be 100 meters, (b) it addresses potential receptors such as those who may be near a facility when an accident occurs, and (c) many DOE contractors already use 100 meters as a typical onsite receptor location for calculating radiological releases. The distance to the facility fence or other boundary may be used if that location is used to control personnel access to that facility.

Offsite: The site boundary location with the highest ground-level concentration is considered to be conservative because it is not likely that : (a) the receptor will be at that particular site boundary location at the time of the postulated release, and (b) the wind will be blowing in that particular sector at the time of the postulated release.

Local: This is interpreted to mean the area immediately surrounding the facility and/or operation to which only workers involved in and knowledgable about the facility and/or operation have access. This area could be defined by a separate facility fence, with controlled entrance points. These workers would come under the applicable OSHA regulations and guidelines, and would have received all appropriate orientation and training associated with the facility and/or operation.

5.2.4.2 Risk assessment receptors: The onsite and offsite receptors for the risk assessment of ground level releases are the same as for hazard classification analysis, and are justified on the same bases. However, since risk assessment includes the amelioration and controls, the distance at which the highest ground-level concentration occurs may be impacted. For example, the "worst-case" onsite receptor might be at 300 or 400 meters downwind in the event of an elevated release (stack) rather than the 100 meter distance. By the same mechanism, the "worst-case" offsite receptor might be beyond the site boundary.

5.2.5 Dispersion models:

5.2.5.1 Hazard classification and categorization: Use of a straight-line Gaussian dispersion model is recommended to provide a consistent approach which will facilitate comparison between sites. Use of (a) a D stability class and a 4.5 m/s windspeed, or (b) 50% site-specific meteorology is consistent with the approaches taken by FEMA, DOT, and EPA in chemical release evaluations. These assumptions, which differ from those used in radiological analyses, were adopted by FEMA, DOT, and EPA to conservatively address source term generation as well as dispersion. For

instance, Pasquill F stability and a 1 m/s windspeed is conservative for dispersion, but may not be at all conservative when used to determine the amount of material becoming airborne following a spill. The Pasquill D stability and 4.5 m/s assumptions are generally conservative when considering both source term generation and dispersion for chemical releases.

Building wake effects are not considered because DOE Order 5480.23 (DOE 1992a) mandates that unmitigated releases be used for determining hazard category. For consistency, it is recommended that DOE Order 5481.1B (DOE 1990a) hazard classification be performed using the same approach.

Plume meander corrections are not considered for toxic releases because they can artificially mask higher concentrations. This happens because a plume meander correction accounts for the "meandering" of a plume within a 22.5-degree sector. Conceptually, this has the effect of exposing the centerline receptor to the plume intermittently. However, since the mathematical model for plume meander averages the concentration over the entire sector, the concentration that the receptor actually sees is lowered (masked) to an average, continuous concentration. This is appropriate for radiological doses, because the exposure is integrated over time. However, since the exposure to toxic releases is not integrated, the plume meander correction is not applicable to toxic releases.

Another problem with taking plume meander into account is that some plume meander models require a release to occur for a certain length of time before plume meander can be taken into account (NRC 1983). This is because plume meander is likely to occur sometime during a long period (generally an hour or longer), but not necessarily during a short time period. One cannot usually "guarantee" that a release will occur for a given length of time, especially for safety and emergency response programs that are designed to mitigate releases as much as possible. For example, fire departments try to

extinguish a fire as soon as possible, which minimizes the associated release time.

5.2.5.2 Risk assessment model: Risk assessment scenario modeling includes mitigation effects and is site specific. Therefore, more complex and more real models and data (such as site-specific meteorology, if available) are justified. Also, differences in chemicals and release scenarios prevent recommendation of a specific recipe for evaluation - one scenario may be more conservative if a low outdoor temperature is assumed, and another scenario may be more conservative if a high outdoor temperature is assumed. Even dispersion models cannot be specified - the Gaussian plume model may be conservative for some releases, but nonconservative for something like a dense gas release. Therefore, the model "appropriate" for the scenario being evaluated should be used. The word "appropriate" implies a sufficient amount of conservatism.

Building wake effects may be considered in risk assessments because it is an actual phenomena.

Atlthough plume meander is also an actual phenomenon, it should not be considered in risk assessments for the same reasons it should not be considered in hazard classification analyses (see Section 5.2.5.1).

6.0 Topics for Further Discussion:

6.1 Chemical mixtures: Exposure to mixtures of two or more chemicals released simultaneously may lead to additive, synergistic, or antagonistic effects.

6.2 Combined radiological and nonradiological releases: In the past, the effects of exposure to radionuclides and nonradioactive materials have with a few exceptions (e.g., atmospheric releases of UF_6, which rapidly hydrolyzes to particulate UO_2F_2 and HF gas), been treated separately. This may not be a conservative approach.

6.3 Implementation with respect to design: In compliance with DOE orders and guidance (DOE 1989b and UCRL 15910, 1990), there are some differences in the approaches currently being used by different M&O contractors.

7.0 References:

ACGIH 1994 "Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices", *American Conference of Governmental Industrial Hygienists*, Cincinnati, OH, (1994-1995)

AIHA 1989 "Concepts and Procedures for the Development of Emergency Response Planning Guidelines (ERPGs)", *American Industrial Hygiene Association ERPG Committee*, (December 1989). (New data sets issued as they are developed).

AIHA 1993 "Emergency Response Planning Guidelines", *American Industrial Hygiene Association ERPG Committee*, American Industrial Hygiene Association, Akron, OH (1993).

Alexeef 1989 Alexeeff, G.V., M.J. Lipsett, and K.W. Kizer: "Problems Associated with the Use of Immediately Dangerous to Life and Health (IDLH) Values for Estimating the Hazard of Accidental Chemical Releases", *Amer. Ind. Hyg. Assoc. J. 50 (11): 598-605* (1989).

Beck 1989 Beck, Barbara D., Edward J. Calabrese, and Paul D. Anderson, "The Use of Toxicology in the Regulatory Process. Less Than Lifetime Exposure, p.15". In: Principles and Methods of Toxicology, Editor A. Wallace Hayes. Second Edition, Raven Press (1989).

Bretherick 1991 Bretherick, L.: "Handbook of Reactive Chemicals", 4th Edition, 1991. (Butterworths, Boston).

CFR 40:302 "List of Hazardous Substances and Reportable Quantities", *Code of Federal Regulations: Protection of Environment*, 40 CFR Part 302. Table 302.4, pp. 228-298 (7-1-91 Edition).

CFR 29:1910.1000 "Toxic and Hazardous Substances, Air Contaminants", *Code of Federal Regulations: Labor: 29: Part 1910.1000*, Subpart Z - pp 6 - 33, (Revised as of July 1, 1990).

CFR 29:1910.119 "Process Safety Management of Highly Hazardous Chemicals; Explosives and Blasting Agents; Final Rule. Appendix A List of Highly Hazardous Chemicals, Toxics and Reactives", *Code of Federal Regulations: Labor: 29 Part 1910.119* , (February 24, 1992).

Crump 1984 Crump, K.S. and R.B. Howe: "The Multistage Model with a Time-Dependent Dose Pattern: Applications to Carcinogenic Risk Assessment", *Risk Analysis 4, No. 3, 173-176* (1984).

Crutchfield 1992 — Crutchfield, C.D. and J.B. Sullivan: "Situations and Exposures Immediately Dangerous to Life and Health". In: Hazardous Materials Toxicology, Clinical Principles of Environmental Health (J.B. Sullivan and G.R. Krieger, eds.) Williams and Wilkens, Baltimore, pp 297-302 (1992).

DOE 1983 — "Occupational Safety and Health Program for DOE Contractor Employees at Government-Owned Contractor-Operated Facilities", *DOE ORDER 5483.1A,* (6-22-1983).

DOE 1989a — "Environmental Protection, Safety, and Health Protection Standards", *DOE ORDER 5480.4* , (5-16-1989).

DOE 1989b — "General Design Guidelines", *DOE ORDER 6430.1A,* (4-6-89).

DOE 1990a — "Environment, Safety, and Health Program for Department of Energy Operations", *DOE ORDER 5481.1B,* (9.23.86, updated through 3.27.90)

DOE 1990b — "DOE Protective Action Guides and Protective Actions for Accidental Toxic Chemical Releases to the Atmosphere", *DOE/EH,* (August 1990).

DOE 1990c — "Generic Procedures Guide for Incorporating Toxic Chemical Emergency Response into Emergency Planning at DOE Facilities", *Toxic Procedures, Draft,* (Dec. 28, 1990).

DOE 1991a — "Emergency Categories, Classes, Notification and Reporting Requirements", *DOE ORDER 5500.2B,* (4.30.91).

DOE 1991b — "Planning and Preparedness for Operational Emergencies", *DOE ORDER 5500.3A* , (4.30.91).

DOE 1991c — "Event Classification and Emergency Action Levels", *DOE Emergency Management Guide,* (4.24.92).

DOE 1991d — U.S. Department of Energy, Secretary of Energy Notice: "Nuclear Safety Policy", September 9, 1991.

DOE EPG 5500.1 — "Guidance for a Hazards Assessment Methodology", (11-5-1991).

DOE 1992a — "Nuclear Safety Analysis Reports", *DOE ORDER 5480.23,* (4.30.92).

DOE 1992b — "Emergency Management System", *DOE ORDER 5500.1B,* (4.30.91, as revised through 2.27.92)

DOE 1992c — "Hazard Assessment", *DOE Emergency Management Guide.* (6.26.92)

EPA 1987 "Emergency Planning for Extremely Hazardous Substances", *Technical Guidance for Hazard Analysis*, U.S. Environmental Protection Agency, Federal Emergency Management Agency; and U.S. Department of Transportation, EPA-OSWER-88-0001, (December 1987).

EPA 1992 "Health Effects Assessment Summary Tables (HEAST)", OERR 9200.6-303 (92-1), NTIS No. PB92-921199, (March 1992).

EPA 1993 "Integrated Risk Information System (IRIS)": *Electronic Data Base, containing health risk and U.S. EPA regulatory information on specific chemicals,* United States Environmental Protection Agency (Updated monthly).

FR 51, 1986a "Guidelines for the Health Risk Assessment of Chemical Mixtures", *The Risk Assessment Guidelines of 1986* EPA/600/8-87/045, Federal Register Vol. 51, No. 34014-25, (August 1987).

FR 51, 1986b "Guidelines for Carcinogen Risk Assessment", *Notices: Environmental Protection Agency,* Federal Register Vol. 51, No. 185, (Wednesday, September 24, 1986).

FR 52, 1987 "The list of Extremely Hazardous Substances and their Threshold Planning Quantities", *Rules and Regulations. Appendix A to Part 355*, pp. 352-358, Federal Register Vol. 52, No. 77, (Wednesday, April 22, 1987).

FR 53, 1988 "Integrated Risk Information System (IRIS)": *Health Risk Assessment Guidelines*, Federal Register Vol. 53, No. 106, (Thursday, June 2, 1988).

FR 54, 1989 "Air Contaminants", *Department of Labor, Occupational Safety and Health Administration, Final Rule,* 29 CFR 1910, pp. 2329-2984 (1-19-1989).

IARC 1982a "An Evaluation of Chemicals and Industrial Processes Associated with Cancer in Humans Based on Human and Animal Data", *International Agency for Cancer Research Working Group,* IARC Monographs Volumes 1 to 20, Cancer Research, Vol. 40, pp 1-20 (1982).

IARC 1982b "IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans", *International Agency for Cancer Research Working Group:*, Supplement 4, IARC, Lyon, France (Oct. 1982).

ICRP 60, 1990 "1990 Recommendations of the International Commission on Radiological Protection", *Annals of the ICRP Vol. 21, No. 1-3,* Pergamon Press (1991).

ILO 1991 "Occupational Exposure Limits for Airborne Toxic Substances", *Values of selected countries prepared from ILO-CIS data base of exposure limits*, International Labor Office, Geneva. 3rd Ed.(1991)

Kim 1990 Kim, K.S., and W.R. Waltz, "Interim Hazards Classification Guide for Non-Reactor Facilities at the Savannah River Site", Revision (U), (July 27, 1990).

NAS 1985 "Emergency and Continuous Exposure Guidance Levels for Selected Airborne Contaminants", V 1-7, *COMMITTEE ON TOXICOLOGY. Board on Toxicology and Environmental Health Standards, Commission on Life Sciences, National Research Council*, National Academy Press, Washington, DC. (1985).

NAS 1986 "Guidelines and Methods for Preparing Emergency Exposure Guidance Level (EEGL), Short-Term Public Emergency Guidance Level (SPEGL), and Continuous Exposure Guidance Level (CEGL) Documents", *COMMITTEE ON TOXICOLOGY*, Board on Environmental Studies and Toxicology, Commission on Life Sciences, National Research Council. National Academy Press, Washington DC (1986).

