COMPONENT PART NOTICE

THIS PAPER IS A COMPONENT PART OF THE FOLLOWING COMPILATION REPORT:

TITLE: Proceedings of the Conference on Toxicology (18th) Held in Dayton, Ohio on 1-3 November 1988

TO ORDER THE COMPLETE COMPILATION REPORT, USE AD-A235 912.

THE COMPONENT PART IS PROVIDED HERE TO ALLOW USERS ACCESS TO INDIVIDUALLY AUTHORED SECTIONS OF PROCEEDING, ANNALS, SYMPOSIA, ETC. HOWEVER, THE COMPONENT SHOULD BE CONSIDERED WITHIN THE CONTEXT OF THE OVERALL COMPILATION REPORT AND NOT AS A STAND-ALONE TECHNICAL REPORT.

THE FOLLOWING COMPONENT PART NUMBERS COMPRISE THE COMPILATION REPORT:

AD#: ADP006 354 thru   AD#:
AD#: ADP006 372.   AD#:
AD#:   AD#:

1

Accesion For	
NTIS CRA&I	☑
DTIC TAB	☐
Unannounced	☐
Justification	
By	
Distribution /	
Availability Codes	
Dist	Avail and / or Special
A-1	

THE APPLICATION OF TOXICOLOGICAL PARAMETERS IN EMERGENCY RESPONSE AND PLANNING

Robin K. Wiener and Deborah K. Silver

ICF Technology Incorporated, 9300 Lee Highway, Fairfax, VA 22031-1207

ABSTRACT

Effective emergency preparedness and response planning is needed to assist responders in making sound decisions under the stressful and confusing conditions accompanying a major accidental release of hazardous materials. One of the most important decisions to be made is the extent and duration of the evacuation of persons located near the accident site. If a decision must be made as to whether or not to evacuate nearby populations, an estimation of the areal extent (sometimes referred to as a toxic hazard corridor or vulnerable zone) of the evacuation must be determined. This corridor, or zone, is based on estimates of the amount of material released, rate of release, vapor dispersion characteristics, and concentration limit or "level of concern" that could cause some damage, irreversible health effects, or death. There is a strong dependency between the concentration limit chosen and the resulting evacuation area dimensions. It is, therefore, important for planners and emergency responders to have accurate estimates of concentration limits as well as guidance in the proper use and interpretation of these limits. This paper will illustrate several causes where the selection of the concentration limits has played an important role.

INTRODUCTION

While the handling, storage, and transportation of hazardous materials are routine in our society, only recently have the public, Congress, and regulatory agencies begun to realize and address the fact that these substances, in many cases, pose substantial risk to the public as well as to the environment and property. It is paramount that the emergency responder, who is often the only line of defense preventing disastrous loss of life following an accident or release, have state-of-the-art data and the means to interpret and apply those data to the situation at hand. Effective emergency preparedness and response planning is needed to assist responders in making sound decisions under the stressful and confusing conditions accompanying a major accidental release of hazardous materials. One of the most important decisions to be made is the extent and duration of the evacuation of persons located near the accident site. If a decision must be made whether or not to evacuate nearby populations, an estimation of the areal extent of the evacuation must be determined. This is referred to as the "toxic hazard corridor" (THC) by the Department of Defense (DoD) and the "vulnerable zone" by the Environmental Protection Agency (EPA); both terms have the same meaning.

The THC is based on estimates of the amount of material released, rate of release, vapor dispersion characteristics, and concentration limit or "level of concern" that could cause some damage, irreversible health effects, or death. Of the various meteorological, source term, and other chemical and thermodynamic parameters needed for use in these estimates, there is a strong dependency between the concentration limit chosen and the resulting evacuation area dimensions. In general, the THC is proportional to the inverse of the concentration limit squared. Therefore, as the concentration limit is lowered, the corresponding THC length increases, but at a higher rate. Not knowing the consequences of an additional release in terms of a chemical's harmful concentration level is problematic to the government agencies (e.g., the EPA) that are responsible for ensuring public safety, primarily because uncertainty in the concentration level may result in an underestimation or overestimation of the THC. Underestimation of the THC could result in the exposure of many people to a toxic vapor cloud, while overestimation could result in needless and even potentially dangerous evacuation (especially to the elderly or others with health problems). It is, therefore, important for planners and emergency responders to have accurate estimates of concentration limits as well as guidance in the proper use and interpretation of these limits.

