APPENDIX H

GENERAL CONSIDERATIONS FOR EVACUATION OR IN-PLACE SHELTERING

An accidental release of hazardous materials sometimes necessitates evacuation of people from certain areas to prevent injury or death. These areas can include those directly affected by toxic fumes and gases or fire and those areas that may be potentially affected during the course of the incident (e.g., through wind shift, a change in site conditions). Evacuation is a complex undertaking. Rather than attempting to provide specific step-by-step guidance for each possible scenario, we will discuss in this appendix general considerations that should be addressed in advance by the local emergency planning committee (LEPC). Specifically, this appendix will discuss: deciding whether evacuation is appropriate and necessary (Section H.1); steps in conducting an evacuation (Section H.2); and in-place sheltering as an alternative to evacuation (Section H.3).

> This document will not give you evacuation distances nor provide definitive guidance on estimating evacuation zones.
>
> Decisions about whether or not to evacuate as well as about evacuation distances are incident-specific and must be made at the time of an actual release.
>
> The estimated vulnerable zones should be used for planning purposes only and should not be used as an evacuation zone in an emergency response situation.

H.1 MAKING A DECISION ON EVACUATION

The first evacuation consideration, determining whether an evacuation is necessary, involves a comprehensive effort to identify and consider both the nature of and circumstances surrounding the released hazardous material and its effect on people. No safe exposure levels have been established for the extremely hazardous substances (EHSs) and therefore it is not possible to calculate evacuation distances using the methods outlined in this guidance. Section H 1.1 discusses how hazardous conditions and inherent properties of the released materials affect evacuation decisions. Section H.1.2 discusses how life safety factors affect the decision on whether or not to order an evacuation.

The Department of Transportation's (DOT's) Emergency Response Guidebook provides initial isolation and evacuation distances for transportation incidents. The evacuation distances given in the guidebook are preceded by the following advice: "The [initial isolation/evacuation] table is useful only for the first twenty to thirty minutes of an incident.... There are several good reasons for suggesting that the use of the table be limited specifically to the initial phase of a no-fire spill incident during transport. The best calculations for these tables are not reliable for long vapor travel times or distances. At their best they are estimates for a cool, overcast night with gentle and shifting winds moving a non-reactive, neutrally-buoyant vapor." The DOT Emergency Response Guidebook is intended to help first responders to make informed judgments during the initial phases of a hazardous materials transportation incident. LEPCs are cautioned not to use it as a substitute for a specific plan for responses to hazardous materials incidents.

H.1.1 Hazardous Conditions Affecting Evacuation Decisions

Numerous factors affect the spread of hazardous substances into the area surrounding a leaking/burning container or containment vessel. Evacuation decision-makers must carefully consider each of these factors in order to determine the conditions created by the release, the areas that have been or will be affected, and the health effects on people. The factors that affect evacuation include amount of released material(s), physical and chemical properties of the released material(s), health hazards, dispersion pattern, atmospheric conditions, dispersion medium, rate of release, and potential duration of release. Each of these factors is explained below.

To begin with, it is necessary to know the material's physical and chemical properties, including:

- Physical State - solid, liquid, or gas;
- Odor, color, visibility;
- Flammability: flashpoint, ignition temperature, flammable limits;
- Specific Gravity: whether material sinks or floats on water;
- Vapor Density: whether vapors rise or remain near ground level;
- Solubility: whether material readily mixes with water,
- Reactivity, whether material reacts with air, water, or other materials;
- Crucial Temperatures: boiling point, freezing point.

It is also necessary to know the health effects resulting from a short-term exposure:

- Acute or chronic hazards;
- Respiratory hazards;
- Skin and eye hazards; and
- Ingestion hazards.

Another consideration is the dispersion pattern of the released hazardous material, for example:

- Does the release follow the contours of the ground?
- Is it a plume (vapor cloud from a point source)?
- Does the release have a circular dispersion pattern (dispersing in all directions)?

Atmospheric conditions must also be addressed when determining the appropriate evacuation response to a hazardous material release. Atmospheric conditions that may affect the movement of material and evacuation procedures include.

- Wind (speed and direction);
- Temperature;
- Moisture (precipitation, humidity);
- Air dispersion conditions (inversion or normal); and
- Time of day (daylight or darkness).

Other considerations important in making evacuation decisions include:

- Whether the hazardous material is being released into air, land, and/or water and its concentration in air or water;
- Size and potential duration of the release; and
- Rate of release of the material, as well as the projected rate (the rate of release may change during the incident).

H.1.2 LIFE SAFETY FACTORS TO CONSIDER IN PLANNING AN EVACUATION

Life safety factors to consider when planning an evacuation include the number and types of people that require evacuation and the resources needed to conduct a safe and effective evacuation. Whether the people are actually located in an area that contains hazards or are located in an area that is only threatened by hazards is a critical component of evacuation planning.

Populations in a Hazardous Area

When considering people who are actually located within a hazardous area, the LEPC must address whether responsible authorities should order people to remain indoors, rescue individuals from the area, or order a general evacuation. The "remain indoors" option should be considered when the hazards are too great to risk exposure of evacuees. (See Section H.3 for further discussion of in-place sheltering.) It may be necessary to rescue people from the hazardous area, but this would involve supplying protective equipment for evacuees to ensure their safety. The third option is to order a general evacuation. In this case people must evacuate by means of private transportation or by transportation provided by local or State government, a private sector company, or volunteer groups.

Populations in a Threatened Area

For an area that is only threatened by a hazardous release, it should be determined whether

potential evacuees can be evacuated before hazards reach the area. To safely evacuate the area, a significant amount of lead time may be required. Depending on the hazards and their movement (as described above), evacuation assistance personnel may not have much lead time.

