Development of Emergency Response Planning Guidelines (ERPGs)

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ABSTRACT

Emergency Response Planning Guidelines (ERPGs) are airborne concentrations of chemicals that have been evaluated for three levels of emergency response. These are a nuisance level, and level that would affect egress from an exposure or a level that is near, but below a life threatening concentration. The ERPG is a volunteer committee of the American Industrial Hygiene Association that is comprised of industrial hygienists and toxicologists. This paper describes the history of emergency response guidelines and process of the evaluation.

INTRODUCTION

In Bhopal, India, the release of 40 tons of methyl isocyanate (MIC) on December 3, 1984 resulted in the death of more than 2500 people [1–3]. Many other residents suffered irreversible health effects. The public in India and worldwide was angered that an event of this magnitude could happen because the local community had no idea that such a dangerous chemical was housed in such large quantities, adjacent to a residential area. This tragedy resulted in the widespread realization of the need for the development of chemical emergency response plans (ERPs). Little was known about the toxicity of MIC. It was primarily used as a captive chemical intermediate in the production of carbamate pesticides, and a toxicological profile had never been developed for MIC.

Residents living near chemical plants in localities all over the world demanded that they be given information on chemicals being produced or used in their communities. In the United States, this public outcry resulted in the promulgation of the Superfund Amendments and Reauthorization Act (SARA) of 1986 [4], which contained provisions entitled Emergency Planning and

Community Right-to-Know (EPCRA). This was also known as Title III of SARA, and EPCRA required each state to appoint a State Emergency Response Commission (SERC). The SERCs are required to divide their states into Emergency Planning Districts and to name a Local Emergency Planning Committee (LEPC) for each district. This legislation, along with provisions under Title III of the Clean Air Act of 1990 [5], required local communities to set up ERPs. As a result, many chemical companies began developing ERPs, which included health-based exposure values. It was soon realized that if each company had its own exposure values, the toxicological basis and rationale for each set of values might vary from one company to the next based on the data available to each of them. A multiplicity of guidance numbers would be confusing. A better approach was for stakeholder chemical companies to work together in developing a single set of emergency response exposure values for chemicals of interest that would be useful to emergency response planners and managers [1–3,6].

In 1986, there were no suitable emergency numbers for emergency planners. Occupational exposure guidelines and standards (7–9) were available for a number of chemicals. However, these

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values are inappropriate for evaluating brief emergency exposures to the general public. Occupational exposure levels were developed for the protection of healthy workers. They are based primarily on repeated dose studies conducted over months and years in order to simulate the daily exposure of workers over their working lifetime. They are not designed to protect children, the elderly, or otherwise “susceptible” individuals—such as asthmatics—from a single, brief catastrophic exposure.

Additional exposure numbers were available [10–15]. However, these levels were for healthy workers and were not designed to protect many within the general public. Of these, NIOSH developed a series of values representing exposure levels, which were “immediately dangerous to life and health” (IDLH) [14], which have been used indiscriminately for the general public. IDLHs were designed to be used in identifying respiratory protection requirements in the NIOSH/OSHA Standards Completion Program. They were intended for the workplace where protective clothing and equipment is at hand, and they do not take into account exposure of the more sensitive individuals—such as the elderly, children, or asthmatics—living in the surrounding community.

Whereas several organizations have recommended the use of various “emergency numbers,” none of the numbers available in 1986 had been specifically developed for potential accidental releases to the community, with the exception of the few National Research Council’s (NRC) short-term Public Emergency Guidance Levels (SPEGLs) [10]. The process of developing SPEGLs is a thorough one, but time consuming, which limited the number that could be published. Thus, it became evident that a new set of numbers for emergency planners and managers was needed as quickly as possible for a wide variety of chemicals.

