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Project Summary

Prevention Reference Manual: Control Technologies, Volume 2. Post-Release Mitigation Measures for Controlling Accidental Releases of Air Toxics

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Reducing the possibility of accidental toxic chemical releases reduces the possibility of harm to human health and to the environment. When such a release does occur, however, its consequences must be reduced. This can be accomplished by means of a variety of mitigation measures that can contain, capture, destroy, divert, or disperse the released chemical.

Mitigation measures begin with the initial siting and layout of a facility to decrease the area that would be affected by a release. The extent of the area potentially affected, the concentrations of toxic chemicals reaching those areas, and the duration of exposure can be estimated by vapor or gas dispersion modeling. The extent and magnitude of an actual release can be determined using meteorological instruments. These systems, along with emergency planning and training, are the first steps in the mitigation process. Other measures involve the use of mitigation techniques such as leak plugging, containment systems, and spray or foam systems. The general application costs of these methods are discussed.

This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Post-release mitigation measures are measures that can reduce the consequences of an accidental toxic chemical release after it has occurred. Mitigation measures decrease the quantity of a chemical that can reach the environment and human or other receptors. These measures also limit the area exposed to the chemical and/or the duration of exposure.

The release of a toxic chemical is the final event in a sequence of events leading to the release. If the measures that a facility uses to prevent or protect against an accidental release fail to contain the chemical, mitigation measures to reduce the adverse effects of the release must be invoked. The mitigation measures addressed in this manual, Volume 2 of the Prevention Reference Manual series, include (1) emergency planning, (2) siting and layout, (3) dispersion modeling, (4) detection and warning systems, (5) meteorological instrumentation, and 6) technical measures that can effectively control a release.

Emergency Planning and Training

Emergency planning and training ensure the rapid and appropriate response of the people charged with applying mitigation measures and define the mitigation measures to be employed.

The details of emergency planning and training vary from facility to facility. In general, however, any program should address certain basic elements: program initiation; hazard evaluation; countermeasures identification, evaluation, selection, and implementation; resource requirements and availability; organization; and mobilization and demobilization.

The Community Awareness and Emergency Response (CAER) program developed under the auspices of the Chemical Manufacturers Association discusses the implementation of community emergency response plans. The goal of this program is to improve community awareness and to integrate industrial emergency response plans with those of the community. Major steps in a CAER program are (1) community status review and program coordination, (2) facility status review, (3) implementation, (4) community involvement, (5) emergency exercises.

The community emergency response plan will determine the basic training needs. The general objectives of training are to increase the awareness, knowledge, and skills of management, and of operating, maintenance, and special emergency response personnel. Emergency exercise activities involve integrating the training of plant personnel with that of community emergency personnel.

Facility Siting and Layout

Plant siting and layout concerns the placement of hazardous facilities relative to sensitive receptors in the surrounding community and within plant boundaries. Important things to consider in this area, apart from distance, include taking advantage of terrain features such as hills that might act as natural barriers and avoiding the funneling effects of valleys.

One study of the contribution of different hazard factors to accidental releases has found that poor facility siting played a role in 5.8% of the cases and that poor layout of equipment within the facility was a factor in 3.9% of the cases.

Although siting is usually carefully examined only for new facilities, the expansion or modification of an existing facility may require a reevaluation, especially if the expansion involves chemicals or processes that pose more hazard than presented by the original facility. Poor utility service, poor emergency response and fire protection, off-site traffic congestion that hinders the response of emergency vehicles, and poor drainage are possible effects of poor siting.

Proper layout concerns the placement and spacing of the components and equipment of a process facility to minimize the consequences of an accidental release. In a well-designed facility, process operability will be made as smooth as possible and hazardous areas will be segregated.

Both the Chemical Manufacturers Association (CMA) and the National Fire Protection Association (NFPA) have issued standards and guidelines for facility layout. Some key features to be considered are facility boundaries, work boundaries, railway lines that pass through the area, ignition sources, control rooms, waste disposal areas, storage and production units, and loading and unloading areas.

Detection and Warning Systems

Detection and warning systems give advance notice that a release is incipient or has occurred; they also define the magnitude and location of the release so that other mitigation measures can be taken. Detection and warning systems built into the process control system are widely used in the chemical process industry. Such systems monitor process operating conditions such as temperature, pressure, and flow rate, and trigger audible and visual alarms when these process variables exceed design limits. Other detection systems identify hazards after a release has occurred. Post-release detection systems are important because the more quickly an airborne release of a hazardous material is detected, the greater is the opportunity to control the effect on the community.

Vapor Dispersion Modeling

Vapor dispersion modeling is used to predict the extent, duration, and concentration of the plume or cloud of released toxic vapor or gas. Numerous dispersion models of varying levels of sophistication and accuracy, and with varying ability to be verified by actual field data, are available. The results predicted by these models depend on a source term that describes the characteristics of the initial release, and a dispersion term that describes the characteristics of the cloud or plume. These models can inform decisions about plant siting and layout, the placement of detection and warning systems and meteorological instrumenta tion, and the selection of technic mitigation measures.