Identifying People to be Evacuated

Numerous factors must be considered to ensure that an evacuation is conducted in a safe and effective manner, including how many people will be involved, where they are located, their degree of mobility, and whether there are any communication barriers to address. Potential evacuees may be found in many different locations:

- Residences
- Educational institutions
- Medical institutions
- Health care facilities
- Child care facilties
- Correctional facilities
- Offices
- Commercial establishments
- Manufacturing/industrial/research facilities
- Government facilities
- Places of public assembly
- Parks and other recreational areas
- Sporting arenas/stadiums
- Roadways

In addition to the above considerations, the LEPC must determine what persons will require special assistance in evacuating the area and whether there exist any barriers to communication between evacuees and evacuation assistance personnel. Special consideration should be given to:

- Persons lacking private transportation
- The elderly
- Children
- Handicapped persons
- The infirm
- Prisoners
- Non-English speaking persons

Resources Needed

To accomplish a safe and effective evacuation, the LEPC must provide for appropriate and sufficient resources, including personnel, vehicles, and equipment appropriate for emergency situations.

Among the agencies that would likely supply personnel during an evacuation operation are the Red Cross, police department, fire department, and emergency medical service agencies.

In addition to personnel, specially equipped vehicles may have to be put in service, including:

- Lift-equipped buses and taxi cabs for handicapped persons;
- Ambulances for infirm and handicapped persons; and
- Vehicles for transporting persons lacking private transportation.

Making prior arrangements to ensure the availability of these vehicles in times of emergency will result in a more timely and effective evacuation.

The type of equipment that will be necessary during an evacuation includes:

- Protective gear for evacuation assistance personnel (e.g., masks to protect the lungs, protective covering for the skin and eyes);
- Protective gear for evacuees who may have to be taken through an area of heavy chemical concentration;
- Communication equipment (e.g. portable and mobile radios, mobile public address systems, bull horns); and
- Evacuation tags (a tag or marker attached to a door to indicate that the occupants have been notified) for buildings that have been evacuated.

H.2 CONDUCTING AN EVACUATION

Should it be decided that an area is to be evacuated, the evacuation must be conducted in a

well-coordinated, thorough, and safe manner. Evacuation involves a number of steps, which include assigning tasks to evacuation assistance personnel, informing potential evacuees, providing transportation as necessary, providing emergency medical care as necessary, providing security for evacuated areas, and sheltering evacuees as necessary.

H.2.1 Evacuation Tasks

The first step is to assign tasks to evacuation assistance personnel. These tasks include information concerning:

- The specific area to evacuate
- Protective gear to be worn
- Instructions to be given to evacuees
- Transportation of evacuees who are without private transportation
- Assistance to special populations
- Shelter locations
- Security for evacuated areas
- Traffic and pedestrian control
- Communication procedures

The progress of the evacuation efforts must be monitored by those in charge who should also provide continuous direction to evacuation assistance personnel.

H.2.2 Evacuation Warning and Instruction

The second step in an evacuation is to inform people that they must evacuate and to provide them with accurate instructions. This procedure can be accomplished in several ways:

- Door-to-Door. Requires significant manpower; is a slow process but is very thorough.
- Public Address System (from a mobile unit or within a building). Requires less manpower than a door-to-door evacuation and is quicker to accomplish but is not as thorough
- Combination of Door-to-Door and Public Address System. For some sections of an area door-to-door notification may be more expeditious, whereas in other areas evacuation instructions given via a public address system may be adequate and less time consuming.

The potential evacuees might also be alerted to the emergency by means of an alerting and warning system that prompts them to tune in to their radios for instructions from the Emergency Broadcast System or a similar broadcast system.

H.2.3 Movement of Evacuees

The third step in an evacuation is to provide movement assistance to evacuees. Movement assistance includes:

- Arranging transportation for evacuees who are without private transportation;
- Arranging for movement of the infirm and handicapped;
- Traffic control;
- Encouraging evacuees to move along in an expeditious manner.

Buses and/or vans will be needed for transportation of large groups of evacuees. Evacuating the infirm and handicapped will involve lift-equipped buses, vans, and/or ambulances. Traffic control involves restricting access of vehicles into the evacuated area and facilitating speedy vehicular movement out of the evacuation area.

H.2.4 Emergency Medical Care for Evacuees

Should evacuees become exposed to hazards during an evacuation, emergency medical care must be provided. If a hazardous vapor cloud were to move suddenly upon a large group of people being evacuated, numerous casualties would be possible. For this reason, it is advantageous to have emergency medical service (basic and advanced life support) units standing by in case they are needed.

H.2.5 Security in Evacuated Areas

Once an area is evacuated, law enforcement personnel must guard the area to prevent looting and other unauthorized actions. Security forces operating in or around an evacuated area must be dressed in appropriate chemical protective gear.

H.2.6 Sheltering of Evacuees

The final step in the evacuation process is to provide shelter to the evacuees. Merely advising people to evacuate an area is inadequate. Providing shelter for them in a safe and comfortable building is of great importance, particularly at night or during inclement weather. In order to effectively serve the needs of evacuees, a shelter should have the following facilities, services, and characteristics:

- One qualified person to serve as Shelter Manager -- usually a Red Cross or local government representative
- Sufficient space to avoid overcrowding
- Restroom facilities
- Shower facilities
- Specialized facilities for the handicapped
- Chairs, tables, and other furniture
- Adequate lighting, temperature control, ventilation, and uncontaminated water
- Telephone system and/or two-way radio
- Food and refreshments
- Adequate safety features to meet fire, building, and health requirements
- Medical surveillance and care
- Care for the young, elderly, and handicapped
- Information available for evacuees concerning the emergency
- Sufficient parking near the shelter

Shelters should be identified and management and operational procedures should be established as part of a preparedness plan. When selecting shelters, locations must be chosen that are in areas beyond current and projected areas of hazard contamination. To ensure that evacuees are continuously sheltered in safe areas, the following actions are necessary:

- Collect and evaluate data on the spread of hazards toward shelters.
- Establish and maintain communications with shelters.
- Make provisions for the monitoring of hazards in and around each shelter and evaluate the resulting data.
- Advise shelter managers when shelters will have to be evacuated because of approaching hazards.