NSC 1990 Deaths and Death Rates by Age and Sex, 1987. Accident Facts, National Safety Council, 1990 Edition, Chicago, Illinois.

NIOSH 1987 "Registry of Toxic Effects of Chemical Substances" (RTECS): *U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health* (April 1987) (Now available only as an online database.

NIOSH 1994 "NIOSH POCKET GUIDE TO CHEMICAL HAZARDS", *U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health*, Washington DC (1994).

NRC 1983 "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants", *Nuclear Regulatory Commission Regulatory Guide 1.145-7* (Feb. 1983)

Sax 1991 Sax, N.Irving, "Dangerous properties of Industrial Materials", 7th Edition (1991) (Van Nostrand Reinhold Company, New York).

SuperChems™ '92 "Technical Reference Manual, Version 1.1", *Arthur D. Little, Inc.* Cambridge, MA., (1992).

UCRL-15910 1990 "Design and Evaluation Guidelines for Department of Energy Facilities Subjected to Natural Phenomena Hazards" *UCRL-15910*, (June 1990).

Table 1

Recommended Nonradiological Hazard Classification Guidelines for use with DOE Order 5481.1B

	PRIMARY CONCENTRATION / CANCER RISK GUIDELINES	
HAZARD CLASS	ONSITE	OFFSITE
HIGH	---	≥ ERPG-3 ≥ 2 E 00 ICR
MODERATE	≥ ERPG-3 ≥ 2 E 00 ICR	≥ ERPG-2 ≥ 2 E-2 ICR
LOW	≥ ERPG-2 ≥ 2 E-2 ICR	≥ ERPG-1 ≥ 2 E-4 ICR

Note: These guidelines are to be applied as follows:

Concentrations are first calculated as peak 15-minute average values, and this is the applicable value for all chemicals for which the toxicity effect is immediate (i.e., concentration-dependent, e.g., irritants, corrosives, and any chemical that has a PEL-STEL, PEL-C, TLV -STEL or TLV-C value - see section 4.2).

If this procedure appears to yield overly conservative results for chemicals whose toxic effects depend upon the total quantity of chemical taken into the body (i.e., dose-dependent - see section 4.2), then for those chemicals only, the peak 1-hour average concentration may be used as the basis for comparison with the guideline concentrations.

Class D stability and a windspeed of 4.5 m/s (or 50% site-specific meteorology) is used, and no credit may be taken for plume meander or building wake effects.

Table 2

Recommended Nonradiological Hazard Categorization Guidelines for use with DOE Order 5480.23

HAZARD CATEGORY	RECEPTOR LOCATION	RECOMMENDED GUIDELINES
1	OFFSITE	≥ ERPG-3 ≥ 2 E 00 ICR
2	ONSITE	≥ ERPG-3 ≥ 2 E 00 ICR
3	LOCAL	≥ ERPG-3 ≥ 2 E 00 ICR

Notes: These guidelines are to be applied as follows:

Concentrations are first calculated as peak 15-minute average values, and this is the applicable value for all chemicals for which the toxicity effect is immediate (i.e., concentration-dependent, e.g., irritants, corrosives, and any chemical that has a PEL-STEL, PEL-C, TLV -STEL or TLV-C value - see section 4.2, p. 9-10).

If this procedure appears to yield overly conservative results for chemicals whose toxic effects depend upon the total quantity of chemical taken into the body (i.e., dose-dependent - see section 4.2), then for those chemicals only, the peak 1-hour average concentration may be used as the basis for comparison with the guideline concentrations.

Class D stability and a windspeed of 4.5 m/s (or 50% site-specific meteorology) is used, and no credit may be taken for plume meander or building wake effects.

Table 3

Recommended Nonradiological Risk Guidelines

	PRIMARY CONCENTRATION / CANCER RISK GUIDELINES	
EVENT FREQUENCY (yr^{-1})	ONSITE	OFFSITE
$\leq 10^{-6}$	> ERPG-3	> ERPG-2
$> 10^{-6}$ to $\leq 10^{-4}$	$\leq$ ERPG-3 $\leq$ 2 E 00 ICR	$\leq$ ERPG-2 $\leq$ 2 E-2 ICR
$> 10^{-4}$ to $\leq 10^{-2}$	$\leq$ ERPG-2 $\leq$ 2 E-2 ICR	$\leq$ ERPG-1 $\leq$ 2 E-4 ICR
$> 10^{-2}$ to $\leq 10^{0}$	$\leq$ ERPG-1 $\leq$ 2 E-4 ICR	$\leq$ PEL-TWA $\leq$ 2 E-6 ICR

Note: These guidelines are to be applied as follows:

Concentrations are first calculated as peak 15-minute average values, and this is the applicable value for all chemicals for which the toxicity effect is immediate (i.e., concentration-dependent, e.g., irritants, corrosives, and any chemical that has a PEL-STEL, PEL-C, TLV -STEL or TLV-C value - see section 4.2, p. 9-10).

If this procedure appears to yield overly conservative results for chemicals whose toxic effects depend upon the total quantity of chemical taken into the body (i.e., dose-dependent - see section 4.2), then for those chemicals only, the peak 1-hour average concentration may be used as the basis for comparison with the guideline concentrations.

Atmospheric models appropriate to the site and/or accident scenario being evaluated should be chosen (e.g., dense gas model, buoyant plume model, straight-line Gaussian plume model, etc.) so that a conservative risk assessment results. Credit may be taken for mitigating structures and components that remain functional in the accident scenario being analyzed.

These guidelines are applicable to the analysis of nonradiological hazardous materials in both nuclear and non-nuclear facilities.

Table 4

Recommended Hierarchy of Alternative Concentration-Limit Parameters (ERPG-Equivalent values)

Primary Guideline	Hierarchy Group	Hierarchy of Alternative Guidelines	Source of Concentration Parameter
ERPG-3	1	EEGL (30-min) IDLH	AIHA 1993 NAS 1985 NIOSH 1990
ERPG-2	2	EEGL (60-min) LOC PEL-C TLV-C TLV-TWA x 5*	AIHA 1993 NAS 1985 EPA 1987 CFR 29:1910.1000 ACGIH 1994/5 ACGIH 1994/5
ERPG-1	3	PEL-STEL TLV-STEL TLV-TWA x 3*	AIHA 1993 CFR 29:1910.1000 ACGIH 1994/5 ACGIH 1994/5
PEL-TWA	4	TLV-TWA SPEGL (60-min) CEGL	CFR 29:1910.1000 ACGIH 1994/5 NAS 1985 NAS 1985

Notes:

- * Applicable only to chemicals whose effects are dose-dependent.
- The protocol is to use the primary guidelines first and then the alternative guidelines in the order presented for each hazard level when the primary guideline does not exist.
- Calculate the peak 15-minute average concentration at the receptor point of interest (e.g., the site boundary).
- Compare with the relevant concentration-limit guideline value. The ratio gives the hazard index (HI), which should be ≤ 1 to be acceptable.
- Make no adjustment for time for which concentration-limit guideline value was developed.
- Are toxic effects of chemical immediate (by definition, any chemical that has a PEL-STEL, PEL-C, TLV-STEL, or TLV-C value)?
- If not, toxic effects are assumed to be dose-dependent, unless information to the contrary is available, i.e.,

  $D\,(mg) = C\,(mg/m^3) \times R\,(m^3/min) \times T\,(min) \times f\,(absorbed\ fraction)$

  For these dose-dependent chemicals only, the peak 1-hour average concentration may be used. Note that there are chemicals which exert concentration-dependent effects that also exhibit dose-dependent effects at lower concentrations, e.g., benzene.
- If application of this hierarchy to a particular chemical gives rise to a value for a lower hazard class that is higher than the value for the next higher hazard class (e.g., ERPG-1-equivalent value greater than ERPG-2-equivalent value), then that value should be adjusted downwards to match that of the next higher hazard class (see Table 6 for examples).

Note: Some substances may cause immediate irritation, even with very short exposures, e.g. hydrgen sulfide.

Table 5

Health Effects Associated with Toxic Chemical Risk Guidelines
(Potential health effects resulting from acute exposure to chemicals)

Note: "It is recognized by the (American Industrial Hygiene Association Emergency Response Planning) committee (and all who make use of these values should remember) that human responses do not occur at precise exposure levels but can extend over a wide range of concentrations. The values derived for ERPGs[1] should not be expected to protect everyone, but should be applicable to most individuals in the general population. In all populations there are hypersensitive individuals who will show adverse responses at exposure concentrations far below levels where most individuals would normally respond". (Source: AIHA Emergency Response Planning Guidelines document preface).

Potential life threatening effects and other potential severe effects

---------- ERPG-3 ----------

MOST PEOPLE:	No life-threatening health effects, but could experience Irreversible or other serious health effects or symptoms which could impair ability to take protective action
A FEW PEOPLE:	Life-threatening health effects, as well as irreversible or other serious health effects or symptoms which could impair ability to take protective action

---------- ERPG-2 ----------

MOST PEOPLE:	No Irreversible or other serious health effects or symptoms which could impair ability to take protective action
A FEW PEOPLE:	Irreversible or other serious health effects or symptoms which could impair ability to take protective actionl

---------- ERPG-1 ----------

MOST PEOPLE:	Mild transient adverse health effects or perception of a clearly defined objectionable odor
A FEW PEOPLE:	Potential health effects

---------- PEL-TWA ----------

MOST PEOPLE:	No appreciable risk of health effects
A FEW PEOPLE:	Potential health effects

Table 6
Chemical-Specific Primary or Hierarchy-based Alternative Concentrations (based on all available October 1994 concentration limits)

CHEMICAL NAME	ERPG-Equivalent Concentrations Selected for Primary Guideline				UNITS
	PEL-TWA	ERPG-1	ERPG-2	ERPG-3	
Acetone	750	1000	8500	8500[1]	ppm
Acrolein	0.1	**0.1**	**0.5**	**3**	ppm
Acrylic Acid	2[2]	**2**	**50**	**750**	ppm
Acrylonitrile (Ca) (Set 11)	2	6[3]	**35**	**75**	ppm
Allyl Chloride	1	**3**	**40**	**300**	ppm
Aluminum Oxide	10	15[2]	15[2]	25	mg/m3
Ammonia	25	**25**	**200**	**1000**	ppm
Arsenic (Inorganic) as As (Ca)	0.01	0.03	1.4	5	mg/m3
Arsenic (Organic compounds) as As	0.03[2]	0.03	0.05	5	mg/m3
Arsine (Ca) (Set 12)	0.05	0.15	**0.3**	**0.3**	ppm
Benzene (Ca)	1	50[4]	150[4]	1000[4]	ppm
Beryllium (Ca)	0.002	0.006	0.025[5]	0.1[5]	mg/m3
Bromine	0.1	**0.2**	**1**	**5**	ppm
Bromotrifluoromethane	1000	3000	25000	40000	ppm
1,3-Butadiene (Ca)	2	**10**	**50**	**5000**	ppm
Carbon Disulfide	4	12[6]	**50**	**500**	ppm
Carbon Monoxide (Set 11)	35	**200**	**350**	**500**	ppm
Carbon Tetrachloride (Ca) (Set 9)	2	**20**	**100**	**750**	ppm
Chlorine	0.5	**1**	**3**	**20**	ppm
Chlorine Trifluoride (Set 9)	0.1	**0.1**	**1**	**10**	ppm
Chloroacetyl Chloride	0.05	**0.1**	**1**	**10**	ppm
Chloroform (Ca)	2	100[5]	1000[5]	5000[5]	ppm
Chloropicrin	0.1	0.2[2]	**0.2**	**3**	ppm
Chlorosulfonic Acid	1[7]	**2**	**10**	**30**	mg/m3
Chlorotrifluoroethylene	5[3]	**20**	**100**	**300**	ppm
Crotonaldehyde (Ca)	2	**2**	**10**	**50**	ppm
Dichlorodifluoromethane (FC12)	1000	1500[2]	1500[2]	1500	ppm
Dichlorofluoromethane (FC21)	10	30	100	5000	ppm
Dichlorotetrafluoroethane (FC114)	1000	3000	10000	15000	ppm
Diketene	0.5[3]	**1**	**5**	**50**	ppm
Dimethylamine	10	15[6]	**100**	**500**	ppm
Dimethylformamide	2[2]	2[4]	100[4]	200[4]	ppm
1,1-Dimethylhydrazine (Ca)	0.5	1.5	5	15	ppm
Epichlorohydrin (Ca)	2	**2**	**20**	**100**	ppm
Ethanolamine	3	6	50	50[1]	ppm
Ethylene Glycol	4	20[10]	40	60	ppm
Ethylene Oxide (Ca)	1	3	**50**	**500**	ppm
Fluorine	0.1	2	7.5	10	ppm
Formaldehyde (Ca)	0.75	**1**	**10**	**25**	ppm
Hexachlorobutadiene	0.02	**3**	**10**	**30**	ppm
Hydrazine (Ca)	0.1	0.3	0.8[5]	10[5]	ppm
Hydrogen Chloride	0.5	**3**	**20**	**100**	ppm
Hydrogen Fluoride	2[2]	**2**	**20**	**50**	ppm
Hydrogen Peroxide(30%)	1	2[4]	10[4]	30[4]	ppm

For footnotes, see page 36.