USE OF TOXICOLOGICAL PARAMETERS

THCs are used in many diverse applications, including (1) risk assessment to determine the extent of exposure, (2) dispersion modeling to calculate THCs, (3) emergency planning to determine vulnerable areas in an accident situation, and (4) emergency response activities. The question in each of these applications is which concentration limit to use. Various organizations have developed exposure guidelines over the years for specific chemicals and applications. However, very few concentration limits have been developed specifically for the applications of risk assessment, emergency response, planning, and dispersion modeling. The limits that have been developed for these specific applications generally are limited in the number of chemicals for which they have been developed. For example, guidelines that are often used are as follows.

- ***Threshold Limit Value (TLV).*** The TLV was developed by the American Conference of Government Industrial Hygienists for the protection of healthy male workers in the workplace, not the general public.

- ***Short-Term Public Emergency Guidance Levels (SPEGLs).*** Developed by the National Research Council (NRC) of the National Academy of Sciences (NAS) for the DoD for unpredicted (i.e., accident) short-term exposure to the public. Although these limits have been developed specifically for the application discussed in this paper, SPEGLs have only been developed for five chemicals to date.

- ***Permissible Exposure Limits (PELs).*** Developed by the Occupational Safety and Health Administration (OSHA) for worker exposure.

- ***Immediately Dangerous to Life and Health (IDLH).*** Developed by the National Institute for Occupational Safety and Health (NIOSH) exclusively for respiratory selection in the workplace.

- ***Emergency Response Planning Guidelines (ERPGs).*** The ERPGs currently are under development by a consortium of chemical companies and are based on guidelines published by the NAS. The limits are being developed for community exposure. ERPGs have been developed for approximately 35 chemicals.

The exposure limits mentioned above represent only a limited example of the various exposure guidelines available. As one can see from the list, only the ERPGs and the SPEGLs have been developed specifically for the use of emergency planning, response, and/or risk assessment. However, the number of chemicals for which they can be applied is fairly limited. ERPGs have been developed for 35 chemicals to date, while SPEGLs have only been developed for five. The question then becomes how does one apply these other limits for emergency response/planning when they are not developed for these purposes. Following are several examples of how these limits have been adapted for varying applications, and, in some cases, with less than optimal results.

VANDENBURG AIR FORCE BASE

Vandenburg Air Force Base (VAFB) in California is the home of the Western Test Range and the site of Delta, Titan, and Atlas launch facilities. These launch vehicles utilize varying amounts of hypergolic propellants (hydrazines and nitrogen tetroxide) which are highly toxic. For this reason, THCs are calculated and plotted at VAFB before initiation of any operation that could or will result in an accidental or planned release of propellants (i.e., those releases that are known to occur during operations such as venting). Predictions are based on analysis of potential sources strength (rate of release of propellant to the atmosphere), the type of propellant involved, exposure limits for the propellant, and prevailing meteorological conditions.

Until recently, the exposure limits used at VAFB to calculate THCs varied depending on the release condition (planned vs. accidental) and the population potentially exposed (workers vs. general public). For planned releases in an occupational environment, VAFB used the TLVs described above. These values are based on a time-weighted average exposure during an 8-h work day and a 40-h work week within which a worker may be repeatedly exposed [1]. For accidental releases in the occupational environment, Emergency Exposure Guidance Levels (EEGLs) were used. EEGLs were developed by the NAS/NRC Committee on Toxicology and are recommended for use in estimating short-term (30 min) worker exposure, not public exposure. The EEGL is a ceiling level for a single, unpredicted exposure lasting 1 h or less and never more than 24 h [2]. Emergency Exposure Guidance Levels take into consideration both the short-term and long-term reproductive, carcinogenic, neurotoxic, and respiratory effects of a single acute exposure, as well as the age and sensitivity of the population and the length of expsoure [1].