Should shelters have to be evacuated, alternate locations must be identified and shelter coordinators notified.

To ensure the health and safety of evacuees at shelters, provisions should be made for evacuee medical surveillance and care. This is especially important for evacuees who may have been exposed to hazardous materials vapors. Ideally, each shelter should have medical professionals assigned to care for evacuees. They must be alert to symptoms caused by hazardous materials and be responsible for treating victims or calling for emergency medical assistance. Evacuees showing symptoms should be separated from those unaffected. The medical professional can also assist evacuees who need prescription medicines.

H.2.7 Re-entry into Evacuated Areas

Before making the decision to authorize re-entry, data collected by the monitoring crews must be verified and the advice of health officials considered.

Once the decision to authorize re-entry has been made, re-entry operations must be coordinated. These operations may be looked upon as an evacuation in reverse, as many of the same steps must be undertaken. Re-entry operations involve:

- Notifying people that they can return to evacuated areas.
- Providing evacuees with special information or instructions.
- Coordinating transportation for evacuees who require it.
- Providing traffic control and security in areas being re-entered.
- Advising people to report lingering vapors or other hazards to emergency services.
- Advising people to seek medical treatment for unusual symptoms that may be attributable to the hazardous materials release.

H.3 IN-PLACE SHELTERING

Evacuation decisions are of necessity very incident-specific and the use of judgment will be necessary. If the release occurs over an extended period of time, or if there is a fire that cannot be controlled within a short time, then evacuation may be the sensible option. Evacuation during incidents involving the airborne release of EHSs is sometimes, but by no means always, necessary. Airborne toxicants can be released and move downwind so rapidly that there would be no time to evacuate residents. For short-term releases, often the most prudent course of action for the protection of the nearby residents would be to remain inside with the doors and windows closed and the heating and air conditioning systems shut off. An airborne cloud will frequently move past quickly. Vulnerable populations, such as the elderly and sick, may sustain more injury during evacuation, than they would by staying inside and putting simple countermeasures into effect.

There are other disadvantages associated with evacuation during incidents involving airborne releases of EHSs. Changes in wind velocity and direction are difficult to predict and could be very important if evacuation were undertaken during a release. Differences in temperature between air layers could also cause the toxic cloud to disperse in ways that would be hard to predict. These factors and others make it difficult to estimate how long the community would be exposed to a toxic cloud. Also, no safe exposure or concentration levels have been established for the general population with regard to releases of chemicals included on the list of EHSs.

In-place sheltering, therefore, may be a sensible course of action, when the risks associated with an evacuation are outweighed by the benefits of in-place sheltering. In order for this protection measure to be effective, the affected population must be advised to follow the guidelines listed below:

- Close all doors to the outside and close and lock all windows. (Windows seal better when locked). Seal gaps under doorways and windows with wet towels and those around doorways and windows with duct tape or similar thick tape.
- Building superintendents should set all ventilation systems to 100 percent recirculation so that no outside air is drawn into the structure. Where this is not possible, ventilation systems should be turned off.
- Turn off all heating systems and air conditioners.
- Seal any gaps around window type air-conditioners, bathroom exhaust fan grilles, range vents, dryer vents, etc. with tape and plastic sheeting, wax paper, or aluminum wrap.
- Turn off and cover all exhaust fans in kitchens, bathrooms, and other spaces.
- Close all fireplace dampers.
- Close as many internal doors as possible in homes or other buildings.
- If an outdoor explosion is possible, close drapes, curtains, and shades over windows. Stay away from windows to prevent potential injury from flying glass.
- If you suspect that the gas or vapor has entered the structure you are in, hold a wet cloth over your nose and mouth.
- Tune in to the Emergency Broadcast System channel on the radio or television for information concerning the hazardous materials incident and in-place sheltering.

It should be understood that following the above guidelines will increase the effectiveness of in-place sheltering as a protective action. Following these guidelines does not ensure that this type of protective action will indeed be effective.

APPENDIX I

INFORMATION COLLECTION TO EVALUATE SITES FOR EMERGENCY PLANNING

I.1 OVERVIEW

This appendix presents a process for collecting information that will be needed to assess the hazards posed by particular sites and to develop community emergency plans. The National Response Team's Hazardous Materials Emergency Planning Guide (NRT-1) should be consulted when preparing such plans. The process focuses on an examination of the sites that use, produce, process, or store extremely hazardous substances (EHSs). The types of information to be collected include descriptions of the chemicals present, ongoing measures for the control of potential releases, and the available response resources and capabilities at the site and within the community, including existing emergency plans. Initial requests for information should be made in a way that promotes continued cooperation between the personnel at the sites and the community planners. The information should be sought in a way that encourages facilities to participate actively in the planning process along with local government and other community groups. Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA) requires facilities to assist local planning committees by supplying information and designating an emergency planning coordinator (see Chapter 1). The Chemical Manufacturers Association (CMA) has published A Manager's Guide to Title III that suggests ways for participants in the Community Awareness and Emergency Response (CAER) program to cooperate with local planning committees.

Many sites will already have safety and contingency plans in response to regulatory requirements or as part of normal operating procedures. The community should learn what the facility is doing to identify and deal with the possible release of acutely toxic chemicals. The plant site may have identified community impacts resulting from accidental chemical releases and have taken measures to reduce risks. The planners can then identify what additional steps and resources, such as personnel, training, and equipment, might be needed at the facility or in the community.