THE DEVELOPMENT OF ERPGS

In 1986, several companies, responding to internal needs, independently undertook development of emergency planning guideline numbers. These goals were set:

- The numbers are useful primarily for emergency planning and response.
- The numbers are suitable for protection from health effects due to short-term exposures.
- They are not suitable for effects due to repeated exposures, nor as ambient air quality guidelines.
- The numbers are guidelines. They are not absolute levels demarking safe from hazardous conditions.
- The numbers do not necessarily indicate levels at which specific actions must be taken.
- The numbers are only one element of the planning activities needed to develop a program to protect the neighboring community.
- The selection of chemicals needing emergency planning guidelines generally should be based on volatility, toxicity, and releasable quantities.

Two decades later, these goals are now characteristics of ERPs. Uniform procedures and definitions provided more consistent

guidelines. In addition, sharing guidelines for different chemicals would avoid redundant efforts and increase the number of available guidelines [1–4,15].

As a result, the Organization Resources Counselors, Inc. (ORC) established a task force to address the need for reliable, consistent, and well-documented emergency planning guidelines. The Emergency Response Planning Guideline (ERPG) Task Force was formed and began developing ERPG documents. The Committee was aligned with the American Industrial Hygiene Association (AIHA) because its membership included industrial hygienists and toxicologists from stakeholder chemical companies, government agencies, academic institutions, and the public sector. As a result, the Emergency Response Planning Committee (ERP Committee) was formed in 1987 with the specific charge to develop suitable documents for emergency response planning. In 1988, the ERP Committee began producing Emergency Response Planning Guidelines (ERPGs) [1–3,15,16].

ERPGs gained worldwide recognition and acceptance and are currently used throughout the world. In 1991, the European Chemical Industry Ecology and Toxicology Centre (ECETOC) published the concept of Emergency Exposure Indices (EELs) [17]. However, emergency planners published only three documents, mainly because of the wide acceptance of ERPGs [15,17,18]. Instead of developing additional EELs, Dutch scientists joined the ERPG Committee and have aided in the development of these documents. At the request of the U.S. Environmental Protection Agency (EPA) and the Agency for Toxic Substances and Disease Registry, NRC convened a Subcommittee on Guidelines for Development of Community Emergency Exposure Levels (CEELs) in 1993 [19]; however, no CEEL documents were ever produced [1,2,3,15]. In an effort to move forward, representatives from the EPA approached the ERP Committee in 1995 and expressed their interest in developing similar numbers for emergency response planning. After several meetings, EPA spearheaded the development of Acute Exposure Guideline Levels (AEGs) through the NRC/AEGL Committee, which was established in 1996 [20]. The ERP Committee welcomed EPA’s efforts to develop similar exposure values and helped them establish the AEGL Committee. From the outset, the plan was to work independently of each other. The AEGs have a basis very similar to ERPGs as the ERP Committee has worked with EPA in setting up this program [1,4,15].

The ERP Committee has established three guidance concentration levels. Each of these levels is defined and briefly discussed below:

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

ERPG-3 is a worst-case planning level, when there is the possibility that exposure to levels above ERPG-3 will be lethal to some members of the community. This guidance level could be used to

determine the maximum releasable quantity of a chemical should an accident occur.

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

Above ERPG-2 concentrations, some members of the community may experience significant adverse health effects. This level could impair an individual's ability to take protective action. These effects might include dizziness, severe eye or respiratory irritation, CNS depression, or muscular weakness. This is the level utilized by emergency planners/responders to model the dispersion of the chemical cloud over the community.

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

The ERPG-1 level identifies the concentration that does not pose a health risk to the community but may be noticeable due to odor, discomfort, or irritation. For some materials, because of their properties, there may not be an ERPG-1 level. Such cases would include substances for which sensory perception levels are higher than the ERPG-2 level. In such cases, the ERPG-1 level would be listed as "Not Appropriate." It is also possible that no valid sensory perception data are available for the chemical. In this case, the ERPG-1 level would be given as "Insufficient Data."

It is recognized that there is a range of time periods that one might consider for these guidelines; however, the decision was made to focus on a single time period—one hour. This decision was based on the availability of toxicity information and on a reasonable estimate for an exposure scenario due to dispersion. Most acute inhalation toxicity studies are for either one hour or four hours because EPA, the Consumer Product Safety Commission, the Department of Transportation, the Organization of Economic and Community Development, and other government agencies require studies for one or both of these time periods. Acute inhalation lethality data are rarely available for 10 minutes, 30 minutes, or 8 hours. However, when warranted, the ERP Committee has set ERPGs for different time periods (see the 1999 addendum to the hydrogen fluoride ERPG document).

