United States Environmental Protection Agency
Research and Development
Air and Energy Engineering Research Laboratory
Research Triangle Park NC 27711
EPA/600/S8-87/034l Feb. 1988

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Project Summary

Prevention Reference Manual: Chemical Specific, Volume 12: Control of Accidental Releases of Sulfur Dioxide

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Interest in reducing the probability and consequences of accidental toxic chemical releases that might harm workers within a process facility and people in the surrounding community has prompted preparation of this manual and a series of companion manuals on the control of accidental releases of toxic chemicals. This manual on sulfur dioxide (SO_2) summarizes information to help regulators and industry personnel identify and control release hazards associated with SO_2.

To reduce the risk associated with an accidental release of SO_2, the potential causes of accidental releases in process facilities that handle and store SO_2 must be identified. The SO_2 manual provides examples of such causes, as well as measures that may be taken to reduce the accidental release risk. Such measures include recommendations on: plant design practices; prevention, protection, and mitigation technologies; and operation and maintenance practices. Conceptual cost estimates of example prevention, protection, and mitigation measures are provided.

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

Increasing concern about the potentially disastrous consequences of accidental releases of toxic chemicals has prompted preparation of a series of manuals for regulators and industry personnel on the prevention of accidental releases of toxic chemicals. The manual on SO_2 is one of several chemical-specific manuals that address issues associated with the storage, handling, and process operations involving toxic chemicals as they are used in the U.S.

Historically, there appear to have been no major releases of SO_2 in the U.S. Major incidents elsewhere have not been common.

The major industrial uses of SO_2, which is a major commodity chemical in industry, are in: sulfuric acid production, food processing, water and waste water treatment, the sulfate pulping process for the manufacture of paper, metallurgical applications, sulfation and sulfonation of specialty chemicals, and repackaging.

Potential Causes of Releases

SO_2, a toxic, highly irritating gas that can have immediate effects on the eyes, throat, lungs, and skin, is extremely stable to heat, even up to 2000°C. It does not form flammable or explosive mixtures with air; it will, however, react with water or steam to produce toxic and corrosive fumes.

Large-scale accidental releases of SO_2 can result from leaks or ruptures of large storage vessels (including tank cars on site) or failure of process machinery (e.g., pumps and compressors) that maintains a large throughput of SO_2 gas or liquid. Smaller releases may come from ruptured lines, broken gage glasses, or leaking valves, fittings, flanges, valve packing, or gaskets.

SO_2 can promote equipment failure because of its high coefficient of thermal expansion and the corrosiveness of sulfurous acid, which is formed when dry SO_2 contacts moisture. Accidental releases may be caused by problems in the process, with equipment, or in plant operations.

Examples of process causes of a SO_2 release include:

- Excess SO_2 feed to a chlorine dioxide reactor, leading to an excessive exothermic reaction, combined with failure of the cooling system;
- Backflow of process reactants to a SO_2 feed tank;
- Loss of condenser cooling to distillation units;
- Inadequate water removal from hydrocarbon feeds in the extraction process, leading to progressive corrosion;
- Excess feeds, leading to overfilling or overpressuring equipment; and
- Overpressure in SO_2 storage vessels resulting from overheating because of fire, or from overfilling.

Equipment causes of accidental releases resulting from hardware failure include excessive stress because of improper fabrication, construction or installation; mechanical fatigue and shock resulting from age, vibration, or stress cycling; thermal fatigue and shock in reaction vessels, heat exchangers, and distillation columns; brittle fracture, especially in carbon steel equipment subjected to extensive corrosion; creep failure in high temperature equipment subjected to extreme operational upsets; and all forms of corrosion.

Incorrect procedures and human error can result in an operation-caused accidental release. Examples are overfilled storage vessels; improper process control system operation; error in loading and unloading operations; poor quality control; inadequate maintenance, especially of preventive and protective systems such as pressure relief systems; and lack of inspection and nondestructive testing of vessels and piping to detect weakening from corrosion.

Hazard Prevention and Control

To develop a thorough release prevention plan, control must be maintained over: process design, physical plant design, protective systems, and operating and maintenance practices.

Process design involves the basic chemistry of a process and how this chemistry is affected by the variables of flow, pressure, temperature, and composition. The first concern in process design is understanding how deviations from expected conditions could result in an accidental release. Any aspect of a process may be modified to enhance the integrity of the system. For example, the quantities of materials used, the pressure and temperature conditions, the type and sequence of unit operations, control strategies, and instrumentation may be changed to increase safety and process control.

Physical plant design concerns equipment, siting and layout, and transfer/transport facilities. Most common materials of construction are resistant to commercial dry liquid SO_2, dry SO_2 gas, and hot SO_2 gas containing water above its dew point. These include cast iron, carbon steel, copper, brass, and aluminum. Wet SO_2 gas, sulfurous acid, and sulfite solutions, however, are all corrosive to many metals, including iron, steel, nickel, copper-nickel alloys, and nickel-chromium-iron alloys. Corrosion is a serious hazard, so it is important to use appropriate materials for applications that may involve some exposure of the SO_2 to small amounts of moisture. Special care should be taken to ensure that all replacement parts or new equipment are made of materials that are compatible with the chemicals involved in the process.

The siting and layout of a SO_2 facility must take into account other processes in the area, the proximity of population centers, prevailing winds, local terrain, and potential natural external effects such as flooding. Facilities and individual equipment items should be situated so as to reduce personnel and community exposure in the event of release. Specially designed buildings, barriers, and routes for evacuation and access to emergency equipment are important siting and layout considerations. Storage rooms and other large inventories of SO_2 should be kept away from possible sources of fire or explosion and should be located in cool, dry, well-ventilated areas.

Transfer and transport facilities should also be located away from sources of heat, fire, and explosion. Congestion of personnel and vehicles should be avoided, and correct procedures should be followed when unloading and handling even small SO_2 storage vessels such as cylinders and drums.

Protection technologies for the containment and neutralization of any SO_2 release include enclosures and scrubbers. Enclosures contain the spilled liquid or gas until it can be transferred to scrubbers for neutralization or to other containment and discharged at a controlled rate. Concrete block or concrete sheet buildings and bunkers are suitable for SO_2.

Scrubbers such as spray towers, packed bed scrubbers, and venturis can be used to control SO_2 releases from vents and pressure relief discharges, from process equipment, or from secondary containment enclosures. Alkaline solutions such as calcium hydroxide, sodium hydroxide, or sodium carbonate are used to achieve effective absorption.

If an accidental release occurs, mitigation technologies can reduce the consequences. Such measures include physical barriers such as dikes, impounding walls, and basins, as well as water spray and fogs and foams where applicable. The purpose of mitigation technique is to divert, limit, or disperse the spilled or released chemical to reduce the atmospheric concentration and the area affected.

Since accidental releases of toxic materials may result from deficiencies in operation and maintenance as well as from deficiencies of design, the safe operation of plants using SO_2 is important. Employees should be trained in the proper procedures for handling SO_2, in potential hazards, cleanup, and emergency procedures. Well-defined procedures and practices can decrease the possibility of a hazardous release and can reduce the magnitude of any release that occurs.

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The complete report, entitled "Prevention Reference Manual: Chemical Specific, Volume 12. Control of Accidental Releases of Sulfur Dioxide," (Order No. PB 88-103 734/AS; Cost: $18.95, subject to change) will be available only from:

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