The information collection process is outlined here as a series of discussion points, which are presented as examples of the types of information that a community may want to use to assess potential hazards. A community planning committee may use some, all, or none of these discussion points. Depending on the community's initial perception of potential risks, the discussion points can be tailored by the committee to meet specific local needs. Some of these points will be rather simple and direct, such as those used to determine what EHSs are located at a site, and their quantity. Other points should generate additional discussion, for example, whether any EHSs are handled or stored near other chemicals that are flammable, explosive, or reactive. If such a situation does exist, subsequent discussions should be designed to: (1) identify these chemicals, (2) determine how the facility isolates the chemical of concern (e g., the chemical of concern is stored in fire-proof containers, or the adjacent flammable, explosive, or reactive chemical is stored under conditions to prevent leakage or explosion), and (3) what additional precautions are taken to ensure that a release will not affect the surrounding community.

Planners should always be aware that:

- The specific identity of an EHS may sometimes be withheld as a trade secret. In the absence of specific chemical identity, however, important information such as the physical state and the levels of concern (LOCs), as defined in this document, should be provided.
- The information-gathering effort should not be adversarial but rather an attempt by all concerned to cooperate in describing and solving a potential problem facing the entire community;
- Facilities may be sensitive concerning what they consider proprietary business information;

- Asking a particular question does not imply that there is a definite problem, but rather shows a desire to identify and address potential problems; and
- Title III of SARA requires facilities to provide information to planners that will enable hazards analysis.

I.2 ORGANIZATION

The suggested discussion points for gathering and analyzing information for a hazard assessment are presented in four sections:

- Site activities and management programs;
- Site location information;
- Site measures for managing and controlling chemical releases; and
- Site interface with community response and preparedness programs.

Information obtained from these discussion points and the information sources discussed in Chapter 2 will assist the planners in assessing site-specific hazards and should be considered along with the factors used for assessing chemical releases outlined in Chapter 2 and detailed in Appendix H. Even if the sites have safety and contingency plans in place, the community planners should not neglect the procedures suggested in Chapters 2 and 3, as they will enable the community to assess hazards posed by different sites and to develop contingency plans in order of priority.

The discussion points outlined here are far ranging. Not all of them will be necessary to elicit information required for site-specific assessment. However, most will need to be discussed for the final phase of this program, the formulation of emergency plans. For this reason they are included here. Planners may select those points that best suit their needs for each phase of the process.

The first section outlines the points of information that the community planners will want to obtain about the type and quantity of chemicals used, produced, processed, or stored and to evaluate the appropriateness and timeliness of any planning that may already have been done at the site. If little emergency preparedness work has been done, the planners need to know the site's chemical handling and processing activities, related management programs, and capability for responding to chemical release emergencies.

Next, the planners will want to find out about those physical, topographic, meteorological, and demographic factors that, although external to the facility itself, have an important bearing on how to prepare for an emergency involving a release from the facility. The facility may already have assembled this kind of information as part of its internal planning process.

Most companies, for reasons of plant and employee safety, community concern, regulatory requirements, or as a matter of corporate policy, have analyzed the potential on-site and off-site impact of a chemical release. Plans for promoting on-site safety, emergency plans, and liquid spill and hazardous waste release prevention plans may already have been developed as a result of standard industrial practice or regulatory requirements. If such plans are available, they can be a valuable starting point for the larger task facing the planners, that is, developing an up-to-date comprehensive community emergency plan, in addition to the initial task of ranking the site-specific hazards.

The final step for the community planners is that of developing, or updating, the community emergency plan. NRT-1 should be consulted for this step. Based on emergency planning efforts that may already have been undertaken at the site, as well as on the planners' assessment of the site's activities and management programs, the planners can assess the adequacy of the site's emergency plans and those of the community. A solid foundation will now exist upon which future cooperative planning and updating can occur.

I.3 SITE ACTIVITIES AND MANAGEMENT PROGRAMS

This section contains example discussion points that will assist planners in collecting basic information about the site's processes and related management programs. With this information and using the procedures outlined in Chapter 2 and 3, the planners can assess a site's potential

hazards as well as evaluate its emergency response resources and capabilities. This information will also be useful in developing a community emergency plan. The planners first need information about the hazardous materials that exist at the site and then about how these materials are handled and managed.

1. Chemicals of Concern That Could Be Released:

   - Chemicals used, produced, processed, or stored that meet the criteria (see Appendix B) or are on EPA's EHS list (see Appendix C), whether or not they exceed the threshold planning quantities (TPQs). (The specific chemical identity of an EHS may sometimes be withheld as a trade secret. In the absence of the specific identity, however, important information such as the physical state and the LOC, as defined in this document, should be obtained.)
   - Chemicals that could result from reaction, combustion, or decomposition of chemicals at the site.
   - High temperature, high pressure processing and storage of chemicals.

2. Shipping and Transfer of EHSs:

   - Frequency of shipments (daily, weekly, irregular schedule).
   - Quantity of shipments (tons, gallons, number of drums, tanks, and vats).
   - Form of shipment (e.g., tank truck, rail car, drums, boxes, carboys, pipelines, barges).
   - Transportation routes through the community (roads, railroads, pipelines).
   - Unloading systems:
     - pumping versus gravity feed systems, and
     - underground versus aboveground pipelines.
   - Unloading procedures:
     - monitoring by plant personnel, and
     - remote monitoring by tank level gauges, alarms, automatic cut-off valves, and similar means.

3. Storage Conditions:

   - Quantities normally stored in aboveground tanks and underground tanks.
   - Drum storage areas (indoors and outdoors).
   - Storage of gas cylinders.
   - Use and operation of secondary spill-containment systems.
   - Techniques used for the separation of incompatible chemicals.
   - Special systems used for the storage of reactive, flammable, and explosive chemicals.

