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The history and development of emergency response planning guidelines

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Abstract

In 1988, the Emergency Response Planning Guideline Committee was formed to review a series of documents summarizing chemical toxicity which had been developed by a combined interindustry effort. This Committee, is a part of the American Industrial Hygiene Association and is composed of representatives from academia, government and industry, with backgrounds in industrial hygiene, medicine and toxicology. Since its founding, the Committee has published 35 review documents containing recommendations for emergency exposure planning levels. Currently, the Committee is working on another 25. Most of the chemicals selected for this process are on the SARA Title III Extremely Hazardous Substance List or the OSHA Highly Hazardous Chemical List.

1. Introduction

The tragic accidental release of methylisocyanate in Bhopal, India underscored the need for the chemical industry to pool its resources and work with local and national authorities in the development of emergency response plans [1–3]. These activities have been occurring at many levels around the world. In Europe for example, the European Chemical Industry Ecology and Toxicology Centre (ECETOC) has formed a task force which has produced a guide for reviewing chemicals and estimating the hazard associated with an accidental release [4].

In the U.S., under SARA Title III and similar regulations, local communities are required to set up emergency response plans in locations where potential hazards exist such as nuclear power plants or chemical manufacturing operations [5]. These plans frequently include utilization of emergency response teams which may include fire fighters, first aid professionals, and police. Representatives from industry and members of the community are working together to develop emergency response plans. Where chemicals are involved,

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it is important to know the identity of the chemical; the toxicity of the chemical and the amount used or stored at the plant. It is also important to have an idea of the area that could be affected if the chemical is accidentally released, and to have an understanding of air-flow patterns around the area [6, 7]. With this information, local emergency response teams can make estimates of dispersion in the event of a catastrophic release and make appropriate plans for evacuation of the local community, if necessary. In addition, the teams need to know how to monitor for these chemicals in the air; what type of protective equipment is required; what is appropriate breathing protection; when to administer first aid; what constitutes an effective first aid treatment; and if there is an effective way to disperse the cloud or neutralize the chemical.

Much of this information should be well known to the plant safety personnel, especially current information on protective equipment, monitoring, respirator selection, and containment practices. Information on air-flow modeling must be developed locally. Information on the toxicity of the chemical and treatments for exposure should be obtained from expert sources.

There are many references and guides which offer recommendations for maximum permissible exposure levels for a variety of chemicals. For workplace standards, one can refer to the OSHA-Permissible Exposure Levels (PELs) [8], the American Conference of Governmental Industrial Hygiene's Documentation for the Threshold Limit Values (TLVs) [9]; the American Industrial Hygiene Association's (AIHA) Workplace Environmental Exposure Level Guides [10] or the NIOSH Recommended Exposure Levels [11]. None of these, however, are designed for emergency situations or even single, acute exposures, in general. On one hand, they typically consider workers whose health status may be somewhat better than that of the general population. Also, they are designed for long-term exposure scenarios such as 8 to 10 hours per day, 5 to 6 days per week for several years. In contrast, the emergency exposure should, by definition, be a rare event of short duration, possibly at a high or unknown concentration, but one which could involve a heterogeneous population.

Currently, there are two reference sources available for emergency exposures. The first was developed by the National Research Council (NRC) for use by the military. These are called Emergency Exposure Guidance Levels or EEGLs [12]. While these can be very helpful, they have been developed for a population of healthy young adults and are not applicable to the general public. They provide a single value which is the estimate for the highest exposure which will not interfere with one's ability to perform specific tasks. While Short Term Emergency Guidance Levels (SPEGLs) have also been developed by the NRC to address exposures to civilians living in and near military installations, these cover only a few chemicals.

The second series of publications deal with the toxicity associated with potential exposures to acutely toxic chemicals [13], that is, possible community exposure resulting from the accidental release of a chemical. These series of

documents are called Emergency Response Planning Guides (ERPGs) and are published by the American Industrial Hygiene Association's Emergency Response Planning Committee. The development of these decuments will be described in the balance of the paper.

1.1 History

Following Bhopal, the chemical industry increased its efforts to develop comprehensive assessments of the risks from possible chemical exposures resulting from accidental chemical releases. A key component was the development of a comprehensive understanding of the toxicology of the chemical substances in question.