Table 6.
Chemical-Specific Primary or Hierarchy-based Alternative Concentrations (Continued) (based on all available October 1994 concentration limits)

CHEMICAL NAME	ERPG-Equivalent Concentrations Selected for Primary Guideline				UNITS
	PEL-TWA	ERPG-1	ERPG-2	ERPG-3	
Hydrogen Sulfide	10	15[6]	30	100	ppm
Isobutyronitrile	8[8]	10	50	200	ppm
Isopropyl Alcohol	400	400[2]	400	2000	ppm
Lithium Bromide	1	7	15	500[9]	mg/m3
Lithium Chromate	0.05	0.05	0.1	500[9]	mg/m3
Lithium Hydride/Hydroxide	0.025	0.05[5]	0.1[5]	0.5[5]	mg/m3
Mercury Vapor (as Hg)	0.05	0.075	0.1	10	mg/m3
Methane	5000	5000[10]	5000[3]	5000[3]	ppm
Methyl Alcohol/Methanol	200	200	1000	5000	ppm
Methyl Chloride (Ca) (Set 9)	50	100	400	1000	ppm
Methyl Fluoride (as fluoride)	2.5	7.5	12.5	500[9]	mg/m3
Methyl Iodide (Ca)	2	25	50	125	ppm
Methyl Mercaptan	0.5	1.5[6]	25	100	ppm
Monomethylamine	10	10	100	500	ppm
Monomethylhydrazine (Ca)	0.24	0.5[3]	0.5	20	ppm
Nickel Carbonyl (as Ni) (Ca)	0.001	0.05[2]	0.05	2	ppm
Nitric Acid	2	2[5]	15[5]	30[5]	ppm
Nitrogen Dioxide	2[2]	2[5]	15[5]	30[5]	ppm
Nitrous Oxide	50	150	10000	20000	ppm
Ozone	0.1	0.3	1	5	ppm
Perchloroethylene	25	100[5]	200[5]	500[5]	ppm
Perfuoroisobutylene	0.1[3]	0.1[3]	0.1	0.3	ppm
Phenol	5	10	50	200	ppm
Phosgene	0.1	0.2[2]	0.2	1	ppm
Phosphine (Set 11)	0.3	1	2.5	5	ppm
Phosphoric Acid	1	3	5	10000	mg/m3
Phosphorous Pentoxide	1[3]	5	25	100	mg/m3
Sodium Hydroxide	2[2]	2[5]	40[5]	100[5]	mg/m3
Sodium Monoxide	10[11]	30	50	500[9]	mg/m3
Sodium Peroxide	10[11]	30	50	500[9]	mg/m3
Styrene (Ca) (Set 10)	50	50	250	1000	ppm
Sulfur Dioxide	0.3[2]	0.3	3	15	ppm
Sulfuric Acid (Oleum,Sulfur Trioxide)	1	2	10	30	mg/m3
Tetrafluoroethylene	10[3]	200	1000	10000	ppm
Titanium Tetrachloride	0.5[7]	5	20	100	mg/m3
Toluene	100	150	200	500	ppm
Trichloroethylene (Ca)	50	100[5]	500[5]	1000[5]	ppm
Trichlorofluoromethane (FC11)	100	500[10]	1500	2000	ppm
Trichlorotrifluoroethane (FC113)	1000	1250	1500	2000	ppm
Trimethylamine	10	15[6]	100	500	ppm
Uranium Hexafluoride (Set 10)	0.2	5	15	30	mg/m3
Vinyl Acetate	5[2]	5	75	500	ppm
Vinylidene Chloride	1	20	25[3]	25[3]	ppm
Xylene	100	150	200	900	ppm

For footnotes, see page 36.

Notes for Table 6:
Chemical-Specific or hierarchy-based Alternative Concentrations:

Values given as alternatives in the absence of ERPG values were selected from the concentration-limit parameters given in Appendix Table A3-2, using the hierarchy presented in Table 4. This table does not include all the chemicals for which ERPG values have been adopted since 1992, but does include the recently adopted ERPG values for chemicals on the original Rev. 1 report list. All officially adopted ERPG values are bolded.

(Ca) indicates that chemical is a confirmed or suspected human carcinogen.

At *least* one guideline value was found for all but 2 (sodium monoxide and sodium peroxide) of the 88 chemical substances on this list. Neither is listed among over 2000 chemicals on the ILO-CIS data base of exposure limits (ILO 1991). Values from 15 major countries are included in this list. It is concluded that the above two substances do not qualify as being "extremely hazardous", but default values (see 9 and 11 below) can still be derived for them.

1 New (1994) IDLH values not used for these chemicals because the values are lower than the well-documented ERPG-2-equivalent limit.
2 Values 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.
3 Estimated values, based on available limits and toxicological data.
4 Values sent out for ERP Committee ballot in 1994.
5. DOE-sponsored draft ERPG values.
6 For these chemicals, ERPG-1 values that are odor-based have not been used. The next available hierarchy value is used instead of the ERPG-1 value because the ERPG-1 value is based on perception rather than health effects (see Figure 6 & Appendix 3). For each of the chemicals below, the adjustment involved a factor of at least 10. Without adjustment, the hierarchy values would have been as follows:

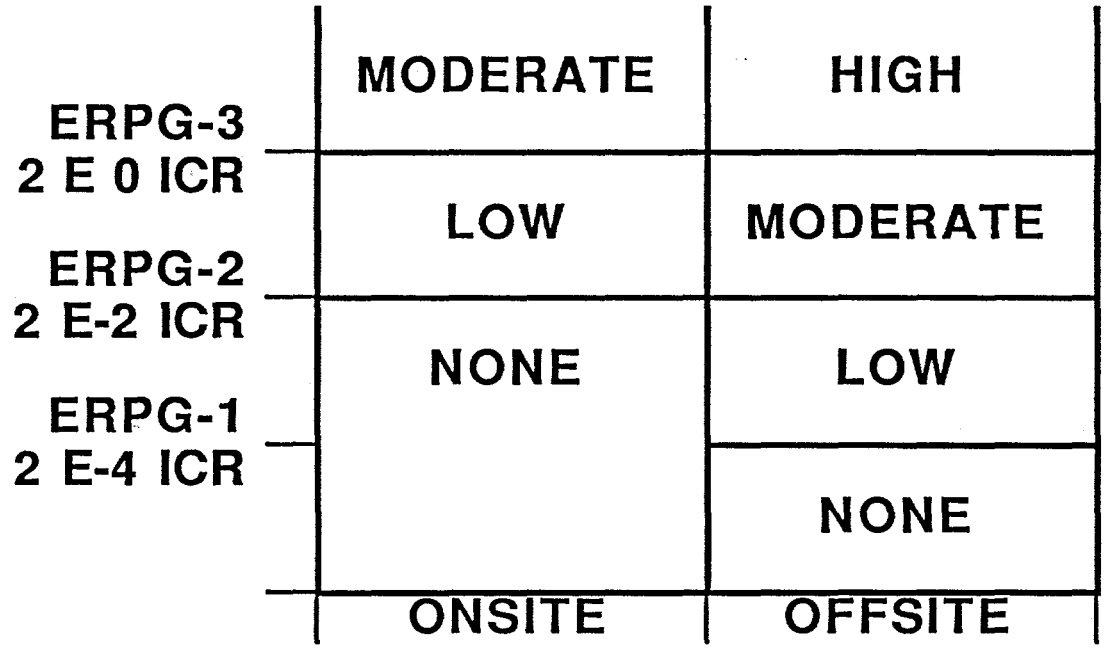
Chemical	Formula	PEL-TWA	TLV-TWA	ERPG-1	ERPG-2	ERPG-3
Carbon disulfide	CS_2	4	10	(1)	50	500
Dimethylamine	$(CH_3)_2.NH$	10	5	(1)	100	500
Hydrogen Sulfide	H_2S	10	10	(0.1)	30	100
Methyl mercaptan	CH_3SH	0.5	0.5	(0.005)	25	100
Trimethylamine	$(CH_3)_3N$	10	5	(0.1)	100	500

Note: All values are in ppm. The ERPG-1 values that have been adjusted, using the hierarchy values from Appendix Table A3-2, are in parentheses.

7 Value based on AIHA Workplace Environmental Exposure Levels (WEELs).
8 Based on NIOSH Recommended Exposure Limit.
9 Recommended upperbound value for respirable particulate material.
10 24-hour EEGL-TWA.
11 Value for Particulate Material Not Otherwise Classified (PNOC).

Figure 1

Graphical Representation of Recommended Nonradiological Hazard Classification Guidelines for use with DOE ORDER 5481.1B (see Table 1)

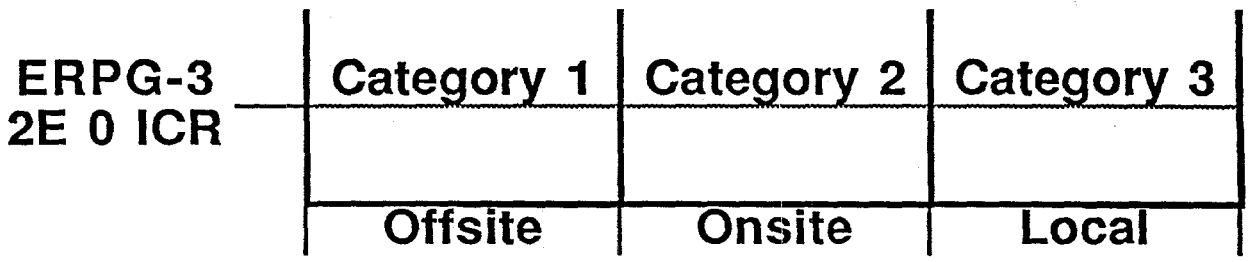


Note: Concentration and Incremental Cancer Risk (ICR), which are presented as increasing upwards, are not to scale.

Application example: If the calculated onsite concentration is $\geq$ ERPG-3, the facility hazard classification is "moderate". If the calculated offsite concentration is $\geq$ ERPG-3, the facility hazard classification is "high".

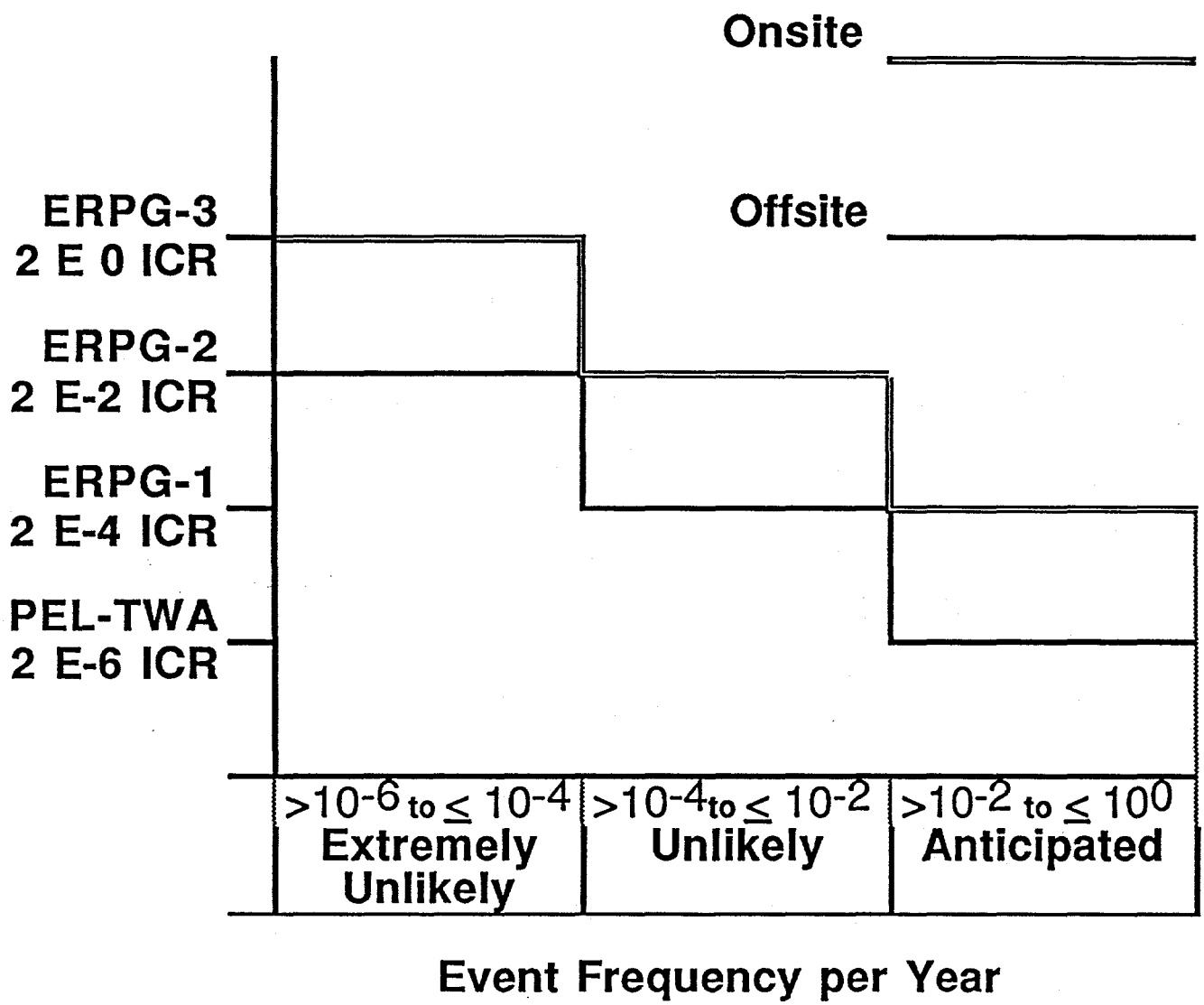
Figure 2

Graphical Representation of Recommended Nonradiological Hazard Categorization Guidelines for use with DOE Order 5480.23 (see Table 2)



Note: Application example: If the calculated concentration is ≥ ERPG-3 onsite, and < ERPG-3 offsite, the hazard category for the facility or operation is "moderate".