4. Handling Procedures for EHSs:

   - Special safety systems used in connection with high temperature or high pressure operations.
   - Secondary equipment containment systems for reactor and other processes.
   - Pumping versus gravity-feed systems.
   - Materials handling by automatic systems versus manual systems.
   - Use of alarm systems for tank level gauging, temperature and pressure sensing.
   - Redundancy for critical process (i.e., availability of back-up equipment in case of failure, or automatic system shut-down after a system failure).
   - Frequency of inspection and testing of critical process equipment, alarm systems and similar equipment.

5. Site Management Characteristics:

   - Hours of operation and production rates during different shifts (planning needs may differ between day and night shifts).
   - Degree of around-the-clock coverage by trained, responsible, and fully authorized technical and management staff.

- Plant security (e.g., fencing, guards on duty, remote sensing by TV monitors, alarm connections to local police and fire departments).
- Plant wastewater and stormwater drainage: direct discharges to local surface water versus discharge to on-site or off-site treatment plants.
- Site emissions to the air covered by Federal and State environmental regulations.
- Hazardous and non-hazardous solid wastes generated, treated, stored, or disposed on-site. Wastes transported off-site.

6. Site Process Design and General Operations:

   - Listing and description of relevant site processes for synthesis, manufacture, formulation, repackaging, distribution, and handling of EHSs.
   - Design and construction specifications covering such aspects as handling temperature and pressure, and materials' compatibility.
   - Process design to consider safety devices, alarms, and back-up systems to ensure the integrity of the process and to protect the facility during normal and unusual conditions of operation.
   - Programs for managing changes in the design or operation of process equipment and changes in chemical component amounts, concentrations, or types.
   - Preventive maintenance programs for facilities and equipment critical to safe process operation.
   - Maintenance training and implementation that addresses the potential for preventing or controlling the release of EHSs.
   - Description of "best engineering practice" and "state-of-the-art" process design, construction, operation, and maintenance for similar facilities within the industry.

I.4 SITE LOCATION INFORMATION

These example discussion points allow the community planners to describe the vulnerable zone in greater detail and to assess the adequacy of both site and community preparedness programs.

1. Significant Physical, Topographic, and Meteorological Features:

   - Distance to site fenceline or boundaries from chemical storage and process areas.
   - Transportation access/egress including surface, air, and water routes.
   - Terrain characteristics of importance such as mountains, hills, canyons, valleys, and plains.
   - Meteorological features, including profiles of wind speed and direction, precipitation, and temperature.
   - Distance to nearest surface-water body, including drainage ditches and other conduits, and flood plains.

2. Site Demographic Characteristics:

   - Distance to nearby populations such as communities, subdivisions, commercial or industrial sites, and transportation corridors.
   - Distance to public facilities such as schools, hospitals, parks, playgrounds and stadiums.
   - Numbers of people within vulnerable zone distances and a characterization of how those numbers can fluctuate hourly, daily, and seasonally.
   - Value of property and commercial goods located within potential vulnerable zone.

I.5 SITE MEASURES FOR MANAGING AND CONTROLLING CHEMICAL RELEASES

This section contains example discussion points to help the community understand those actions

already taken by a facility to identify hazardous situations and to describe the potential effects on people, property, and the environment. The planners should identify the control measures site management has put in place to control releases of EHSs, their by-products and decomposition products, or other chemicals that meet the criteria. Facilities are defined under Section 302 of Title III of SARA (see glossary).

1. Site, Community, and Environmental Impacts of Potential Emergencies:

   - Site analyses or models to predict location, intensity, and duration of hazards related to chemical releases.
   - Community, State, or Federal activities or studies that the site has integrated with their own release modeling efforts.
   - Past experiences or incidents at the site.
   - Past experiences with similar chemicals and processes.
   - Past facility and transportation incidents in the community involving hazardous materials. Relationship of past response efforts to possible future needs. Note that transporters are not required to keep historical records.
   - Activities or studies by trade groups, professional societies, or academia that could be of value.

2. Control and Response Plans in Operation, under Development, or on File:

   - Spill Prevention Control and Countermeasures (SPCC) Plan covering the release of hazardous substances as defined under authority of the Clean Water Act.
   - General site safety plan covering routine and non-routine operations, maintenance, emergencies, training, and inspections.
   - Site emergency response and preparedness plans.
   - Resource Conservation and Recovery Act of 1976 (RCRA) Part B Emergency Response Plan covering site and community response procedures and contingencies for release to the environment of hazardous wastes as required by the regulations under RCRA in 1976 and as amended in 1980 and 1984.
   - Site and corporate policies for developing, implementing, and updating all such plans.

3. Equipment Available On-Site for Emergency Response:

   - Basis for having such equipment on-site.
   - Description of "good practice" and "state-of-the-art" equipment for similar facilities within and chemicals handled by the industry.
   - Fire-fighting systems (fire hydrants, sprinklers, extinguishers, chemical fire retardants, protective clothing).
   - Fogging or misting systems for vapor release control.
   - Neutralization materials for acids or caustics.
   - Dedicated dump tanks, absorbers, scrubbers, or flares for liquid/vapor release control.
   - Absorbants, foams, and specialized chemical agents for containing and controlling releases.
   - Emergency power systems in case of power outage.
   - Containment booms for surface-water spills.

4. Leak and Spill Detection Systems:

   - Basis for installation of these systems.
   - Description of "good practice" and "state-of-the-art" systems for similar chemicals handled by the industry.
   - Gas detection monitors or explosimeters for determining sources and severity of leaks.
   - Oil spill detection devices for nearby sewers or drains to surface-water bodies.