For planned releases affecting the general public, limits were derived from the NAS/NRC's short-term public limits (STPLs). Again, the values are based on 30-min exposures. For unsymmetrical dimethylhydrazine (UDMH) and anhydrous hydrazine (AH), the STPL values are one-half the EEGL values. Finally, for accidental releases affecting the general public, the NAS/NRC's public emergency limits, renamed short-term public emergency limits (SPELs), were used. SPELs are defined as single, unpredicted exposures lasting 1 h or less and never more than 24 h, in which the public may experience temporary discomfort or health effects but no irreversible harm [3]. The SPEL is usually used for accidental releases of nitrogen tetroxide (N_2O_4) that may involve the public.

Approximately one year ago, the Air Force Surgeon General's office reduced the exposure limits used for the hydrazine fuel at VAFB to new values, called SPEGLs. The SPEL for N_2O_4 also became the official permissible exposure level. These values were adopted for calculating THCs at VAFB and were independent of groups exposed and release type. The new values were taken from SPEGLs developed by NAS/NRC for fuels and SPEL for N_2O_2. SPEGLs/SPELs are guidance levels for exposure based on a single, unpredicted event lasting 1 h or less, and not more than 24 h, and they are expected to be rare, once-in-a-lifetime occurrences. The SPEGL/SPEL concentration levels are significantly lower than SPEL values (i.e., approximately 1% of the SPEL value for UDMH and AH).

Resulting from this reduction in exposure limits was the generation of much longer THCs. VAFB estimated that the new THCs were as much as 14 times longer than the previous THCs [4] and required much larger areas to be evacuated during normal operations, which impinged on operations unrelated to the material being transferred or utilized. Both 1 STRAD, a division of the Strategic Air Command (SAC), and the Space and Missile Test Organization, a division of AFSC, protested the new longer hazards corridors and petitioned the Air Force Surgeon General to revise the permissible exposure levels. A few months ago the Surgeon General responded by recommending a new set of exposure levels.

These new exposure levels are based on two populations, workers and the public, and two scenarios: (1) the possiblility of a release that results from moving or utilizing a hazardous material during planned operations, and (2) a release as a result of an accident or emergency. The use of different hazard corridors for operations and emergencies is similar to the original method of estimating hazard corridors. For planned operations, one-half of the IDLH is used. The IDLH limits were developed by NIOSH as follows.

> "IDLHs were developed exclusively for respirator selection in the workplace. . . . The IDLH concentration represents the maximum concentration of a substance in air from which healthy male workers can escape without loss of life or irreversible health effects

under conditions of a maximum 30-min exposure time. . . . EPA recognizes that the IDLH was not designed as a measure of the exposure levels required to protect general populations." (EPA's *Technical Guidance for Hazards Analysis*, p.D-2)

The size of the THC will be drastically reduced using one-half of the IDLH values instead of the SPEGL/SPEL values; THCs for UDMH and A-50 will decrease by a factor of 8, AH by a factor of 15, and N_2O_4 by a factor of 3. However, in the event of an accidental release, the SPEGL/SPEL limits will be used to estimate hazard corridors for evacuation of all personnel.

Both SAC and ASFC have agreed to accept the Surgeon General's recommendation and use the new limits and the two-tier approach, significantly reducing the number of personnel that must be evacuated before operations compared with the SPEGL/SPEL approach. This two-tier approach makes it easier for VAFB to transfer the hazardous materials during planned operations without requiring mass evacuations, while still protecting the public in the event of an accidental release.