Many companies already had toxicology information on their major products and most had developed contingency plans to address accidents. While much of these data were shared, a forum was needed to aid in the exchange and review of this information and for review and discussion of other information available in the published literature. In this way, companies could pool their information and scientific expertise to develop a comprehensive understanding of the chemicals in question. This forum was provided in 1987 through the Organization Resources Counselors (ORC) [14]. Working through the ORC, member companies sent scientific representatives to form a review committee. The committee discussed the selection of candidate chemicals for review. The criteria considered included quantities produced, number of people and sites using the substance, number of companies using the substance, whether it appeared to be a highly toxic substance, and the physical properties of the chemical (i.e. gas or volatile liquid which could lead to widespread distribution, or a solid with limited potential for dispersion). In addition, the chemicals listed on the Hazardous Substance List from SARA Title III were considered. Recently, consideration has been extended to include those chemicals on the new OSHA list of Highly Hazardous Chemicals [15].

Member companies were then asked to write review documents, modeled after the AIHA's WEEL guides and NRC EEGLs, on compounds for which they had extensive knowledge. They also included recommendations for emergency exposure limits. These documents were then reviewed by the full ORC Committee for completeness, accuracy and quality.

As the process evolved, it was recognized that there would be a significant advantage to having these documents peer reviewed by an interdisciplinary group of occupational health professionals. To this end, the members of the ORC committee worked with the American Industrial Hygiene Association (AIHA) to create a review committee. The AIHA has members from academia, government and industry and broadly represents the area of occupational health. This led to the formation of the AIHA's Emergency Response Planning Committee in 1988, as an *Ad Hoc* Committee within the Workplace Environmental Exposure Level (WEEL) Committee. Two years later, the ERPG Committee was made a full, permanent AIHA Committee.

2. Function of the emergency response planning committee

The Committee is composed of representatives from academia, government and industry. While some members may write Emergency Response Planning documents for their institutions, the Committee is a Review Committee. Its function is to take documents written by others, review them, edit them, and make recommendations for emergency exposure planning levels based on the available toxicology information. The guidelines by which the Committee functions are described in the preface document reproduced below.

PREFACE TO EMERGENCY RESPONSE PLANNING GUIDELINES

The emergency Response Planning Guideline (ERPG) values are intended to provide estimates of concentration ranges above which one could reasonably anticipate observing adverse effects as described in the definitions for ERPG-1, ERPG-2, and ERPG-3 as a consequence of exposure to the specific substance.

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

The ERPG-2 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hr without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action.

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

The committee recognizes (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 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. Furthermore, since these values have been derived as planning and emergency response guidelines, *not* as exposure guidelines, they do not contain the safety factors normally incorporated into exposure guidelines. Instead, they are estimates, by the committee, of the thresholds above which there would be an unacceptable likelihood of observing the defined effects. The estimates are based on the available data summarized in the documentation. In some cases where the data are limited, the uncertainty of these estimates is large. Users of the ERPG values are strongly encouraged to review carefully the documentation before applying these values.

In developing these ERPGs, human experience has been emphasized to the extent data are available. Since this type of information is rarely available, however, and, when available, usually is only for low level exposures, animal exposure data most frequently form the basis for these values. The most pertinent information is derived from acute inhalation toxicity studies that have included clinical observations and histopathology. The focus is on the highest levels not showing the effects described by the definitions of the ERPG levels. Next, data from repeat inhalation exposure studies with clinical observations and histopathology are considered. Following these in importance are the basic, typically acute, studies where mortality is the major focus. When inhalation toxicity data are either unavailable or limited, data from studies involving other routes of exposure will be considered. More value is given to the more rigorously conducted studies, and data from short-term studies are considered to be more useful in estimating possible effects from a single 1-hr exposure. Finally, if mechanistic or dose-response data are available, they are applied, on a case by case basis, as appropriate.

It is recognized that there is a range of times that one might consider for these guidelines; however, it was the committee's decision to focus its efforts on only one time period. This decision was based on the availability of toxicology information and a reasonable estimate for an exposure scenario. Some using these guideline levels will prefer other, usually shorter, exposure periods and will seek ways of extrapolating ERPGs for other exposure durations. The usual method for such extrapolation is to use the Haber relationship, expressing the constancy of the product of exposure concentration and exposure duration ($Ct=K$). However, users are cautioned against such extrapolation. The Haber relationship, with or without some of the proposed modifications, does not hold over more than small differences in exposure time.