- Wind direction indicators for determining the direction of released chemical aerosols or vapors.
- Chemical spill detection systems for corrosives, organics, and other volatilizable liquid spills.
- Degree to which such systems are remotely monitored and can initiate an automatic response.
- Activation sensors for rupture disks and relief valves.
- Sensors to detect overfilling of tanks and initiate automatic response.

5. Site Emergency Response Procedures:

- Chain of command for leak or spill notification within the plant (24-hour notification system).
- Employee evacuation plan.
- Response procedures for operations and staff personnel.

6. Community Notification Procedures:

- Criteria for notifying the community of a release.
- Procedures for notification, such as sounding alarms and contacting community officials, local police and fire departments, nearby populations, and the media.
- Ongoing education of citizens and workers to inform them of the exact meaning of notification alarms.

7. Outside Emergency Response Resources:

- Contracts with local cleanup contractors.
- Arrangements with local hospitals or other medical facilities.
- Mutual aid agreement with other local industries.

8. Training and Preparedness:

- Frequency of employee training in emergency response procedures.
- Extent of emergency response training (training sessions, emergency drills, involvement of local police and fire departments in emergency training and drills, which employees receive training).
- Frequency of updating of contingency plans (regular basis or only after changes in plant operating procedures).
- Inspection of emergency equipment (frequency and extent).
- Description of "good practice" and "state-of-the-art" practices for similar facilities within the industry.

I.6 SITE INTERACTIONS WITH COMMUNITY RESPONSE AND PREPAREDNESS PROGRAMS

These discussion points help the community evaluate its emergency response resources and capabilities and those of the facilities. They are designed to identify planning activities, resources used, and response capabilities established within the community. Information will be required from a variety of local emergency response agencies and government agencies. These discussion points may need to be addressed only once for the entire community. This information will be used directly to develop the community emergency plan and will assist the planners in evaluating what emergency response resources may be needed in addition to those already in place or planned by the facility or community.

1. Planning Documents and Activities:

- Existing community hazardous chemical emergency plans.
- Current status of community emergency plan or planning process for EHSs or other hazardous chemical emergencies.
- Status of technical reference library or other information systems for response procedures for chemicals.
- Structure and authority of existing community planning and coordination body (e.g.,

task force, advisory board, interagency committee) to plan for and deal with emergencies.

- Status of previous surveys or assessments of potential risks to the community from facility or transportation accidents involving hazardous chemicals.
- Status of any existing assessments of prevention and response capabilities within the community's own local emergency response network.
- Frequency of training seminars, exercises, or mock accidents performed by the community in conjunction with local industry or other organizations.
- Integration of any existing hazardous chemical plans into any existing community contingency plans for other emergencies.

2. Planning Review and Update:

- Community personnel and programs for periodic analysis, review, and update of the community contingency plan.
- Corporate and on-site facility officials designated to maintain and update the site contingency plan and to interact with the local emergency planning group.
- Corporate and facility policies in this regard.

3. Training and Preparedness:

- Capacity and level of expertise of the community's emergency medical facilities, equipment, and personnel.
- Arrangements for assistance from or mutual aid agreements with other jurisdictions or organizations (e.g., other communities, counties, or States; industry; military installations; Federal facilities; response organizations).
- Availability of any specific chemical or toxicological expertise in the community -- either in industry, colleges and universities, or on a consultant basis.
- Availability of equipment and materials on the local level to respond to emergencies. Accessibility of equipment, materials, and manpower in emergency situations.
- Completeness of a list of important resources and their availability for speedy response activities: wreck clearing, transfer, transport, cleanup, disposal, analytical sampling laboratories, and detoxifying agents.
- Training and equipment available to the local emergency services (fire, police, medical).
- Proximity of specialized industry response teams (e.g., CHLOREP, AAR/BOE), State/Federal response teams, or contractor response teams available to the community. Average time for them to arrive on the scene.
- Definition of community emergency transportation network.
- Designation of specific evacuation routes; public awareness of evacuation routes.
- Designation of specific access routes designated for emergency response and services personnel to reach facilities or accident sites.
- Other procedures for protecting citizens during emergencies (e.g., remain indoors, wear gas masks).

4. Community, State, and Federal Agencies and Other Organizations that Can Contribute to or Should Have a Role in the Contingency Planning Process:

- Fire Department.
- Police/Sheriff/Highway Patrol.
- Emergency Medical/Paramedic Services associated with local hospitals or fire or police departments.
- Emergency Management Agency/Civil Defense.
- Public Health Agency.
- Environmental Agency.

- Red Cross.

- Other local community resources such as transportation department, public housing, communications.

5. Communications:

- A list of specific community points of contact and a description of what their duties and responsibilities are in an emergency.

- Agencies involved, areas of responsibility (e.g , emergency response, evacuation, emergency shelter, medical/health care, food distribution, control of access to accident site, public/media liaison, liaison with Federal and State responders, locating and manning the command center), the name of the contact, position, 24-hour telephone number, and the chain of command.

- Status of the emergency communications network in the community to alert the public, keep the public informed with up-to-date information, and provide communications between the command center, the accident site, and off-scene support.

- Components available for the communications network (e.g., special radio frequency, network channel, siren, dedicated phone lines, computer hook-up).

- Status of community source list with the name, position, and phone number of a contact person for technical information assistance. This can be Federal, State, industry associations, and local professional groups.