Figure 3
Graphical Representation of Recommended Nonradiological Risk Guidelines (see Table 3)



Note: Concentration and Incremental Cancer Risk (ICR), which are presented as increasing upwards, are not to scale.

Application example: If the calculated onsite concentration is ≤ ERPG-2, the permissible event frequency per annum is in the range > 10^{-4} to ≤ 10^{-2}. If the calculated offsite concentration is ≤ ERPG-1, the permissible event frequency per annum is in the range > 10^{-4} to ≤ 10^{-2}.

Figure 4

FLOW CHART: Application of Toxic Chemical Guidelines

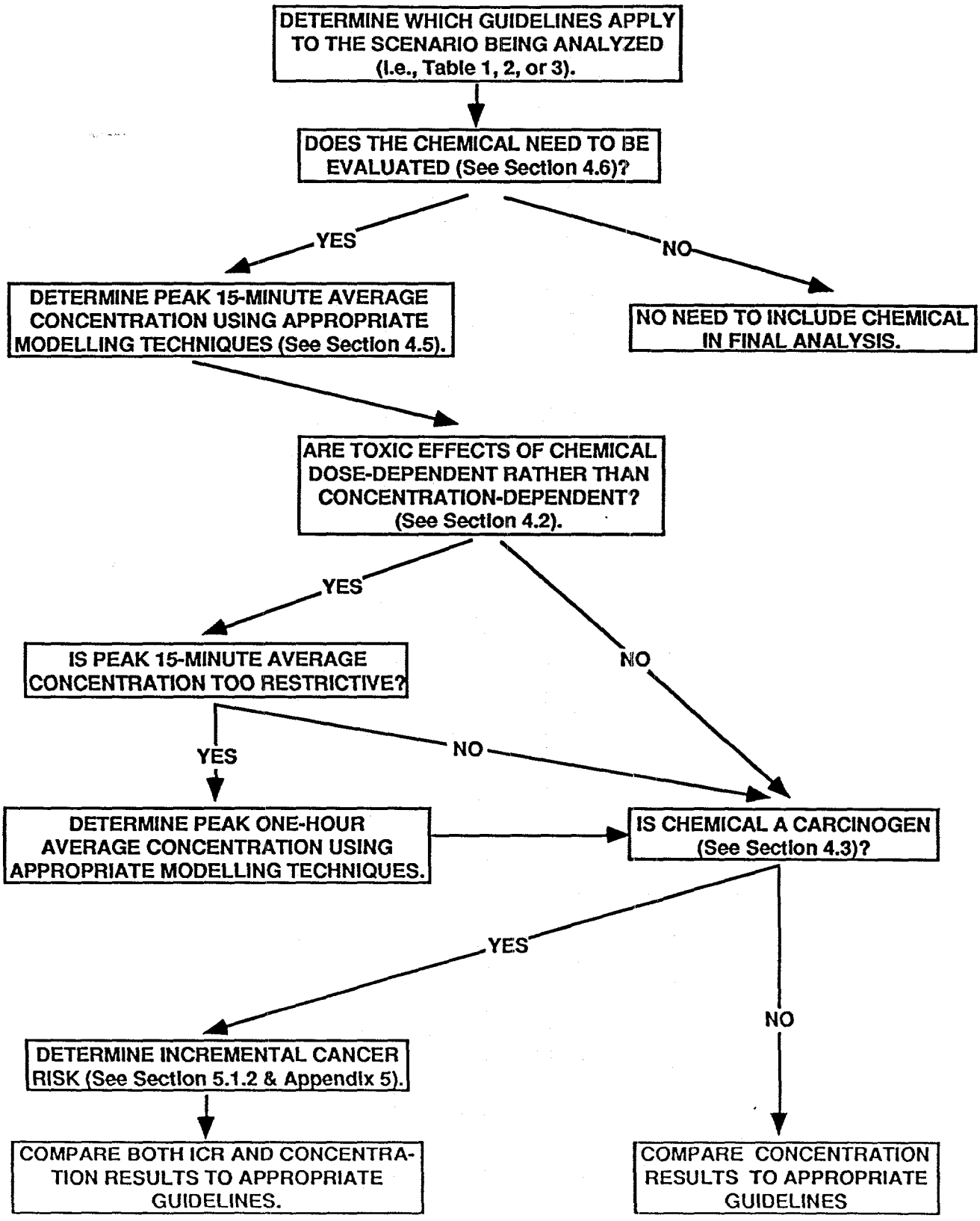


Figure 5: Alternative Guideline Concentrations versus PEL-TWA

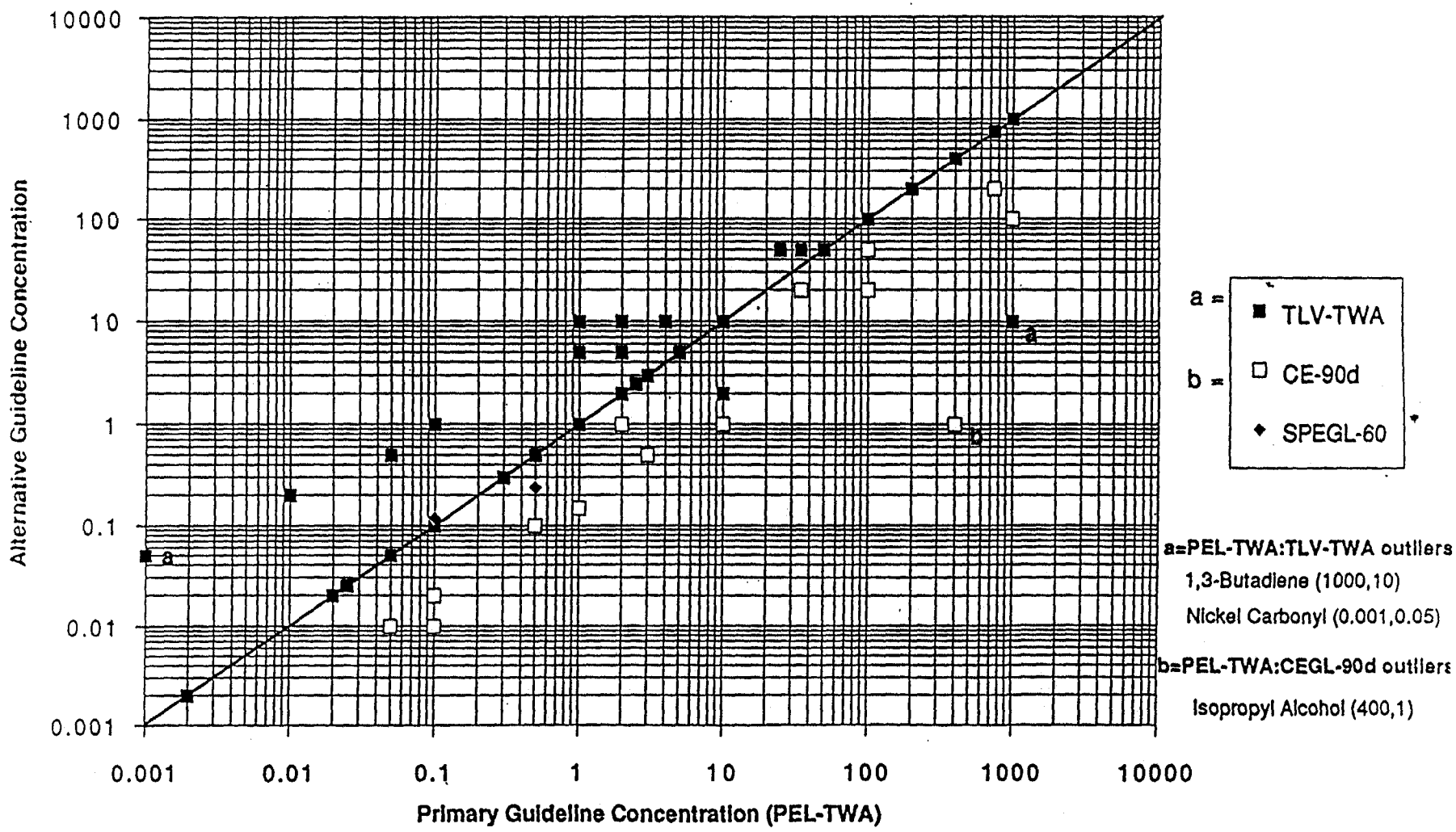


Figure 6: Alternative Guideline Concentrations versus ERPG-1

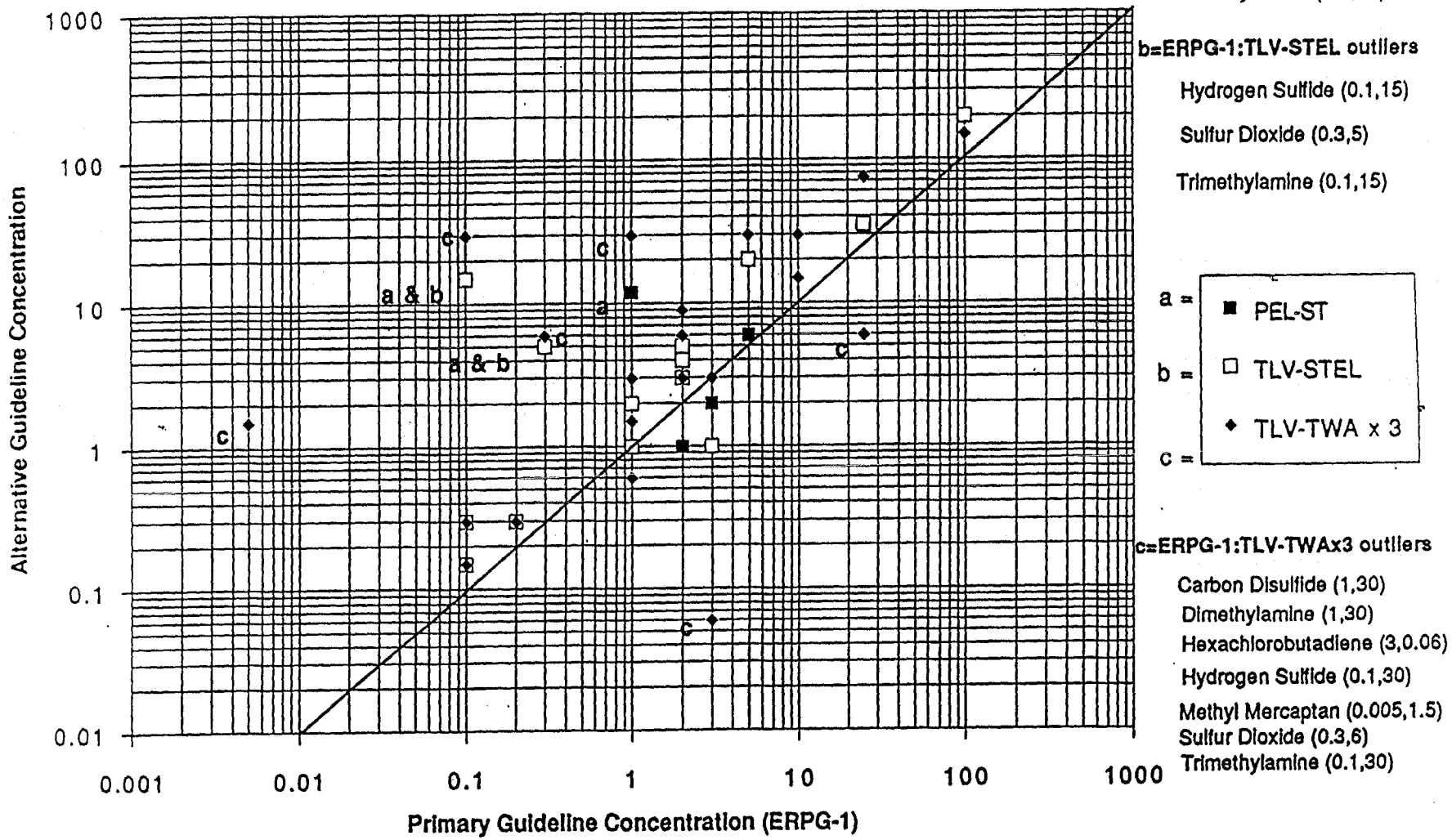
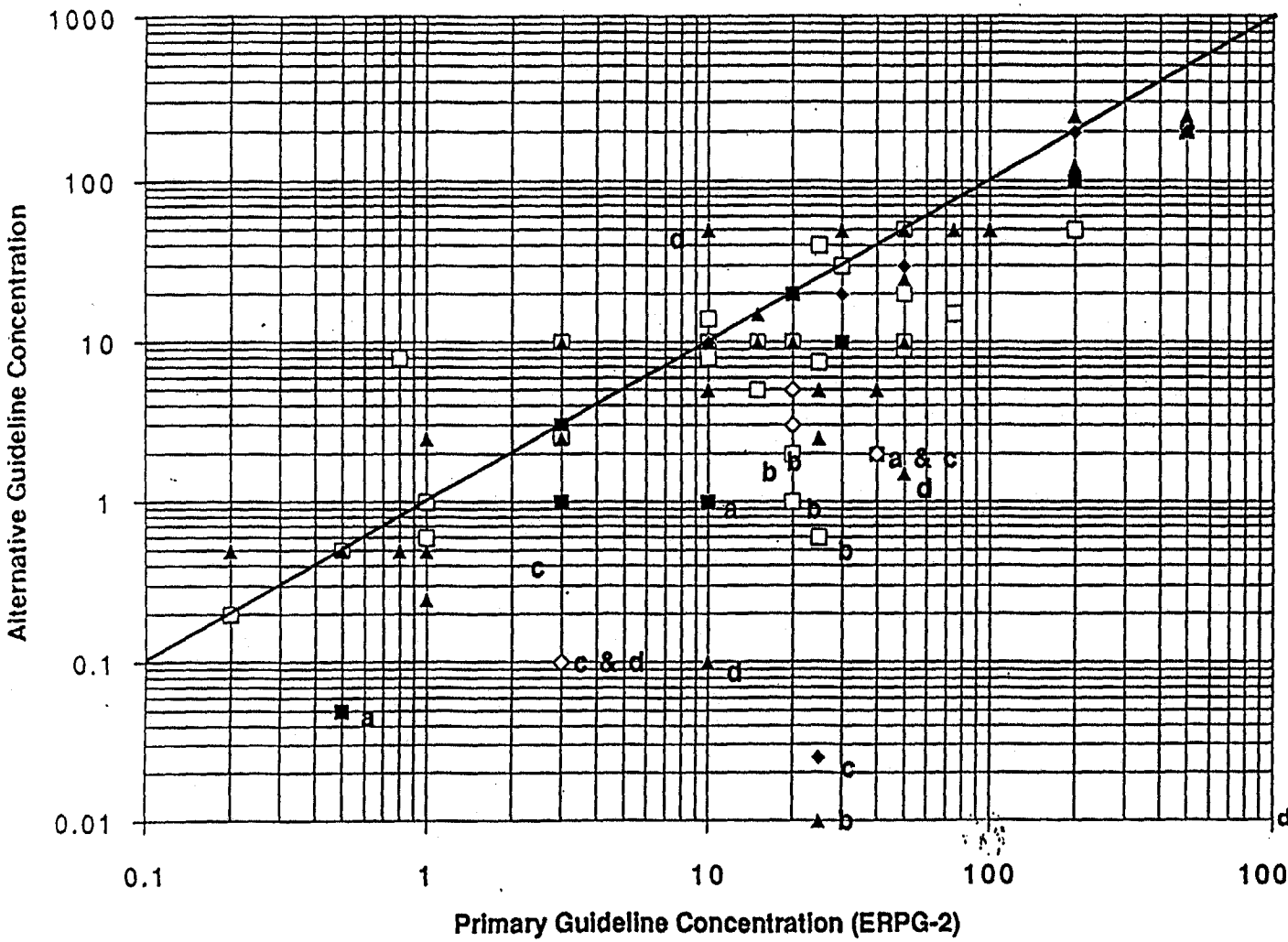


Figure 7: Alternative Guideline Concentrations versus ERPG-2



a=ERPG-2:EEGL-60 outliers

Acrolein (0.5,0.05)
Sodium Hydroxide (40,2)
Sulfuric Acid (10,1)

b=ERPG-2:LOC outliers

1,3-Butadiene (50,2000)
Hydrogen Fluoride (20,2)
Phosphorus Pentoxide (25,0.6)
