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Project Summary

Prevention Reference Manual: User's Guide, Overview for Controlling Accidental Releases of Air Toxics

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Concern about the potentially disastrous consequences of accidental releases of toxic chemicals has led to increased interest in reducing the probability and effects of such releases. This *User's Guide*, the first in a series of manuals, presents an overview of available methods for identifying, evaluating, and controlling hazards in facilities that use, manufacture, or store acutely toxic chemicals that could be released into the environment. Hazardous chemicals and their key characteristics are discussed, followed by a discussion of the potential hazards in process and physical plant design and in operational procedures. Formal methods of hazard identification and evaluation are discussed and their major features compared, and an overview of control principles for prevention, protection, and mitigation is presented. Examples of control technologies are listed, and an example guide for inspecting facilities is presented. Important references on the topic of accidental toxic chemical release prevention are cited.

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

The *User's Guide* introduces government agency personnel, industry managers, technical people, and others concerned with reducing the risk of accidental toxic chemical releases to the broad area of accidental chemical release prevention, protection, and mitigation. The manual serves as a guide to the more detailed information in the companion set of manuals and to the general technical literature.

Other manuals in the series will cover chemical specific information, prevention and protection control technologies, and mitigation control technologies. These manuals compile technical information so that approaches can be developed for preventing and controlling accidental toxic chemical releases. They cover various aspects of control, including identification of causes, methods of hazard identification and evaluation, and prevention, protection, and mitigation measures.

The *User's Guide* identifies industrial chemicals of primary concern and summarizes some of the fundamental causes of releases in process operations. Methods used in hazard identification and evaluation are discussed, and an overview of the general principles of hazard control is presented. The manual also presents a guide for inspecting facilities and defines some typical costs of accidental release prevention.

Chemical and Process Operations Hazards

Chemical hazards within a process facility must first be identified, then ranked according to the danger posed. The primary basis for selecting chemicals that represent a potential release hazard

is their acute toxicity, though other properties are also important. The main methods of expressing toxicity are immediate danger to life and health (IDLH), Threshold Limit Value (TLV), low lethal concentration (LC_{LO}), and 50% lethal concentration (LC_{50}). Although the relative acute toxic hazard of chemicals may be ranked according to any of these criteria, the EPA suggests using the IDLH as the primary criterion for estimating consequences of accidental releases.

Significant physical and chemical properties include boiling point, vapor pressure, heat of vaporization, density, viscosity, reactivity, flammability, explosivity, exothermicity, and corrosiveness. Vapor pressure, vapor density, and the IDLH are the minimum data needed to determine if a specific chemical is an acute toxic air release hazard.

The basic causes of accidental releases include: process or operational hazards causing pressure or temperature to exceed process equipment limits; equipment containment failures; operational or maintenance errors; and external damaging factors such as fire, explosion, or mechanical stress.

Each of these general causes can have many contributing causes, forming a chain leading to the final event which results in the release.

Process design considerations important to preventing accidental toxic chemical releases include: process characteristics and chemistry, overall process control, flow control, pressure control, temperature control, quantity control, mixing effects, and composition control. Failures in any of the above systems could cause the system state to exceed the design limits of the equipment or the ability of an operator to respond quickly or accurately enough to maintain control of changes occurring in the process.

A release may also occur if the conditional state of the process exceeds the physical limits of the equipment or if these limits deteriorate below those required for containment. The plant design must be such that equipment and components can withstand normal operating conditions for the anticipated life of the facility and can tolerate abnormal conditions within certain bounds. The complexity and operability of the equipment may influence how well a process is controlled and how easily equipment and components are maintained. Some causes of mechanical failure are: excessive stress, external loading, overpressure, overheating, mechanical fatigue and shock, thermal fatigue and shock, brittle fracture, creep, and chemical attack. Prevention of these failure modes can be incorporated into initial facility design and construction. Though some of these conditions relate to operating conditions that can change over time, many failures can be prevented by the proper selection and use of construction materials.

Another hazard area in process operations involves human error in: decision making; physical actions controlling a process; and the planning and supervision of the design, construction, and operation of facilities at all stages of a plant's life cycle. Examples of this kind of hazard are a lax management policy that does not enforce its own safety standard or an operator who takes a wrong action at a control panel. Management policy must address special safety procedures for toxic chemicals through all parts of the chemical process life cycle, and the skill and knowledge of the operators must match the needs of the process. Communications procedures in high-hazard facilities should receive high priority, and maintenance practices must ensure that the original specifications are adhered to and that all special preventive and protective systems are functional.

Methods for Hazard Identification and Evaluation

Various formal and systematic methods for hazard identification and evaluation are used for facilities that manufacture, use, or store toxic chemicals. Hazard identification procedures can be divided into four main classes: experience, augmented experience, analytical methods, and creative methods.

The experience method relies on comparing a new situation to a known past situation. In the augmented experience method, each step of a process is reviewed to determine what would happen following equipment failures, process upsets, or operating errors. The analytical approach uses logic diagrams (such as fault trees, event trees, and cause-consequence charts) or checklists. These methods can be combined with quantitative data on probabilities to identify and evaluate the hazard potential of a facility.

Other hazard identification procedures include safety reviews: Dow and Mond Hazard Indices; Hazard and Operability (HAZOP) Studies; Fault Tree and Event Tree Analyses; and Failure Modes, Effects, and Criticality Analyses (FMECAs).

The evaluation step attempts to rank hazards qualitatively or quantitatively or both, seeks to identify measures that reduce the probability that the hazard will be realized, and examines the potential consequences of the hazard if it is realized.

Overview of Principles of Control

The control of accidental chemical releases consists of three basic levels of control: prevention, protection, and mitigation. Prevention measures consider operational and hardware aspects of a chemical process system. When preventive measures fail, a second level of control deals with protection from releases, or the containment, capture, neutralization, or destruction of a toxic chemical after its release from primary containment but before its release into the environment.

If a protection system is deficient and allows a toxic vapor or gas to escape to the environment, the consequences may be reduced by effective mitigation measures. Mitigation refers to equipment and procedures that can be used to reduce the concentration of a chemical below levels that would otherwise occur. Technical measures include the use of water sprays or steam curtains, barriers for dispersion and diversion, and procedures such as closing doors and windows and evacuation.

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The complete report, entitled "Prevention Reference Manual: User's Guide Overview for Controlling Accidental Releases of Air Toxics," (Order No. PB 87-232112/AS; Cost: $18.95, subject to change) will be available only from:
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