DOD SHIPMENTS OF NITROGEN TETROXIDE

In response to increasing public concern over the relative safety of hazardous materials transportation, the U.S. Department of Transportation (DOT) in 1986 re-evaluated the various exemptions it regularly issues for the transport of chemicals classified as "inhalation hazards." At that time, the DOT placed several new requirements upon the exempted transporters of these materials, including certification that the routes used are the "safest practicable." Nitrogen tetroxide, a propellant used by the DoD, is classified as an inhalation hazard and fell subject to these new requirements. Risk assessment was performed by ICF Technology Incorporated for the DoD on each of the highway routes used to transport N_2O_4.

The methodology used to calculate risk was based on an assessment of the probability of an accident occurring and the consequences of such an accident. Consequences were calculated in terms of the number of people potentially affected along the route at any one time, using THCs to decide the area affected.

In October of 1987, the Congressional Subcommittee on Government Activities and Transportation held hearings on Capital Hill to address the need for safer highway routing of "ultrahazardous materials" [5]. The hearings highlighted DoD-sponsored shipments of N_2O_4. Nitrogen tetroxide was selected primarily because it was the only chemical classified as an inhalation hazard for which risk assessments had been performed under the new exemption requirements. One of the issues was the number of persons potentially exposed along each of the routes. Organizations were claiming different numbers of persons exposed. The numbers varied due to several differences, including the use of different dispersion models to calculate the THC, different input parameters (including concentration limits), and different assumptions as to release conditions (i.e., whether or not the propellant would be released under pressure). The Environmental Policy Institute, an environmental nonprofit organization in Washington, DC, proposed that a 12-mile evacuation corridor be used [6], a representative from Lawrence Livermore National Laboratory suggested 4.6 miles [7], and the DOT recommended 0.8 miles [8]. These differences in corridor length result in significant differences in the total number of persons exposed and resulting risk. The problem was eventually resolved by performing two risk assessments for each route, each using a different corridor length [9]. However, this is not a viable long-term solution. Ultimately, a well-defined exposure limit, used in an acceptable dispersion model, is needed for risk assessment applications.

ENVIRONMENTAL PROTECTION AGENCY

Approximately two years ago, the Emergency Planning and Community Right-to-Know Act of the Superfund Amendments and Reauthorization Act, also called Title III, was enacted into law. Title III establishes requirements for federal, state, and local governments, as well as industry, regarding emergency planning and community right-to-know reporting for hazardous chemicals. It differs from OSHA's Hazards Communication Standard in that its focus in not on worker right-to-know, but instead, it is intended to provide communities and emergency response organizations with access to information on hazardous chemicals in their community.

The objective of Title III is to improve state and local emergency response and planning and provide the public access to valuable information pertaining to chemicals within their community. Title III required EPA to identify and publish a list of extremely hazardous substances (EHSs) and threshold planning quantitites (TPQs) that would establish which facilities are subject to emergency planning under Title III. That is, if a facility produces, uses, or stores an EHS in excess of the EHS's TPQ, it must comply with the requirements under Title III.

In defining the criteria to use for selecting chemicals, EPA has to identify the health effects of concern and identify the data to be used. Acute airborne toxicity was selected as the initial criterion for the selection of chemicals to be listed (EPA has recently begun to look at chemicals that pose flammable, reactive, or explosive hazards to surrounding communities; however, the date that the list will be published is unknown). The EPA decided to focus on animal acute toxicity data with the assumption that humans and animals are similar in susceptibility to toxic chemicals. Lethality data were used because it is the most available and commonly reported information provided from animal toxicity testing and because the EPA wishes to avoid accidents resulting in human death.

Initially, 402 chemicals were listed by EPA. Since that time, four chemicals have been added to the list as a result of new information. An additional 40 chemicals were delisted because they do not meet the acute lethality criteria. The current list of EHSs stands at 366 chemicals [10].