Use of these ERPG values for exposure periods shorter than 1 hour should be safe; use for longer periods is not. Extrapolation to higher guidance levels for shorter exposure periods should not be attempted by use of the Haber relationship or modifications thereof without specific validating data. This caution about extrapolations applies to exposures to most toxic substances that are dose-limiting substances, but not generally to sensory irritants that are concentration-limiting substances. With some of these latter substances, exposure should be limited to a given concentration regardless of the exposure time because of the sensory response produced.

Initially, the Committee was exclusively reviewing documents prepared by the ORC member companies. However, from the outset, it was felt that the Committee should consider documents from all reliable sources. The decision to review a document would be based on: (1) The need for a document on the substance in question; these criteria are similar to those used by ORC. (2) The existence of adequate toxicology information to develop exposure guidelines. (3) The quality of the document submitted for review. The Committee has also taken a practical, advocacy role. It has reviewed both the SARA Title III and OSHA Highly Hazardous Chemical lists and is encouraging members of the ORC and the Chemical Manufacturers Association as well as other organizations to draft documents on the most important chemicals on these lists.

Additionally, the Committee is working with the Department of Energy, reviewing Emergency Response Planning Guides developed by DOE on substances of concern to them. The Committee has also reviewed documents written by some of its members, but in those cases the author does not serve in any direct review capacity.

The scope of the Committee was described in "Concepts and Procedures for the Development of Emergency Response Planning Guidelines", published by the AIHA in December, 1989 [16]. The exposure parameters to be included in the development of these guides were considered at great length. Two key questions were: (1) the number of time intervals, and (2) criteria for and number of exposure levels. There were good arguments for considering both short and long time intervals. The Committee recognized that, while no one time interval would accommodate all needs, nor would two or three. Therefore, it is decided to consider a single one-hour exposure interval. As most acute inhalation toxicity studies utilize exposure periods of from one to four or six hours and most accidental exposures are for periods of less than one hour, the one-hour interval represented a time period that would combine reasonable precision of experimental data with community need.

In considering the number of exposure levels to be defined, the Committee agreed on three. These have been defined in our preface, and correspond to the threshold for recognition of adverse exposure (ERPG-1); the threshold for possible toxic action resulting from exposure (ERPG-2); and the threshold for possible lethal effects (ERPG-3). In cases where the threshold for toxicity occurs at or below the odor threshold or other ERPG-1 criteria, an ERPG-1 is not defined. Otherwise, the three values are defined for all chemicals.

While all available toxicity information is considered during the review process, emphasis is on those endpoints that can be associated with single short term exposures. Thus, acute toxicity and lethality data, which rarely are critical in the risk assessment process, are central in estimating the ERPG levels.

The Committee has been asked to consider possible environmental effects resulting from chemical release. While there is no question that this is a major concern, the Committee did not feel it had the expertise or resources needed to adequately address this issue.

3. Review process

The procedure followed during the reviewing process is outlined in Fig. 1. The reviewers check the references, style and accuracy of information. If necessary, they confer with the author and make revisions before sending it for full Committee review. Additionally, suggestions may be made by either the author or one of the reviewers for ERPG levels.

The Committee's initial review begins with a consideration of the chemical's physical properties. How likely is it to become airborne and in what form and what level? Gases and vapors from highly volatile liquids represent the greatest exposure potential. Some substances can form fumes which can also travel large distances, while other fumes quickly coalesce and settle out.

Next, the acute toxicity data are considered. Of greatest importance is any information on inhalation toxicity. Using this information, the Committee attempts to estimate the one-hour lethal threshold and slope of the dose response curve. Data from all species and time intervals are considered and compared for consistency. The greater the consistency, the greater the confidence one has in the data. Naturally, more recent studies and those with good analytical data are considered first. Unless there is something unique about a particular animal model, it is assumed that man will be as sensitive as the most sensitive specie tested.

After a review of the acute data, subacute and subchronic data are evaluated. Subacute and subchronic studies are conducted for much longer time periods than covered by ERPGs, therefore, their primary use is in the identification of possible target organs. This provides better insight on the possible effects that could result from exposure to the chemical. These data can also provide the physician with help in determining treatment. This information is compared to any information on systemic toxicity in the acute studies to see if the target organs are the same.