Titanium Tetrachloride (20,1)

a = EEGL-60
b = LOC
c = PEL-C
c = TLV-C
d = TLV-TWA x 5

c=ERPG-2:PEL-C outliers

Beryllium (25,0.025)
Carbon Trifluoride (3,0.1)
Sodium Hydroxide (40,2)

d=ERPG-2:TLV-TWAx5 outliers

Beryllium (25,0.01)
Hexachlorobutadiene(10,0.1)
Phosphine (50,1.5)

Figure 8: Alternative Guideline Concentrations versus ERPG-3

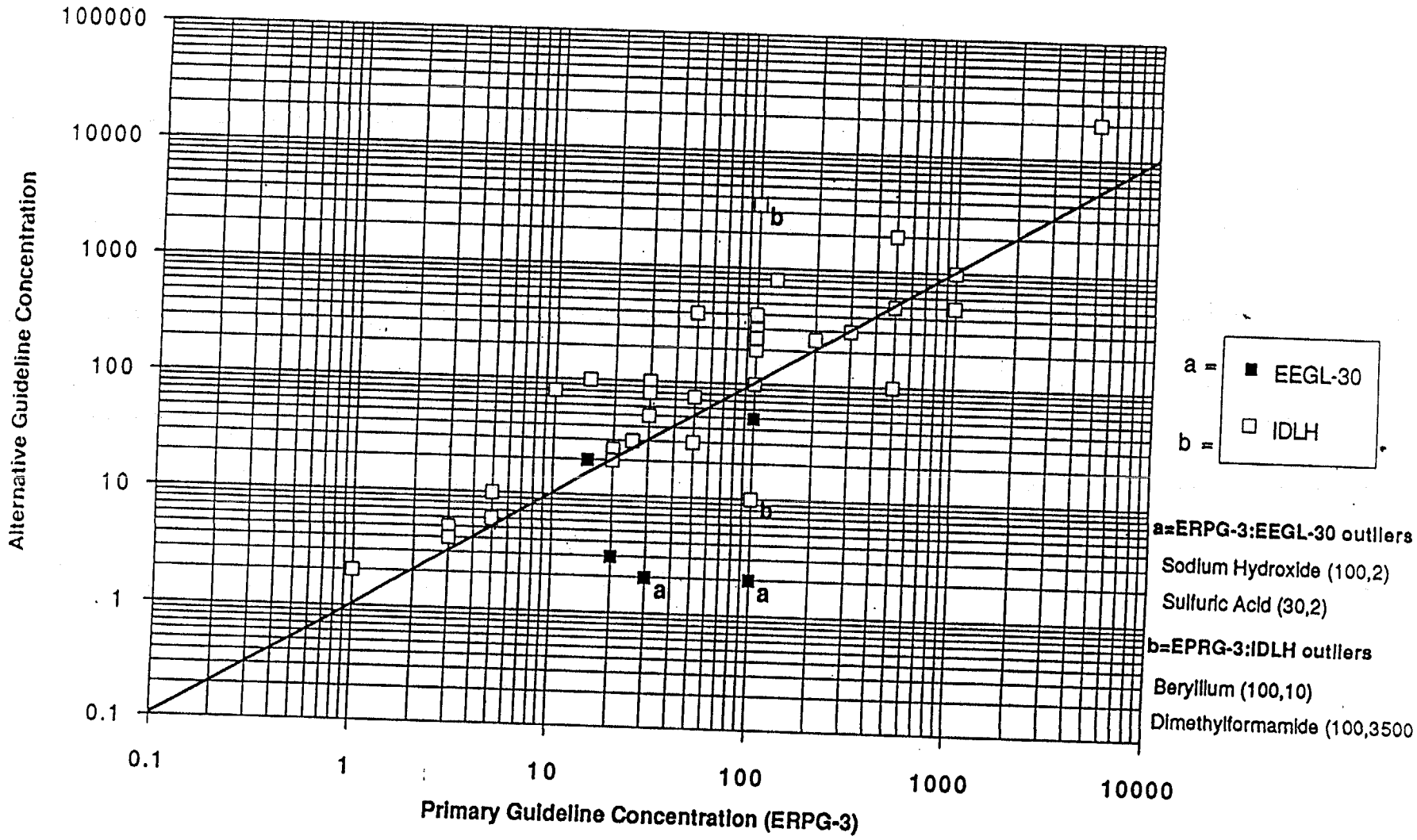
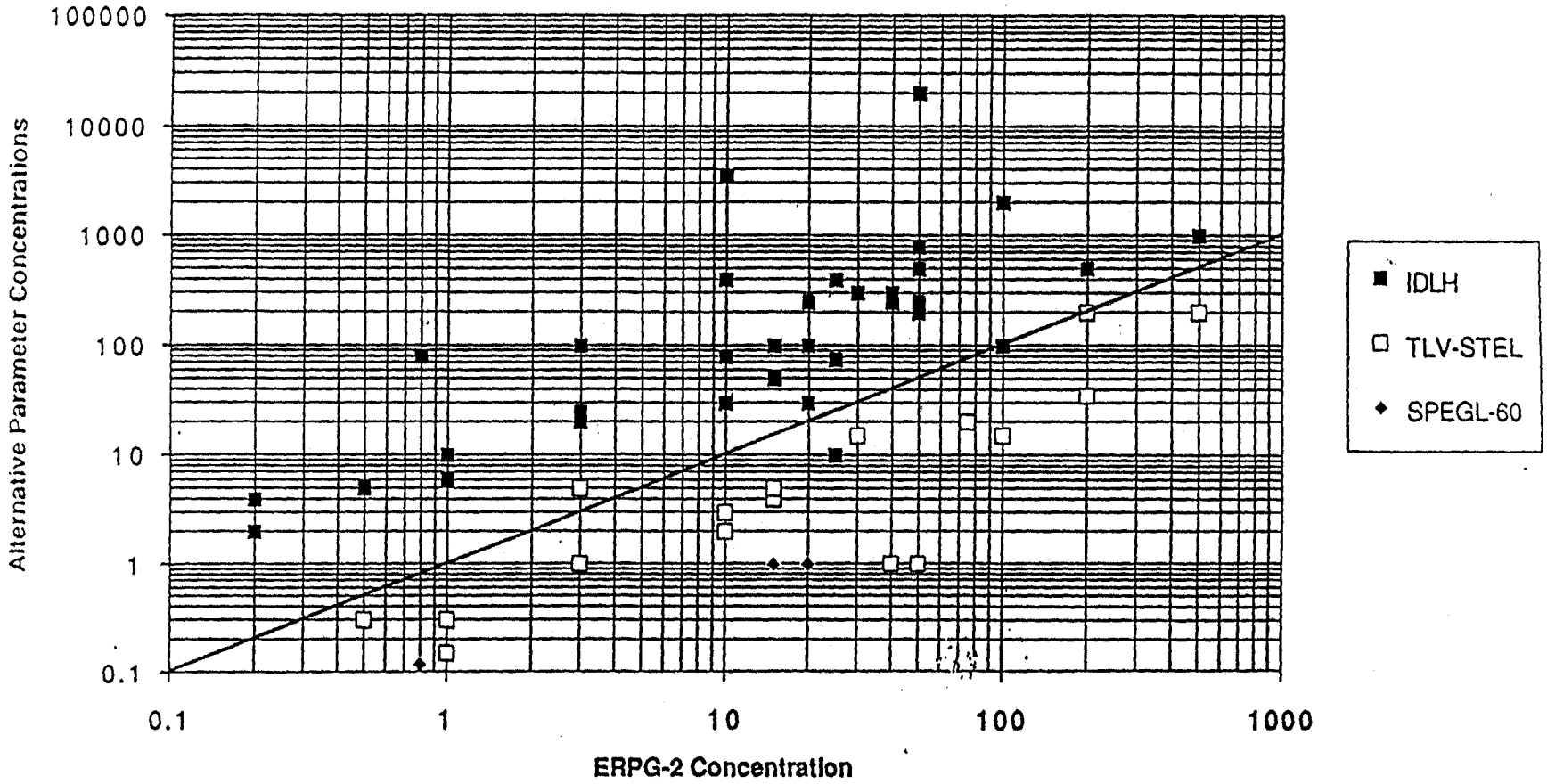


Figure 9: Other Parameter Concentration-Limits versus ERPG-2s



(This page intentionally left blank)

Appendix 1

Acronym Definitions

AGENCIES: (Listed alphabetically)

ACGIH	American Conference of Governmental Industrial Hygienists
AIHA	American Industrial Hygiene Association
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
NAS	National Academy of Sciences
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety & Health Administration
USDOT	U.S. Department of Transportation

GUIDELINES

AIHA Terms (developed for emergency response purposes) (AIHA 1989):

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 nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects."