Models for predicting the effects accidental releases must be able handle short-term releases at high or lo concentrations and at variable releas rates. They must be capable of modelin a release/dispersion of heavier- an lighter-than-air materials and materia that have the same density as air. Suc models should simulate a variety possible release forms, such as a releas from a boiling pool of liquid, or th release from a hole in a pressurize vessel.

Vapor dispersion mathematical mode ing may be used to assess hazards ar plan the emergency response, and give emergency response personnel i formation during an actual accident release.

Meteorological Instrumentatior

Meteorological data can be used to ru vapor/gas dispersion studies to plan f an emergency response to an acciden toxic chemical release. Also, real-tin meteorological data are essential f choosing the correct mitigation an emergency response actions during actual release. Meteorological data c also be used to analyze past events, predict the consequences of vario hypothetical accidental release scenario and in facility design so that potent toxic release points can be located minimize the exposure to employees, t surrounding community, and the enviro ment in general.

Secondary Containment

If an accidental toxic chemical relea occurs, containment systems are used reduce the area exposed to the vapo and to contain the liquid until measu can be taken to recontain or destroy released material. While some conta ment measures are successful w gases, most apply to spilled volat liquids. Stopping or reducing the flow o chemical at its source, such as closin valve or plugging a leak, is also containment measure. Remotely op ated emergency isolation valves are effective way of stopping the flow material. Where a large hole in a ves is the source of escaping chemical, leak must be plugged. The three types leak plugging are chemical patches a plugs, physical patches and plugs, a methods for stopping the flow upstre of the leak.

Physical barrier containment systems usually consist of curbing, trenches, excavated and natural basins, and earth, steel, or concrete dikes. The inventory of toxic material and its proximity to other portions of the plant and the community are primary considerations in the selection of a system. The secondary containment system should be able to contain spills with minimum damage to the facility and its surroundings and with a minimum potential for escalation of the event.

Spray, Dilution, and Dispersion Systems

Spray systems, routinely used in the chemical process industries for fire protection, are also used to disperse, dilute, and absorb released airborne chemicals. Spray systems rely on fixed or mobile equipment that applies a spray of water, other materials, or a condensing cloud of steam directly to the plume or cloud of noxious chemical. Some spray systems are similar to fire fighting systems.

The primary purpose of sprays and steam curtains is to dilute the toxic gas or chemical with air or by absorption of the gas in the liquid drops. Spray- or steam-induced warming of cold vapor clouds that form from liquefied gas releases can also dilute the heavier-than-air cloud or plume. Heating the cloud will decrease its density, causing it to rise, thus decreasing ground-level concentrations of the toxic vapors downwind of the release.

The two most common spray systems are fixed and mobile water sprays. Sometimes a reactive water solution is used, such as a mild aqueous alkaline spray system. Steam curtains are fixed-pipe systems designed so that the individual jets combine to form a continuous curtain of steam that entrains sufficient air to dilute the gas or vapor concentration to below its toxic and/or flammable limit.

Foam Systems

Foams, used to control and extinguish certain types of hydrocarbon fires involving spilled liquids, are used when the fire might not be effectively controlled by water sprays. These systems are based on special chemical materials that generate foams whose characteristics are tailored to the chemical characteristics of the material to which they are applied. Foams act as a physical barrier to prevent or decrease evaporation from liquid surfaces. The application of a foam blanket to a liquid spill may prevent the release of a flammable gas or vapor from reaching an ignition source in concentrations that could result in an explosion or fire. Foams can also help prevent plant personnel or public exposure to dangerous concentrations of a hazardous gas or vapor being emitted from the surface of the liquid. The properties of foam that make it effective for fighting fires are:

- The ability to blanket the spilled liquid surface with a material of lower density than liquid, thereby cutting off the source of combustion air;
- The suppression of flammable vapors so they will not be emitted to the atmosphere to mix with air;
- The prevention of nearby flames from heating the spilled liquid covered by the foams; and
- The cooling of the spilled liquid with water draining from the foam and surrounding surfaces to help prevent reignition.

The six types of foam used to control vapors from chemical spills are (1) regular protein foams, (2) fluoroprotein foams, (3) surfactant foams, (4) aqueous film-forming foams, (5) alcohol or polar solvent foams, and (6) special foams (such as Hazmat NF® foams).

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The complete report, entitled "Prevention Reference Manual: Control Technologies, Volume 2. Post-Release Mitigation Measures for Controlling Accidental Releases of Air Toxics," (Order No. PB 89-155 063/AS; Cost: $28.95, subject to change) will be available only from:
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