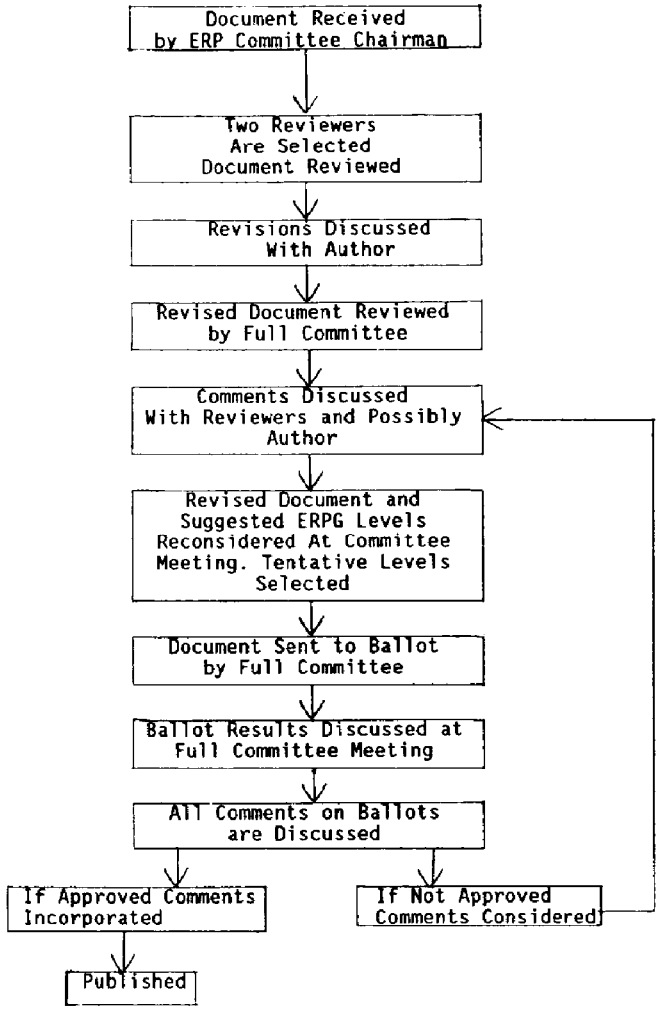

Fig. 1. Emergency response planning guideline review process.

Next, any information on reproductive or developmental toxicity and possible teratogenicity is considered. Because birth defects may arise from a relatively short term exposure to high levels of a chemical, these findings are of great concern and the studies are used in determining the ERPG-2 level. Other information on reproductive or developmental toxicity is considered more generally, along with the subchronic data. If, however, one noted signs of severe embryo toxicity or lethality, it would be considered carefully in the development of estimates of exposure levels for both ERPG-2 and ERPG-3 levels.

Mutagenicity data is generally used only to enhance understanding of the chronic data when it is available. If there are no chronic data, a high, reproducible level of mutagenic activity would be taken as a caution sign. Chronic data again serve primarily to help identify target organs, and to a lesser degree, to look for cumulative effects. Compounds that show carcinogenic activity are

TABLE 1

Currently approved ERPGs (1992)