WEEL Workplace Environmental Exposure Level guides: "... the workplace exposure levels to which it is believed nearly all employees could be exposed repeatedly without adverse effects. All WEELs are expressed as either time-weighted average (TWA) concentrations or ceiling values ..."

NAS Terms (developed for military use) (NAS 1986):

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 h. Exposure at an EEGL might produce reversible effects that do not impair judgement 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: "CEGLs are 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 d".

SPEGL — Short-Term Public Emergency Guidance Level: "The SPEGL is 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 susceptability of the general public. This includes sensitive populations -- such as children, the aged, and persons with serious debilitating diseases".

OSHA Terms (developed for occupational safety) (CFR 29:1910.1000):

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, 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:
$E = (C_aT_a + C_bT_b + \ldots C_nT_n) / 8$
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 which 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."

EPA Terms (developed for emergency planning) (EPA 1987):

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 FEMA and US DOT)

ACGIH Terms (developed for workplace safety) (ACGIH 1994):

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."

NIOSH Term (developed for respirator use) (NIOSH 1990):

IDLH — Immediately Dangerous to Life or Health: "... a condition 'that poses a threat of exposure to airborne contaminants when that exposure is likely to cause death or delayed permanent adverse health effectsor prevent escape from such an environment.' The purpose of establishing an IDLH exposure concentration is to 'ensure that the worker can escape from a given contaminated environment in the event of failure of the respiratory protection equipment'. ..." (p. xii of reference NIOSH 1994)

Appendix 2

Use of IRIS Database

Introduction:

The EPA published notice of availability of IRIS in the Federal Register (FR 53, 1988), under the title: Integrated Risk Information System (IRIS): Health Risk Assessment Guidelines. The summary states:

> "The Integrated Risk Information System (IRIS) is an on-line database of the U.S. Environmental Protection Agency (EPA) that provides risk assessment and regulatory information on chemical substances. This notice describes IRIS and provides information on how to access this health risk information base.
>
> Effective Date: April 15, 1988.
>
> For Further Information Contact: IRIS User Support. USEPA Office of Research and Development, Environmental Guidelines and Assessment Office, MS-114, Cincinnati, OH 45268. Telephone (513) 569-7254."

The Supplementary Information section that follows gives a description of IRIS, and states:

> "EPA staff and contractors are expected to use the risk information for those chemicals in the IRIS database. ... Each of the chemical files contains a chronic health hazard assessment for noncarcinogenic effects and/or for carcinogenic effects as relevant. ... Supplementary information, such as acute toxicity summaries and physical-chemical properties data, are included when available. ... Thus, the information in IRIS represents an expert Agency consensus. ...
>
> "At this time, IRIS chemical files are only available electronically. ...
>
> "The primary qualitative and quantitative risk data on IRIS, the reference dose and carcinogenicity assessments, can serve as guides in evaluating potential health hazards and selecting a response to alleviate a potential risk to human health.
>
> "The CARCINOGENICITY ASSESSMENTS on IRIS begin with a qualitative weight-of-evidence judgement in the form of a classification as to the likelihood that an agent may be a carcinogen for humans. This judgement is made independent of consideration of the agent's potency. A quantitative assessment, including slope factor and unit risks, is then presented. The slope factor is an upper-bound ESTIMATE of the cancer risk for humans per mg of agent/kg of body weight/day. The unit risk, which is calculated from the slope factor, is an ESTIMATE in terms of either risk per ug/L of drinking water, or risk per ug/cu.m of air concentration. ..."

The slope factor (q_1^*) is multiplied by the relevant agent concentration to arrive at an estimate of the risk, i.e., for an airborne pollutant, the risk is

$$R = C\ (mg/m^3) \times q_1^*\ (mg/m^3)^{-1}$$

The RfD or RfC, which have been defined in Appendix 1, can be used to estimate the levels of environmental exposure in water or air at which no adverse health effects are expected to occur. It is important to note that these values were developed for continuous rather than acute exposures. Depending upon the source of the information used to derive them, they are very conservative. Uncertainty factors of 10 are applied to the data for conversion from a "lowest" to a "no observed adverse effect level" (LOAEL to NOAEL), if the best available data is from subchronic rather than chronic studies, if the route of exposure differs from that of interest, for conversion from experimental animals to humans, and for intra-species variability.

In addition to the uncertainty factor, which could vary from 1 to 100,000 but is usually in the range of 100 to 1000, an additional modifying factor of from 1 to 10 may be applied based upon the expert judgement of the assessor.

Preliminary IRIS data is also available in the EPA's Health Effects Assessment Summary Tables (HEAST 1992). Updates of the HEAST tables are issued periodically, and the latest available versions should be consulted. In addition, RfD, RfC, and q_1^* values for either oral or inhalation exposures have in the past been assembled in the bimonthly publication "Environmental Regulatory Update Table: DOE Office of Environmental Guidance (EH-23)", prepared by the Environmental Sciences Division, Oak Ridge National Laboratory. The November/December 1994 issue was ORNL/M-3271/R5. (While previously available free of charge to DOE contractors, it is now available only by subscription, or from NTIS).

Appendix 3

Listing and Analysis of Limit Parameters Found for 88 Chemicals

The chemicals listed in Table A3-1 include all those for which ERPG values had been published through 1992, all additional chemicals for which the Committee on Toxicology of the National Research Council, National Academy of Sciences, had developed EEGLs, SPEGLs, and CEGLs for the US military, and all chemicals for which ERPG values are either in the process of being developed, or which have been identified, by a subcommittee of DOE's Emergency Management Advisory Committee, as having a high priority for ERPG-value development. ERPG values developed and officially adopted through 1994 have been included, but chemicals not on the original list of eighty-eight (88) have not been added.

The statistical analysis which formed the basis for construction of the hierarchy presented in Table 4 was carried out on the concentration-limit values that were available at the end of 1992. Table A3-2 lists all concentration-limit values, updated through 1994, found for these 88 chemicals for each of the seventeen parameters in Table 4. Chemicals for which official ERPGs have been developed since 1992, but which were not on the original list of 88 chemicals, have been included in a new statistical analysis using values for about 200 chemicals and ERPGs for 61 chemicals. This exercise served to confirm the usefulness of the hierarchy of concentration-limit parameters for deriving ERPG-equivalent values for interim use. In making these comparisons, it must be clearly understood that each limit parameter was developed for a different purpose, addressing different populations, different time periods, and different toxicologic endpoints. At times the organizations responsible for development of chemical-specific values derived values that had nothing to do with toxicity and/or available data. For example, about 12% of the original IDLH values were based upon the chemical's lower explosive limit (LEL), since no evidence could be found to the effect that exposure to the chemical concerned was "immediately dangerous to life and health" at lower concentrations. It should be noted that the revised IDLH values (NIOSH 1994) are significantly lower than the 1990 values, and where there was no evidence of a toxicologically-based IDLH concentration, NIOSH now uses one-tenth of the LEL.

Ratios of individual pairs of values (i.e., hierarchy parameter to applicable ERPG) were calculated along with their mean, standard deviation, and coefficient of variation. This was done, first, for all the pairs found (N = total number of pairs of parameters available for comparison), and then repeated excluding all ratios which were judged to be outliers (n = number of ratios used for the statistics, where ratios ≥ 10 or ≤ 0.1 were excluded). These means and coefficients of variation are summarized in Table A3-3. The results of these comparisons were used to develop the hierarchy of recommended alternative guidelines presented in Table 4. The various alternative guidelines are plotted against the primary guidelines, including all available pairs of parameters (n = N), in Figures 3, 4, 5, and 6, respectively.

These recommendations differ somewhat from those used in the past at the Savannah River Site, where IDLH values were used if there was no ERPG-2 value for a chemical. The mean ratio of IDLH to ERPG-2 for which there were official ERPGs values available was $4.17 \pm 169\%$ for n = 34 (n = N), whereas the mean ratio of IDLH to ERPG-3 values was $3.37 \pm 177\%$ for n = 34 and $2.48 \pm 85\%$ for n = 32 (i.e., n < N). The comparison between the original IDLH and ERPG-3 values is clearly much better (see Figures 6 and 7), which is to be expected

since both these parameters are associated with life-threatening effects. (It should be even better with the new IDLH values, but these statistics have not yet been run). Another difference concerns the use of SPEGL (60 min) values. D.O.E.'s Emergency Management Guide (Guidance for Hazard Assessment, 6-26-92) recommends use of the 1-hour SPEGL value in place of ERPG-2 (p. 37). However, SPEGLs were developed for only 5 chemicals: 3 hydrazine compounds, hydrogen chloride, and nitrogen dioxide. In every case, the SPEGL value compares better with the PEL-TWA or TLV-TWA . Of these, only hydrogen chloride has EEGL and CEGL values. 60-minute SPEGL values, which are not listed in Table A3-2, are as follows (NAS 1985): Hydrazine = 0.12 ppm; Hydrogen Chloride = 1 ppm; Monomethylhydrazine = 0.24 ppm; 1,1-Dimethylhydrazine = 0.24 ppm; and Nitrogen Dioxide = 1 ppm.

The subcommittee initially considered recommending the use of PEL-STEL or TLV-STEL values as the primary guideline instead of ERPG-1, since the latter are not based exclusively on toxicologic considerations. Some ERPG-1 values are based on odor or perception threshold concentrations. In some instances, the ERPG-1 value would be equal to or greater than the ERPG-2 value, i.e., severe or irreversible health effects could occur at concentrations lower than those at which the chemicals would be perceived. For these chemicals, no ERPG-1 value has been developed. For some other particularly odiferous chemicals (e.g., the amines and sulfides), the ratio of ERPG-2 to ERPG-1 values is large. In addition, there are five chemicals (carbon disulfide, dimethylamine, hydrogen sulfide, methyl mercaptan, and trimethylamine) for which the ERPG-1 value is one-hundredth or less of the PEL-TWA value, which is the permissible exposure limit for an 8-hour workday, 5 days a week. However, the subcommittee decided to recommend use of ERPG-1 values as primary guidelines for consistency, but to recommend that short-term exposure limit values (PEL-STEL or TLV-STEL) be used for particularly odiferous chemicals. (See footnote 6 to Table 6. Methyl mercaptan lacks short-term exposure limits, so the remaining hierarchy parameter, TLV-TWA x 3, was used in place of ERPG-1).

For reasons already explained, the subcommittee does not, in general, think it appropriate to use fixed fractions or fixed multiples of parameters that have been developed with specific toxicologic endpoints in mind. However, an exception has been made for chemicals that do not have short-term exposure limit or ceiling values, in which case the subcommittee has included in the alternative parameter hierarchy, TLV-TWA x 3 for ERPG-1 and TLV-TWA x 5 for ERPG-2. The justification for this recommendation is contained in the ACGIH 1994-1995 Threshold Limit Value booklet (see Section 2.1). In addition, a value of 10 mg/m^3 has been used as the TLV-TWA for particulates not otherwise classified (PNOC), and where apprpopriate, three times (30 mg/m^3) and five times this value (50 mg/m^3) have been used as the ERPG-1- and ERPG-2-equivalent values, respectively. If no other concentration-limit was available, a value of 500 mg/m^3 is recommended as the ERPG-3-equivalent for particulate materials. This is based on the fact that this concentration constitutes an upper bound for a stable cloud of respirable dust. However, as with all the other surrogate values, consideration should be given to whatever toxicity data are availble before using this value.

A final point is that, even though many of the PEL-TWA, PEL-STEL and PEL-C values have been "vacated" by court order, we did not consider it appropriate to return to the original values for these parameters. These were based on the 1968 ACGIH concentration limits, and are considered to be out-of-date.