APPENDIX J

METHODS FOR EVALUATING HAZARDS USED BY FACILITIES

J.1 INTRODUCTION

Many facilities will have undertaken detailed analyses of their plant operations. This appendix describes three procedures which they may have used to evaluate hazards in everyday operating procedures. They are Hazard and Operability Study (HAZOP), Event Tree Analysis, and Fault Tree Analysis. Some community planners may wish to use these methods or at least be familiar with them. It may be possible for planners to use such studies if they are available for the facilities of concern. The procedures discussed below, as well as others, are described in detail in Guidelines for Hazard Evaluation Procedures, prepared by Battelle Columbus Division for the Center for Chemical Plant Safety of the American Institute of Chemical Engineers (AIChE). These methods for risk analysis are highly complex and the methodologies employed are under continual development by experts in the field. It is therefore suggested that planners intending to use these methodologies seek appropriate technical support.

J.2 HAZARD AND OPERABILITY STUDY

A HAZOP is a technique commonly used by chemical process facilities to identify hazards and difficulties that prevent efficient operation. There are two versions of the technique, one which deals with "deviations" and the other with "disturbances." "Deviations" are caused by malfunction or maloperation of a specific production system. "Disturbances" include problems caused by influences outside the specified system, including other activities and the environment.

The first version of HAZOP to be developed and the most widely known was aimed at deviations and is called a "Guide Word" HAZOP. Each element of the process is evaluated separately. The purpose of the element is specified and notational deviations are generated by associating this purpose of the element with distinctive words or phrases called "guide words." These guide words are "no" or "not," "more," "less," "as well as," "part of," "reverse," and "other than" which, broadly speaking, cover all possible types of deviation.

For each notational deviation, a determination must be made whether this is a possible situation (e.g., no flow or reverse flow in a transfer line that should have forward flow). If this is possible, the conditions in which that situation might occur and the possible hazardous consequences must be identified. The guide words are applied to all materials and all operating parameters (e.g., flow, temperature, pressure). The guide words are applied not only to the equipment, but also to the operating procedures. All phases of operation (e.g., startup, normal operation, shutdown, backwash) must also be included. As would be expected, this approach can be time-consuming and the time taken can vary from several days for a small production unit, to several months for a complex facility.

The second version of HAZOP studies is called a "creative checklist" HAZOP. This version has been developed as a complement to the guide word HAZOP to cover "disturbances." It is of particular value in two situations. These are to enable a HAZOP study to be carried out very early in the design process, even before the detailed design necessary for a "guide word" HAZOP is available; and to cover hazards which may be caused by interactions between units which could be perfectly safe if built in isolation, but may be capable of adverse interactions. This second method uses a checklist of known major hazards and nuisances. The checklist would contain words such as "fire," "explosion," "toxicity," "corrosion," "dust," and "smell." The checklist is initially applied to every material likely to be present; raw materials, intermediates, finished products, by-products and effluents. This establishes qualitatively whether hazards and nuisances exist and also provides a quantitative data base of the numerical intensities of different hazards. Thus "fire" would result in not only a note that a material is flammable but numerical measurements such as a "flash point" and "flammable limits."

Any missing data are pinpointed and timely steps taken to collect such data.

The second method continues with the association of the same checklist with each item of equipment. The materials present in such equipment, together with the inventories, are known as the "materials hazards." As the analysis proceeds, the potential for all major hazards including interactions between units or the unit and its environment are identified. The flow of hazards can be in both directions. For example, the environment may pose hazards to the unit (e.g., flooding and earthquakes), which would have to be considered in the siting, design, and layout of the unit. Although less well known than the guide word HAZOP, the creative checklist HAZOP has been found to be a quick and valuable complementary approach.

While local emergency planners will not possess the resources or need to perform a HAZOP on all facilities in the community, the concept of analyzing deviations from normal performance could be the best way to analyze the most hazardous elements found in the community. For example, if a shipping error caused a volume of a hazardous chemical to be delivered to a local facility that exceeded the capacity of the chemical material loading area, where would the excess material be placed? If part of a train stored on the local rail siding caught fire, is there sufficient space available to segregate the chlorine tank cars that are often kept there?

J.3 EVENT TREE ANALYSIS

Event tree analysis is a systematic approach that focuses primarily on a chain of events or occurrences. While the possible outcome of some events may be intuitive, complex situations must be broken down into a series of sequential events.

The steps in event tree analysis are:

1. Identify the actors in an emergency (e.g., hazardous materials, response personnel);

2. Identify the conditions present;

3. Track what the actors will do under the current conditions; and

4. Visualize the effect of the activities on the outcome of the event.

The following example analysis from Analysis of Hazardous Materials emergencies for Emergency Program Managers: Student Manual FEMA SM-110 (see Appendix L) visualizes the potential outcome of a leaking vessel (in this case a drum) of flammable liquid engulfed in a fire. In this situation, the actors and their activities include:

- Burning fuel is heating the drum;
- Drum is absorbing heat from the burning fuel and heating the contents; and
- Contents of drum are absorbing heat from the drum.

The complex activities of the emergency are divided into sequential events in which the burning fuel generates heat, causing the drum contents to change physical state (liquid to gas). This expansion of the contents will raise the pressure in the drum and stress the drum components.

The possible activities of the drum can then be evaluated. Possibilities include:

- The flat drum head will begin to round out as the internal pressure continues to rise;
- The weld between the drum head and the drum wall will begin to yield; and
- The drum head will separate from the drum wall.

When the drum head breaks away from the side wall, activities of the contents could include:

- As the pressure is relieved through the breach in the drum, the heated contents will expand and flow through the breach.
- Drum contents will escape to the atmosphere, creating a new actor -- vaporized flammable contents.
- Escaping contents will produce a propulsive effect on the drum, propelling it like a rocket.

- If the drum is still surrounded by the burning fuel, the vaporized contents will ignite, forming a fireball and escalating the problem.

When the drum is open, possible activities of the drum and contents include:

- The drum, propelled by the escaping contents, may fly along a trajectory that is dependent upon where the drum was heated. Obstructions may change the direction or distance of travel.
- The released contents may fall along the flight path of the drum, leaving a trail of burning material along the ground.