The logistics are generally against very short time periods. It is impossible to report a spill or release, run the air dispersion models, and have the news agencies report the information to the public within 10 minutes. If the message would be to shelter in place with windows closed and air conditioners turned off to prevent outside air entering the house, the exposure would be over before the public could be alerted to the danger [1,4,15]. For emergency

managers who need to extrapolate to different time periods, there are two generally recognized approaches. For nonirritants, Haber's rule ($\text{concentration} \times \text{time} = \text{constant}$ or $C \times T = K$) is generally valid over a three- or four-fold range of time [21]. A seemingly better method for all chemicals was developed by ten Berge and is given as ($C^n \times T = K$), where in practice, $n = 3$ in extrapolating to a shorter time period or $n = 1$ in extrapolating to a longer time period [22]. For the best possible results, n should be derived from the slope of the dose-response curve.

For a given chemical, it is important to emphasize the use of acute or short-term inhalation toxicity data as well as workplace experience. ERPGs are based on once-in-a-lifetime, one-hour exposure. In evaluating the adverse health effects, both immediate and delayed health effects should be considered. When it is anticipated that adverse reproductive, developmental, or carcinogenic effects might result from a single exposure, these data should be carefully considered in the derivation of the ERPGs. (1–4,15) For chemicals, which are carcinogenic, the mathematical approaches adopted by the NRC are utilized in assessing the risk of developing cancer from a single exposure [10].

It is very important that the rationales for the ERPGs be documented and published. AIHA publishes a pocket-sized handbook [14] that contains the numbers for all ERPG documents. In addition, anyone using these numbers should obtain the complete ERPG documents for those chemicals [16]. These documents provide all of the data and rationales used in deriving the ERPGs.

Since most community exposures are anticipated to be via an airborne pathway, inhalation toxicity data are the most useful. A 1-hour or 4-hour inhalation lethality study (1-hr LC_{50} or 4-hr LC_{50}) in one or more species, a respiratory depression study in Swiss-Webster mice (RD_{50}), an odor threshold, and workplace exposure or human testing to known concentrations are useful in setting ERPGs. Repeated exposure toxicity data as well as developmental toxicity data, sensitization data, and carcinogenicity data are also important in setting the final numbers. Toxicity by routes other than inhalation are supportive, and if the only carcinogenicity or developmental studies available are via oral dosing, such studies are carefully considered in setting ERPG-2 levels. Finally, if mechanistic or dose-response data are available, these are considered and applied if appropriate [1–4,15].

The more complete the data set, the easier it is to set ERPG numbers as there is greater confidence that the effects noted are due to exposure to the chemical. However, it is important that the data be specific to the chemical and relevant to the derivation of ERPGs. It should be noted that some chemicals are extremely reactive (e.g., hydrogen fluoride and chlorosilanes) or may biodegrade or metabolize to products that cause the underlying toxicity.

For an in depth understanding of how draft documents submitted to the ERP Committee are edited and managed, the reader is referred to <http://www.aiha.org/1documents/Committees/ERP-SOPs2006.pdf>.

Emergency Response Planning Guidelines (ERPGs) are intended for emergency planning only. ERPGs can be applied in a variety of mandated or voluntary emergency response planning programs.

These programs generally include accident scenarios in which air dispersion models determine concentration isopleths. ERPGs are also used in programs designed to protect the public from transportation incidents.

ERPGs may be used with air dispersion models, together with information such as vapor pressure and storage volumes, to provide computerized estimates of the direction and speed at which a released plume or cloud will spread over the neighboring terrain. These models will also provide the concentration within the cloud over the time of its dispersion. These models incorporate the quantity and rate of release, volatility, wind speed and direction, temperature, and other environmental conditions. Such models help emergency planners know whom to alert and where first responders should report should a release occur. From these models, action plans can be developed. The plans may vary for any given emergency depending on such things as population density, type of population (e.g., schools), terrain, weather conditions, and other hazards of the released entity (e.g., flammability).