Table A3-1
List of Chemicals for which Limit Parameters were Analyzed

No.	CHEMICAL NAME	Chemical formula	Physical State	CAS NO.	Molecular Weight
1	Acetone	CH3.CO.CH3	L	67-64-1	58.1
2	Acrolein	CH2=CHCHO	L	107-02-8	56.1
3	Acrylic Acid	H2C=CHCOOH	L	79-10-7	72.1
4	Acrylonitrile (Ca)	CH2=CHCN	L	107-13-1	53.1
5	Allyl Chloride	CH2=CH.CH2.Cl	L	107-05-1	76.5
6	Aluminum Oxide	Al2O3	S	1344-28-1	101.9
7	Ammonia	NH3	G	7664-41-7	17.0
8 *	Arsenic (Inorganic) as As (Ca)	As inorg. cmpds.	S	7440-38-2	74.9 (As)
9 *	Arsenic (Organic compounds) as As	As org. cmpds.	S	7440-38-2	74.9 (As)
10	Arsine (Ca)	AsH3	G	7784-42-1	77.9
11	Benzene (Ca)	C6H6	L	71-43-2	78.1
12 *	Beryllium (Ca)	Be	S	7440-41-7	9.0
13	Bromine	Br	L	7726-95-6	159.8
14	Bromotrifluoromethane	CBrF3	G	75-63-8	148.9
15	1,3-Butadiene (Ca)	CH2=CHCH=CH2	G	106-99-0	54.1
16	Carbon Disulfide	CS2	L	75-15-0	76.1
17	Carbon Monoxide	CO	G	630-08-0	28.0
18	Carbon Tetrachloride(Ca)	CCl4	L	56-23-5	153.8
19	Chlorine	Cl2	G	7782-50-5	70.9
20	Chlorine Trifluoride	ClF3	G>11.7C	7790-91-2	92.5
21	Chloroacetyl Chloride	ClCH2.COCl	L	79-04-9	113.0
22	Chloroform (Ca)	CH.Cl3	L	67-66-3	119.4
23	Chloropicrin	C.Cl3.NO2	L	76-06-2	164.4
24 *	Chlorosulfonic Acid	Cl.SO2.OH	L	7790-94-5	116.5
25	Chlorotrifluoroethylene	ClFC=CF2	G	79-38-9	116.5
26	Crotonaldehyde (Ca)	CH3.CH=CHCHO	L	4170-30-3	70.1
27	Dichlorodifluoromethane (FC12)	C.Cl2.F2	G	75-71-8	120.9
28	Dichlorofluoromethane (FC21)	CH.Cl2.F	G>8.9C	75-43-4	102.9
29	Dichlorotetrafluoroethane (FC114)	CF4.C.Cl2	G>3.8C	76-14-2	170.9
30	Diketene	CH2=CC.H2.C(O)O	L	674-82-8	84.1
31	Dimethylamine	(CH3)2.NH	G	124-40-3	45.1
32	Dimethylformamide	HCON.(CH3)2	L	68-12-2	73.1
33	1,1-Dimethylhydrazine (Ca)	(CH3)2.NN.H2	L	57-14-7	60.1
34	Epichlorohydrin (Ca)	C3.H5.O.Cl	L	106-89-8	92.5
35	Ethanolamine	NH2.CH2.CH2.OH	L>10.6C	141-43-5	61.1
36	Ethylene Glycol	CH2.OH.CH2.OH	L	107-21-1	62.1
37	Ethylene Oxide (Ca)	CH2.O.CH2	G>10.6C	75-21-8	44.1
38	Fluorine	F2	G	7782-41-4	38.0
39	Formaldehyde (Ca)	HCHO	G	50-00-0	30.0
40	Hexachlorobutadiene	Cl2.C=C.Cl.C.Cl=C.Cl2	L	87-68-3	260.8
41	Hydrazine (Ca)	H2.N=N.H2	L	302-01-2	32.1
42	Hydrogen Chloride	HCl	G	7647-01-0	36.5
43	Hydrogen Fluoride	HF	G	7664-39-3	20.1
44	Hydrogen Peroxide(30%)	H2.O2	L	7722-84-1	34.0

Note: * indicates that units for these chemicals are in mg/m^3. All others are in ppm.

Table A3-1 (Continued)

No.	CHEMICAL NAME	Chemical formula	Physical State	CAS NO.	Molecular Weight
45	Hydrogen Sulfide	H2.S	L	7783-06-4	34.1
46	Isobutyronitrile	(CH3)2.CH.CN	L	78-82-0	69.1
47	Isopropyl Alcohol	(CH3)2.CH.OH	L	67-63-0	60.1
48*	Lithium Bromide	LiBr	S	7550-35-8	86.9
49*	Lithium Chromate	Li2.CrO4	S	14307-35-8	129.9
50*	Lithium Hydride / Hydroxide	LI.H -> LI.OH	S	7580-67-8 ->	7.95/24.0
51*	Mercury Vapor (as Hg)	Hg	G	7439-97-6	200.6
52	Methane	CH4	G	74-82-8	16.0
53	Methyl Alcohol (Methanol)	CH3.OH	L	67-56-1	32.0
54	Methyl Chloride (Ca)	CH3.Cl	G	74-87-3	50.5
55*	Methyl Fluoride (as Fluoride)	CH3.F	G	593-53-3	34.0
56	Methyl Iodide (Ca)	CH3.I	L	74-88-4	142.0
57	Methyl Mercaptan	CH3.SH	G	74-93-1	48.1
58	Monomethylamine	CH3.NH2	G	74-89-5	31.1
59	Monomethylhydrazine (Ca)	CH3.NH.NH2	L	60-34-4	46.1
60	Nickel Carbonyl (as Ni) (Ca)	Ni.(CO)4	L	13463-39-3	170.7
61	Nitric Acid	HNO3	L	7697-37-2	63.0
62	Nitrogen Dioxide	NO2	G	10102-44-0	46.0
63	Nitrous Oxide	N2.O	G	10024-97-2	44.0
64	Ozone	O3	G	10028-15-6	48.0
65	Perchloroethylene	$Cl_2C=CCl_2$	L	127-18-4	165.8
66	Perfuoroisobutylene	(CF3)2.C=CF2	G	382-21-8	200.0
67	Phenol	C6.H5.OH	S	108-95-2	94.1
68	Phosgene	CO.Cl2	G>8.2C	75-44-5	98.9
69	Phosphine	PH_3	G	7803-51-2	34.0
70*	Phosphoric Acid	H3.PO4	L/S	7664-38-2	98.0
71*	Phosphorous Pentoxide	P2.O5	S	1314-56-3	142.0
72*	Sodium Hydroxide	Na.OH	S	1310-73-2	40.0
73*	Sodium Monoxide	Na2.O	S	12401-86-4	62.0
74*	Sodium Peroxide	Na2.O2	S	1313-60-6	78.0
75	Styrene (Ca)	C6.H5.CH=CH2	L	100-42-5	104.2
76	Sulfur Dioxide	SO2	G	7446-09-5	64.1
77*	Sulfuric Acid (Oleum,Sulfur Trioxide)	H2.SO4	L	7664-93-9	98.1
78	Tetrafluoroethylene	F2.C=CF2	G	116-14-3	100.0
79*	Titanium Tetrachloride	Ti.Cl4	S	7550-45-0	189.7
80	Toluene	C6.H5.CH3	L	108-88-3	92.1
81	Trichloroethylene (Ca)	CH.Cl=C.Cl2	L	79-01-6	131.4
82	Trichlorofluoromethane (FC11)	C.Cl3.F	G>23.7C	75-69-4	137.4
83	Trichlorotrifluoroethane (FC113)	CF3.C.Cl3	L	76-13-1	197.5
84	Trimethylamine	(CH3)3.N	G	75-50-3	59.1
85	Uranium Hexafluoride	U.F6	S	7783-81-5	352.0
86	Vinyl Acetate	CH2=CHOC(O).CH3	L	108-05-4	86.1
87	Vinylidene Chloride	CH2=C.Cl2	L	75-35-4	96.9
88	Xylene	C6.H4.(CH3)2	L	1330-20-7	106.2

Note: * indicates that units for these chemicals are in mg/m^3. All others are in ppm.

Table A3-2:
Concentration Limit Parameters found for Chemicals listed in Table A3-1

	A			B				C					D		
No	PEL-TWA	TLV-TWA	CEGL CE90	ERPG E1	PEL-STEL	TLV-STEL	3.TLV TWA	ERPG E2	EEGL EE60	EPA LOC	PEL-C/ TLV-C	5TLV TWA	ERPG E3	EEGL EE30	NIOSH IDLH
	(1)	(2)	(3)	(4)	(5)	(6)	3x (2)	(7)	(8)	(9)	10/11	5x (2)	(12)	(13)	(14)
1	750	750	200	-	1000	1000	2250	-	8500	-	-/-	3750	-	-	2000
2	0.1	0.1	0.01	0.1	0.3	0.3	0.3	0.5	0.05	0.5	-/-	0.5	3	-	2
3	10	2	-	2	-	-	6	50	-	50	-/-	10	750	-	-
4	2	2	-	-	-	-	6	35	-	50	10/-	10	75	-	85
5	1	1	-	3	2	2	3	40	-	-	-/-	5	300	-	250
6[1]	10	10	-	-	-	-	30	-	15	-	-/-	50	-	25	-
7	-	25	50	25	35	35	75	200	100	50	-/-	125	1000	-	300
8[1]	0.01	0.01	-	-	-	-	0.03	-	-	1.4	-/-	0.05	-	-	5
9[1]	0.5	0.01	-	-	-	-	0.03	-	-	-	-/-	0.05	-	-	5
10	0.05	0.05	-	-	-	-	0.15	0.3	1	0.6	-/-	0.25	0.3	-	3
11	1	10	-	50[2]	5	-	30	150[2]	50	-	25[3]/-	50	1000[2]	-	500
12[1]	0.002	0.002	-	-	-	-	0.006	0.025[4]	-	-	.005[3]/-	0.01	0.1[4]	-	4
13	0.1	0.1	-	0.2	0.3	0.2	0.3	1	-	1	-/-	0.5	5	-	3
14	1000	1000	100	-	-	-	3000	-	25000	-	-/-	5000	-	40000	40000
15	2	2	-	10	10	-	6	50	-	2000	-/-	10	5000	-	2000
16	4	10	-	1	12	-	30	50	50	50	30[3]/-	50	500	100	500
17	35	25	20	200	-	-	75	350	400	-	200/-	125	500	750	1200
18	2	5	-	20	-	10	15	100	-	-	25[3]/-	25	750	-	200
19	0.5	0.5	0.1	1	1	1	1.5	3	3	2.5	-/-	2.5	20	-	10
20	-	-	-	0.1	-	-	-	1	1	-	0.1/0.1	-	10	3	20
21	0.05	0.05	-	0.1	-	0.15	0.15	1	-	-	-/-	0.25	10	-	-
22	2	10	1	100[4]	-	-	30	1000[4]	100	100	50/-	50	5000[4]	-	500
23	0.1	0.1	-	-	-	-	0.3	0.2	-	-	-/-	0.5	3	-	2
24[1]	-	0.3[5]	-	2	-	-	-	10	-	-	-/-	-	30	-	-
25	-	5[5]	-	20	-	-	-	100	-	-	-/-	-	300	-	-
26	2	2	-	2	-	-	6	10	-	14	-/-	10	50	-	50
27	1000	1000	100	-	-	-	3000	-	10000	-	-/-	5000	-	-	1500
28	10	10	1	-	-	-	30	-	100	-	-/-	50	-	-	5000
29	1000	1000	100	-	-	-	3000	-	10000	-	-/-	5000	-	-	15000
30	-	-	-	1	-	-	-	5	-	-	-/-	-	50	-	-
31	10	5	-	1	-	15	15	100	-	-	-/-	25	500	-	500
32	10	10	-	2	-	-	30	100	-	-	-/-	50	200	-	500
33	0.5	0.5	-	-	-	-	1.5	-	-	5	-/-	2.5	-	-	15
34	2	2	-	2	-	-	6	20	-	10	-/-	10	100	-	75
35	3	3	0.5	-	6	6	9	-	50	-	-/-	15	-	-	30
36	-	-	4	-	-	-	20[7]	-	40	-	50/50	-	-	60[6]	-
37	1	1	-	-	-	-	3	50	20	80	5/-	5	500	-	800
38	0.1	1	-	-	-	2	3	-	7.5	25	-/-	5	-	10	25
39	0.75	-	-	1	2	-	-	10	-	10	-/0.3	-	25	-	20
40	0.02	0.02	-	3	-	-	0.06	10	-	-	-/-	0.1	30	-	-
41	0.1	0.1	-	-	-	-	0.3	0.8[4]	-	8	-/-	0.5	10[4]	-	50
42	-	-	0.5	3	-	-	-	20	20	10	5/5	-	100	-	50
43	3	-	-	2	6	-	-	20	-	2	-/3	-	50	-	30
44	1	1	-	2[2]	-	-	3	10[2]	-	7	-/-	5	30[2]	-	75

Notes: 1 mg/m^3; 2 Out for ballot; 3 Z-2 Table ceiling; 4 DOE drafts; 5 WEEL value; [6] 10-min value; 7 24-hr value; 8 PEL-C =TLV-C.