Title III also required local emergency planning committees (LEPCs) to develop emergency plans for accidents involving EHSs within their communities. As part of the emergency plan, vulnerability analyses had to be performed. A vulnerability analysis is an "assessment of elements in the community that are subject to damage should a hazardous materials release occur; includes gathering information on the extent of the vulnerable zone..." [1] Vulnerability analyses require the calculation of a vulnerability zone distance (VZD), similar to the THCs calculated by the DoD. As part of this calculation, a level of concern (LOC) must be selected. LOCs are defined by EPA as follows.

> "Concentration of an EHS 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" [1].

EPA does not mandate which exposure limit must be used in the calculation of the VZD, but it has set guidelines. Initially, the EPA recommended that the IDLH be used by LEPCs for the calculation of a VZD. However, there are several problems with using the IDLH in this application. The IDLH is based on the response of a healthy male worker population to toxic exposure and, therefore, does not adequately address the response of sensitive populations, such as children and elderly persons. In addition, the IDLH is based on a 30-min maximum exposure period and it is questionable as to whether or not this is realistic for accidental releases. After consultation with several members of the scientific community, including the Scientific Advisory Board, EPA reduced the recommended LOC to one-tenth the IDLH. This is acknowledged as an interim solution until more appropriate levels allowing a margin of safety are determined.

As discussed earlier, several chemical companies have formed a consortium to develop a more appropriate value for use in these types of applications (the ERPGs). However, ERPGs have been developed for only a handfull of chemicals. It is possible that EPA will make revisions to their rulemaking and recommend use of the ERPGs as they become available. This is an ongoing process.

ISSUES

Chemical manufacturers and other industries are trying to respond to EPA and DOT initiatives for the development of emergency response plans. The development of the ERPGs is one example of industry's initiatives in this area. Another is industry's voluntary efforts in the area of transportation risk assessment and routing evaluations. However, there has been a general frustration on the part of industry as to how they can maximize public safety, minimize their liability, and, at the same time, still allow for normal operations.

There is an obvious need for coordination among all responsible players, including toxicologists, dispersion modelers, planners, and others who are involved in the application of toxicological parameters for the purposes of accurate emergency response/planning and risk assessment methods. Concerted efforts are required of industry and the government to work together to develop appropriate guidelines. Conferences, such as the Annual Conference on Toxicology sponsored by the Harry G. Armstrong Aerospace Medical Research Laboratory and the

Naval Medical Research Institute/Toxicology Detachment, provide excellent forums for communication and the exchange of ideas. Communication is vital to the proper progression of this work by helping to ensure that research and development efforts are proceeding in the direction needed and that ideas are being shared by those who are in need of the information.

REFERENCES

1 U.S. Environmental Protection Agency (1978) *Technical Guidance for Hazards Analysis.* U.S. EPA, Washington, DC.

2 National Research Council *Emergency and Continuous Exposure Guidance Levels for Selected Airborne Contaminants.* Volumes 4 and 5. National Academy Press, Washington, DC.

3 ICF Technology Incorporated (1987) *Hypergolic Propellant Hazards Response Guide: Vandenburg AFB*, Volume II. ICF Technology Incorporated, Fairfax, VA.

4 Telephone conversation with Daryl Dargitz, WSMC Safety (VAFB) on 4 August 1988.

5 Promoting Safer Highway Routing of Ultrahazardous Cargoes: DOT Oversight (1987) Thirty-first report by the Committee on Government Operations together with additional views.

6 Millar, F. (1987) Statement before the Government Activities and Transportation Subcommittee for the House Committee on Government Operations.

7 Koopman, R.P. (1987) Testimony given before the House Government Activities and Transportation Subcommittee of the Committee on Government Operations, Los Angeles, CA, October 19, 1987.

8 1987 Emergency Response Guidebook (1987) U.S. Department of Transportation, Research and Special Programs Administration, Office of Hazards Materials Transportation.

9 ICF Technology Incorporated (1988) Risk Assessment of Nitrogen Tetroxide Transportation Routes. Prepared for San Antonio-Air Logistic Center, Directorate of Energy Management, Transporation Office, Kelly Air Force Base, San Antonio, TX.

10 52 Federal Register 13378-13410.