An example of how this may be utilized would be in response to a chlorine release. If a rail tanker car (approximately 23,000 gallons) overturned and released its contents of chlorine, a cloud would be formed and dispersed by the prevailing winds. Plumes do not typically have uniform concentrations, rather they have gradients, with the highest concentrations near the spill site, progressively lower as one moves away from the accident location. Concentration lines (isopleths) can be drawn in this plume, which would allow the responders to appropriately evacuate the area. Figure 1 is an example of how ERPGs can be used to draw isopleths. The ERPGs for chlorine (ERPG-1 = 1 ppm; ERPG-2 = 3 ppm; ERPG-3 = 20 ppm) can then be plotted and the area of evacuation based on the ERPG-2 concentrations.

Many air dispersion models, as related to accidental releases of toxic chemicals, stem from assumptions established in Technical Guidance for Hazard Analysis—Emergency Planning for Extremely Hazardous Substances, also known as the Green Book, published in 1987 [23]. This reference provides a basis for

technical applications for community exposure limits. This and similar references often specify that ERPGs be used to determine where within the community protective actions are needed (sheltering in place, evacuation, or isolation zones).

While emergency planners need to know the conditions of the release, the magnitude of a potential release can also be predicted using these models. This allows plant managers to reevaluate possible “worst-case” situations, which might occur as a result of process or human failures. To aid in plant design and community planning, the engineers may select the size of tank that will ensure that a potential release will never reach an airborne concentration above the ERPG-2 level or whatever level the planning group selects as its action level.

ERPGs are general reference levels, the best judgment of hygienists and toxicologists using the best available data, and are intended as a part of an overall emergency-planning program. The levels are not to be used as safe limits for repeated exposures, as definitive delineators between safe and unsafe exposure conditions, or as a basis for quantitative risk assessment. Human responses do not occur at precisely the same exposure level for all individuals, but can vary over a wide range of concentrations. The values derived for ERPGs should be applicable to nearly all individuals in the general population; however, in any population there may be hypersensitive individuals who have adverse responses at exposure concentrations far below levels to which most individuals would respond. ERPGs are estimates of the concentrations above which there would be an unacceptable likelihood of observing the defined effects. The estimates are based on the available data, which are summarized in the documentation [16]. In some cases where the data are limited, the uncertainty of these estimates may be large. Users of the ERPG values are strongly encouraged to review the supporting documentation carefully before applying these values.

Using ERPG values to determine the actions to be taken when planning for or responding to a given emergency requires careful evaluation of site-specific or situation-specific factors. These may

Figure 1. This figure represents how ERPG's are applied to an air plume model for purposes of evacuation and potential injury. A chemical plume decreases in concentrations as it is dispersed by the wind. Plumes many have 3 dimensional characteristics based on their physical chemistry.

include: how the 1-hour ERPG values might relate to exposures of different duration; whether there are populations at special risks (such as the elderly, the very young, or those with existing illnesses); and other factors such as the volatility and vapor density of the chemical, storage quantities, weather conditions, and terrain.

As of April 2008, the ERP committee has published ERPG documents for 134 chemicals as well as many updates. They are developed using the most pertinent exposure data available and are available for public comment prior to their publication. There is a continuing need for additional ERPG levels. The ERP Committee, volunteers working steadily on behalf of communities worldwide, will continue to evaluate data and produce these documents in order to reduce the risk of serious chemical exposures. Chemicals are an integral part of our lives and the potential of exposure to chemicals manufactured, transported, or stored within our communities should not pose an undue risk. In recent days, the threat of terrorism has added concern to the possibility of chemical exposure. It would be great to say, "A catastrophe such as Bhopal will never happen again!" However, "never" does not have a statistical basis, thus it is imperative to plan shrewdly, consider all of the data available, and strive to minimize the risk of significant exposure [1,4,15].

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