The third step in event tree analysis visualizes the sequential interrelationship of the actors. Each event is broken down and placed in logical sequence to make the possible points of intervention readily apparent. In this way, the application of event tree analysis provides a detailed understanding of the mechanical, chemical, and thermal interactions that affect the behavior of actors in an emergency.

Four general factors that affect the behavior of hazardous materials in an emergency are:

- Inherent properties and quantity of the hazardous material;
- Built-in characteristics of the container;
- Natural laws of physics and chemistry; and
- Environment, including the physical surroundings (terrain) and the conditions (weather).

These factors and their interrelationships can provide a basis for visualizing what will happen in an emergency involving hazardous materials.

For most events involving hazardous materials, the scenario begins with a container (e.g., tank, pipe, drum, cylinder, bag) that under normal conditions holds a hazardous material. The event begins when the container is disturbed or stressed in some way. When the stress exceeds the capacity of the container, a breach of the container's integrity occurs and some type of release will occur. The escaping matter and/or energy will follow the patterns governed by the natural laws of physics and chemistry to disperse into the surrounding environment. As the material comes in contact with vulnerable elements in the environment, the duration and intensity of the exposure influences the type of event that results. These basic elements of hazardous events are combined to form a model for the behavior of hazardous materials.

Stress Stage of the Behavior Model

Stress is an applied force or system of forces that tends to strain or deform a container and may trigger a change in the condition of the contents. There are three basic forms of stress: thermal, mechanical, and chemical. Thermal stress results from the effects of extreme temperature changes which may be caused by fire, sparks, friction, electricity, radiative transfer, or extremes of cold or heat.

Mechanical stress is caused by an object which physically contacts the container. The object may puncture, gouge, bend, break, tear or split the container. A chemical stress is caused by a chemical action such as acids corroding the container, pressure generated by decomposition, polymerization, or runaway reactions.

Breach Stage of the Behavior Model

If the container is stressed beyond its structural limits, it will open or breach. Different containers breach in different ways:

- Disintegration, which is the total loss of integrity (e.g., a glass jar shattering).
- Attachments open up (e.g., a pressure relief device malfunctions).
- Punctures from external sources.
- A split, tear or crack of a container (e.g., torn bags or boxes, or split or cracked drums).

Release Stage of the Behavior Model

Once the container is breached, the material can escape to the environment. There are four types of release:

- Violent rupture causes runaway cracking of closed containers and Boiling Liquid Ex-

panding Vapor Explosion (BLEVE), and occurs in less than one second.

- Rapid release through pressure relief devices, damaged valves, punctures, or broken piping will take several seconds to several minutes.
- A spill or leak, which is a non-violent flow through opening in fittings, splits or tears, and punctures may take minutes to days.
- Detonation is an explosive chemical reaction which occurs in less than 1/100th of a second. Examples are military munitions, dynamite, and organic peroxides.

Dispersal Stage of the Behavior Model

Once the hazardous material is released into the surrounding environment, the event is likely to escalate in intensity. The properties and characteristics of the material, in combination with the laws of physics and chemistry, will determine the pattern of the distribution of matter and energy The forms that the matter or energy may take include: fragments, powder, dust, schrapnel, liquid, vapor, vaporizing liquid, gases, infared rays, and shock waves Factors that will affect the movement of materials include temperature differentials, density with respect to water and air, wind speed and direction, and gravity. The dispersion path that is followed may be linear, radial, random, or could follow the contour, upward or outward. The dispersion pattern may be in the form of a cloud, cone, plume, stream, or irregular deposits.

Dispersion patterns will also depend on the physical form of the material (i.e., gas, liquid, or solid). Gases escaping under pressure (e.g., leaks from a cylinder) form a cloud or plume. If enclosed, the cloud will fill the available space; if not enclosed, it may be carried by the wind as a plume. If the vapor's density is greater than air, the material may settle into depressions or travel along the ground as a plume.

Liquids may flow along the ground as a stream while simultaneously vaporizing and acting as a gas (stream with plume) or may be absorbed into the ground or onto clothing worn at the scene (irregular deposits). Solids may scatter (irregular deposits), form dust clouds that are carried by the wind (plume), or stick to surfaces (irregular deposits).

Exposure Stage of the Behavior Model

As the hazardous material moves away from the point of release, exposure to the surrounding environment may occur through a variety of pathways including: ingestion, physical contact, and inhalation. Duration of the exposure and concentration of the material are particularly important aspects of the exposure event.

Damage Stage of the Behavior Model

Damage due to the exposure to the hazardous material includes aspects of the susceptibility of the environment or population. Such susceptibility will differ markedly depending on the time of day, season of the year, age of the population, and ability of the population to escape or otherwise mitigate the event.

The types of damage which may occur include: thermal (heat and cold), radioactive, asphyxiation, toxic or poison, corrosive or chemical, disease (viral or bacterial), and physical or mechanical.

Damage can be expressed in terms of: fatalities, injuries, property destruction, critical system disruption, and environmental disruption.

As shown in Exhibit J-1, event tree analysis traces each event, as it occurs or does not occur, and each safety or control equipment or procedure to identify the possible outcome. Note that several paths through the event tree can have similar or identical outcomes. It is important to trace all possible events through all paths that can affect the outcome. In addition to identifying the possible outcomes and their relative severity, an event tree can visually represent the potential importance of possible equipment or procedures in mitigating the severity of damage. In the example in Exhibit J-1, if both hazardous events occur and procedure A fails, the control procedure B is completely ineffective in altering the outcome or severity of damage.

J.4 FAULT TREE ANALYSIS

Fault tree analysis (FTA) is an analytical technique used to determine the means by which an

Exhibit J-1

Sample Event Tree Analysis