Table A3-2. Concentration Limit Parameters found for Chemicals listed in Table A3-1 (Continued)

No	A			B				C					D		
	PEL-TWA	TLV-TWA	CEGL CE-90	ERPG E1	PEL-STEL	TLV-STEL	3.TLV TWA	ERPG E2	EEGL EE-60	EPA LOC	PEL-C/ TLV-C	5TLV TWA	ERPG E3	EEGL EE-30	NIOSH IDLH
	(1)	(2)	(3)	(4)	(5)	(6)	3x (2)	(7)	(8)	(9)	10 / 11	5x(2)	(12)	(13)	(14)
45	10	10	1	0.1	15	15	30	30	-	30	20[3]/-	50	100	50[6]	100
46	8=rel	-	-	10	-	-	-	50	-	9	-/-	-	200	-	-
47	400	400	1	-	500	500	1200	-	400	-	-/-	2000	-	-	2000
48[1]	-	10	1	-	-	-	7[7]	-	15	-	-/-	50	-	-	-
49[1]	-	0.05	-	-	-	-	0.05[7]	-	0.1	-	-/-	0.25	-	-	-
50[1]	0.025	0.025	-	0.05[4]	-	-	0.075	0.1[4]	-	5	-/-	0.125	0.5[4]	-	0.5
51[1]	0.05	0.025	0.01	-	-	-	0.2[7]	-	-	-	0.1[3]/-	0.125	-	-	10
52	-	-	5000	-	-	-	5000[7]	-	-	-	-/-	-	-	-	-
53	200	200	-	200	250	250	600	1000	200	-	-/-	1000	5000	400	6000
54	50	50	-	-	100	100	150	400	-	-	200[3]/-	250	1000	-	2000
55[1]	2.5	2.5	-	-	-	-	7.5	-	-	-	-/-	12.5	-	-	-
56	2	2	-	25	-	-	6	50	-	-	-/-	10	125	-	100
57	0.5	0.5	-	0.005	-	-	1.5	25	-	40	-/-	2.5	100	-	150
58	10	5	-	10	-	15	15	100	-	-	-/-	25	500	-	100
59	-	-	0.24sp	-	-	-	-	-	-	0.5	0.2/0.2	-	-	-	20
60	0.001	0.05	-	-	-	-	0.15	-	-	0.05	-/-	0.25	-	-	7
61	2	2	-	2[4]	4	4	6	15[4]	-	10	-/-	10	30[4]	-	25
62	-	3	-	2[4]	1	5	9	15[4]	-	5	5/-	15	30[4]	-	20
63	25=rel	50	-	-	-	-	150	-	10000	-	-/-	250	-	20000	-
64	0.1	-	0.02	-	0.3	-	-	-	1	1	-/0.1	-	-	-	5
65	25	25	-	100[4]	-	100	75	200[4]	-	-	200[3]/-	125	500[4]	-	150
66	-	-	-	-	-	-	-	0.1	-	-	-/0.01	-	0.3	-	-
67	5	5	-	10	-	-	15	50	-	10	-/-	25	200	-	250
68	0.1	0.1	0.01	-	-	-	0.3	0.2	0.2	0.2	-/-	0.5	1	-	2
69	0.3	0.3	-	-	1	1	0.9	2.5	-	20	-/-	1.5	5	-	50
70[1]	1	1	-	-	3	3	3	-	-	-	-/-	5	-	-	1000
71[1]	-	10	-	5	-	-	30	25	-	0.6	-/-	50	100	-	-
72[1]	-	-	-	2[4]	-	-	-	40[4]	2	-	2/2	-	100[4]	2	10
73[1]	-	10	-	-	-	-	30	-	-	-	-/-	50	-	-	-
74[1]	-	10	-	-	-	-	30	-	-	-	-/-	50	-	-	-
75	50	50	-	50	100	100	150	250	-	-	200[3]/-	250	1000	-	700
76	2	2	1	0.3	5	5	6	3	10	10	-/-	10	15	20	100
77[1]	1	1	-	2	-	3	3	10	1	8	-/-	5	30	2	15
78	-	-	-	200	-	-	-	1000	-	-	-/-	-	10000	-	-
79[1]	-	0.5[5]	-	5	-	-	-	20	-	1	-/-	-	100	-	-
80	100	50	20	-	150	-	150	-	200	-	300[3]/-	250	-	-	500
81	50	50	-	100[4]	200	200	150	500[4]	200	-	200[3]/-	250	1000[4]	-	1000
82	-	-	100	-	-	-	500[7]	-	1500	-	1000 /[8]	-	-	-	2000
83	1000	1000	100	-	1250	1250	3000	-	1500	-	-/-	5000	-	-	200
84	10	5	-	0.1	15	15	15	100	-	-	-/-	25	500	-	-
85[1]	-	0.2	-	5	-	0.6	0.6	15	-	-	-/-	1	30	-	10
86	10	10	-	5	20	15	30	75	-	15	-/-	50	500	-	-
87	1	5	0.15	-	-	20	15	-	-	-	-/-	25	-	-	-
88	100	100	50	-	150	150	300	-	200	-	-/-	500	-	-	900
N	66/2	71/3	26/1	39/9	29	31	68/6	47/11	35	38	22/10	71	47/11	13/2	65

Notes: 1 mg/m^3; 2 Out for ballot; 3 Z-2 Table ceiling; 4 DOE drafts; 5 WEEL value; [6] 10-min value; 7 24-hr value; 8 PEL-C =TLV-C.

Table A3-3

Ratios of Selected Hierarchy Concentration Limit Parameters

Hierarchy Parameter	Parameter Ratio					No. of Ratios*	
	Ratio of	Mean	CV	r^2	r	N	n
ERPG-3							
EEGL (30-min)	EEGL30:ERPG-3	0.55	100	0.646	0.804	6	4
IDLH	IDLH (original):ERPG-3	2.48	85	0.828	0.910	34	32
ERPG-2							
EEGL (60-min)	EEGL60:ERPG-2	0.99	89	0.918	0.958	13	10
LOC	LOC:ERPG-2	0.82	84	0.819	0.905	27	22
PEL-C	PEL-C:ERPG-2	1.09	60	0.789	0.888	9	6
TLV-C	TLV-C:ERPG-2	0.20	35	-	-	4	2
TLV-TWA x 5	TLV-TWAx5:ERPG-2	1.05	102	0.830	0.911	36	31
ERPG-1							
PEL-STEL	P-STEL:ERPG-1	1.75	59	0.908	0.953	15	11
TLV-STEL	TLV-STEL:ERPG-1	1.90	48	0.935	0.967	16	13
TLV-TWA x 3	TLV-TWAx3:ERPG-1	2.54	60	0.855	0.925	29	22
PEL-TWA							
TLV-TWA	TLV-TWA:PEL-TWA	1.21	87	0.979	0.989	61	55
SPEGL(60-min)	SPEGL:PEL-TWA			-	-	2	2
CEGL	CEGL:PEL-TWA	0.40	95	0.960	0.980	22	12

Notes: These statistics were run on the concentration-limit values available at the end of 1992. They have since been run on values available for about 200 chemicals, including 61 for which official ERPGs were available through 1994, but the new IDLH values had not yet been distributed. Draft DOE-sponsored ERPGs were also used in the original Table A3-3 analysis, but not in the reanalysis.

N = Total number of available comparisons, i.e., number of chemicals having official ERPG values for which the applicable hierarchy parameters have been developed.

n = Number of comparisons used to calculate the mean ratios, coefficients of variation and correlation coefficients. Ratios excluded are considered to be outliers because the values differ from each other by a factor of 10 or more.

CV = Coefficient of variation ($CV = \frac{SD}{\overline{X}} \times 100$)

r^2 = Coefficient of determination of straight line fit to the logarithms of the values, i.e., for

$Y = mX + b$

where

X = ERPG-3, -2, or -1 values

and

Y = Alternative parameter values,

and

r = Correlation coefficient (the square root of r^2).

Means and CVs are on concentration-limit ratios, correlations on concentration limits.

Appendix 4

Guidance on Development of Guideline Concentrations for Chemicals without Published Values

The text of this document states: "If no concentration value or ICR information is available for a given chemical, a knowledgeable individual may be requested to (a) determine whether the chemical needs to be evaluated, (b) develop appropriate values, or (c) perform a case-specific examination that provides suitable justification for the conclusion. This person's recommendations should, wherever possible, be reviewed by a second 'knowledgeable individual' ". The purpose of this appendix is to provide detailed guidance on these options.

Guidelines for being a "knowledgeable individual": An individual with an M.D. or a Ph.D. degree in a relevant discipline (e.g., occupational medicine, toxicology, or industrial hygiene), or board certification in toxicology (D.A.B.T.), or certification in industrial hygiene (C.I.H.).

Values comparable to ERPGs shall be developed in accordance with the methodology currently used by the AIHA ERPG Technical Committee (AIHA 1989). Values comparable to PEL-TWAs shall be developed in accordance with the methodology described in the Federal Register (FR 54, 1989)

If necessary, values shall be adjusted downward to ensure that resulting guidelines for the various risk and hazard classification categories are appropriate [e.g., the guideline for the moderate hazard classification (or the 1E-4/yr to 1E-2/yr frequency range) is lower than the guideline for the high hazard classification (or the 1E-6/yr to 1E-4/yr frequency range), etc.] .

It should be emphasized that all ERPG-equivalent values that are developed should be clearly identified as interim values, to be used only until such time as official ERPGs are published for a chemical. It is recommended that these values and all documentation supporting their derivation be forwarded to the appropriate regulatory agency or professional society with a request that they be considered for formal review and adoption.

Appendix 5

Adjustment of Mean Concentrations to Equivalent Lifetime Concentrations.

For all of the scenarios under consideration, the initial assumption made is that the airborne concentration of the carcinogen outside the facility can be calculated as the peak 15-min average. The procedure (FR 51, 1986b) of adjusting this concentration (C mg/m^3) to an average daily exposure prorated over a lifetime of 70 years [C/(70 x 365) mg/m^3/day], will underestimate the true risk of the exposure. Averaging of an exposure concentration that is not acutely toxic for a particular chemical over seventy years can lead to levels that differ little from background and are harmless. Thus, for chemicals that are confirmed or suspected human carcinogens, adjustments need to be made to the above average concentration to more accurately reflect the true, long-term risk following an acute exposure.

This problem was discussed by Crump and Howe (Crump 1984), who showed that the adjustment to the dose depends upon the number of stages involved in the carcinogenic process for the chemical of interest, which stage is affected by the carcinogen, the age at which exposure occurs, and the duration of the dose. Adjustment factors in the range of 2 to 100 were obtained under various animal exposure conditions. They also state that, in developing water quality guidelines, the EPA used an upward adjustment of carcinogenic potencies derived from less-than-lifetime animal bioassay studies by a factor of $(L/L_e)^3$, where L is the typical lifespan of the species and L_e is the duration of the exposure. If applied to a human exposure of one-year duration, this would give an adjustment factor of 3.43×10^5 for a 70-year lifetime, clearly too large for application to single, acute exposures.

Crump and Howe (Crump 1984) calculated the risk at age 70 from an instantaneous exposure (with no indication as to the actual exposure time), expressed as a fraction of the risk from the same total dose averaged over 70 years. The results depend strongly on which carcinogenic process stage is affected and the age at exposure. For example, if only the first stage of a three-stage carcinogenic process is affected, the risk is 3.0, 1.5, 0.55, and 0.06 for exposure at birth, at age 20, 40, or 60, times the risk from the same total dose delivered over 70 years, respectively. For a six-stage process, the comparable factors are 6.0, 1.1, 0.09, and 0.0004. The Committee on Toxicology of the National Academy of Sciences concluded that adjustment of the dose by a factor of 2.8 would be conservative (NAS 1986).

The important point to be made here is that the dose obtained using the procedure described in the EPA's Superfund guidance document and the Risk Assessment Guidelines of 1986 (FR 51, 1986b) can only be used if the calculated dose is appropriately adjusted. The "instantaneous" (usually of 1 or 2 hours duration, but 15 minutes in the present case) dose is averaged over 70 years. Dose is defined in section 4.2: Exposure Time. Averaging the 15-minute

dose over 70 years reduces it by a factor of 2.45×10^6 (70y x 365 d/y x 96 15-min periods/d). Since the actual risk to an individual from the "instantaneous" exposure has been shown to be higher than that from the same total dose delivered at a constant rate over that individual's lifespan, especially for the very young, it would be prudent to adjust this averaged dose upward by a factor of at least 2.8. In the absence of specific knowledge as to the carcinogenic process in humans for a particular chemical, and the somewhat longer exposure time used above (Crump 1984) (NAS 1986), the subcommittee recommends that an adjustment factor of 5 be applied to the calculated, 70-year average dose, applying this to the concentration averaged by simply dividing by the number of days in 70 years, i.e., 2.56×10^4.

It is recognized that the 70-year lifetime assumption is not consistent with DOE's traditional 50-year lifetime assumption for radiological dose calculations. However, the Subcommittee felt that the EPA method for calculating ICR should be changed only when necessary in its application to the nonradiological guidelines recommended in this report.