Chemical	ERPG-1	ERPG-2	ERPG-3
Acrolein	0.1 ppm	0.5 ppm	3 ppm
Acrylic acid	2 ppm	50 ppm	750 ppm
Allyl chloride	3 ppm	40 ppm	300 ppm
Ammonia	25 ppm	200 ppm	1000 ppm
Bromine	0.2 ppm	1 ppm	5 ppm
1,3-Butadiene	10 ppm	50 ppm	5000 ppm
Carbon disulfide	1 ppm	50 ppm	500 ppm
Chlorine	1 ppm	3 ppm	20 ppm
Chloroacetyl chloride	0.1 ppm	1 ppm	10 ppm
Chloropicrin	NA[a]	0.2 ppm	3 ppm
Chlorosulfonic acid	2 mg/m^3	10 mg/m^3	30 mg/m^3
Chlorotrifluoroethylene	20 ppm	100 ppm	300 ppm
Crotonaldehyde	2 ppm	10 ppm	50 ppm
Diketene	1 ppm	5 ppm	50 ppm
Dimethylamine	1 ppm	100 ppm	500 ppm
Epichlorohydrin	2 ppm	20 ppm	100 ppm
Formaldehyde	1 ppm	10 ppm	25 ppm
Hexachlorobutadiene	3 ppm	10 ppm	30 ppm
Hydrogen chloride	3 ppm	20 ppm	100 ppm
Hydrogen fluoride	5 ppm	20 ppm	50 ppm
Hydrogen sulfide	0.1 ppm	30 ppm	100 ppm
Isobutyronitrile	10 ppm	50 ppm	200 ppm
Methyl iodide	25 ppm	50 ppm	125 ppm
Methyl mercaptan	0.005 ppm	25 ppm	100 ppm
Monomethylamine	10 ppm	100 ppm	500 ppm
Perfluoroisobutylene	NA	0.1 ppm	0.3 ppm
Phenol	10 ppm	50 ppm	200 ppm
Phosgene	NA	0.2 ppm	1 ppm
Phosphorus pentoxide	5 mg/m^3	25 mg/m^3	100 mg/m^3
Sulfur dioxide	0.3 ppm	3 ppm	15 ppm
Sulfuric acid (oleum, sulfur trioxide, and sulfuric acid)	2 mg/m^3	10 mg/m^3	30 mg/m^3
Tetrafluoroethylene	200 ppm	1000 ppm	10 000 ppm
Titanium tetrachloride	5 mg/m^3	20 mg/m^3	100 mg/m^3
Trimethylamine	0.1 ppm	100 ppm	500 ppm
Vinyl acetate	5 ppm	75 ppm	500 ppm

[a]NA = not appropriate.

evaluated using the multistage linear model at a risk level of one in ten thousand. Since the actual exposure period is so short, one hour in a lifetime, carcinogenicity is rarely a significant factor.

Any human experiences are also considered. While one would like to rely heavily on this type of information, rarely does one have a good estimate for exposure level and much of the data is, therefore, anecdotal. This information

is compared, where possible, to the animal data to look for consistency of target organs or any unique responses. Also, data on odor threshold or irritation thresholds can be very helpful in estimating the ERPG-1 level.

Although occupational exposure limits are generally developed for exposures of eight hours or more per day, and for extended periods of time, the basis for these is reviewed very carefully. Frequently, they, along with information on human exposure experiences, are very helpful in determining ERPG-1 levels.

As the review process is going on, the Committee considers all the data in light of the definitions for ERPG-1, -2 and -3. Each value is independently considered, and is based on the data most suitable for that level. For example, irritation data could be used for an ERPG-1 level, developmental or subchronic toxicity data for an ERPG-2 level and acute lethality data for an ERPG-3 level. While many people would like to see a straightforward formula for deriving one ERPG value from the others, considering the definitions associated with each category the slope of the dose response curve, and the variety of effects seen, each value must be independently considered.

Accomplishments

Since its inception in 1988, the ERP Committee has developed planning guides for 35 chemicals and is currently working on another 25. Table 1 lists the chemicals for which ERPGs have been developed and the corresponding ERPG values for these chemicals. Table 2 lists compounds for which ERPGs are being developed.

In developing these values, the Committee had to try to be as precise as possible. If the recommendations were too high, people could be injured. Also, if the levels were set too low, the consequence could be unnecessary fear and concern or even large scale, unnecessary disruption associated with an evacuation. By providing this information and making it available to local communities, they can make better informed decisions in the event of an emergency.

ERPGs are not designed as exposure guides, but as planning guides. The exposure limits together with the supporting information are intended to be one part of a package used by emergency response teams.

TABLE 2

ERPGs currently under review

Acrylonitrile	Dimethyldisulfide	Methanol	Nitrogen dioxide
Arsine	Dimethylformamide	Methylbromide	Perchloroethylene
Benzyl chloride	Dimethylsulfide	Methylchloride	Phosphene
Carbon monoxide	Ethylene oxide	Methylisocyanate	Styrene
Carbon tetrachloride	Hexafluoroacetone	n-Butylacrylate	Toluene
Chlorine trifluoride	Hydrogen cyanide	Nitric acid	Trichloroethylene
			Uranium hexafluoride

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