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Project Summary

Prevention Reference Manual: Chemical Specific, Volume 4: Control of Accidental Releases of Ammonia (SCAQMD)

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The South Coast Air Quality Management District (SCAQMD) of southern California has considered strategies for reducing the risk of a major accidental air release of toxic chemicals. One strategy, which would serve as a guide to industry and communities, includes monitoring activities associated with the storage, handling, and use of certain chemicals. This manual summarizes information that can aid in identifying and controlling release hazards associated with ammonia specific to the SCAQMD.

Ammonia has an IDLH (Immediately Dangerous to Life and Health) concentration of 500 ppm indicating a substantial acute toxic hazard.

To reduce the risk associated with an accidental release of ammonia, the potential causes of releases from processes using ammonia in the SCAQMD must be identified. Some of these potential causes and specific measures for reducing the risk of an accidental release are identified. Such measures include recommendations on: plant design practices; prevention, protection, and mitigation technologies; and operation and maintenance practices. Conceptual costs for some of these measures are estimated.

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 South Coast Air Quality Management District (SCAQMD) conducted a study in 1985 to determine the presence, quantities, and uses of hazardous chemicals in the SCAQMD, which comprises Los Angeles, Orange, San Bernadino, and Riverside Counties. This study culminated in a 1985 report, "South Coast Air Basin Accidental Toxic Air Emissions Study," which outlined an overall strategy for reducing the potential for a major toxic chemical release. The strategy involves monitoring industry activities associated with the storage, handling, and use of certain chemicals to minimize the potential for accidental releases as well as the consequences of any releases that might occur. This volume of the manual discusses process operations and practices relating to the prevention of accidental releases of anhydrous ammonia as it is used in the SCAQMD.

Anhydrous ammonia (NH_3) is a significant commodity chemical, produced by the reaction of hydrogen and nitrogen over a catalyst. The primary use of anhydrous ammonia is in the fertilizer industry, which accounts for nearly 80% of all ammonia produced. It is also used as a raw material in the manufacture of nitric acid, as a reactant with nitric acid in the production of explosives, and in the fibers and plastics industry in the production of synthetic materials. In the SCAQMD, anhydrous ammonia is used or produced in seven processes: (1) a patented waste water treatment process, (2) the manufacture of resins, (3) refrigeration, (4) neutralization of acidic waste streams, (5) preparation of ammonia thiosulfate, (6) reduction of nitrogenoxide (NO_x) emissions, and (7) repackaging.

Potential Causes of Releases

At atmospheric temperatures and pressures, anhydrous ammonia is a pungent, colorless gas that may easily be cooled to a colorless liquid. Because liquid anhydrous ammonia has a large coefficient of expansion, an overpressurization hazard exists if storage vessels have insufficient expansion space or if pipelines full of liquid ammonia are sealed at both ends. In these situations, thermal expansion of the liquid and an increase in temperature can result in containment failure from the hydrostatic pressure exerted by the liquid.

Failure leading to accidental releases may be caused by process, equipment, or operational problems. Most of the accidental releases of ammonia that have occurred in the past 15 years have resulted from pressurized pipeline ruptures, failed storage tanks, and road tanker accidents.

Possible process causes of an ammonia release include: (1) backflow of process reactants to an ammonia feed tank; (2) excess feeds in any part of a process, leading to overfilling or overpressurizing of equipment; (3) loss of condenser cooling in distillation columns; (4) overheating of reaction vessels and distillation columns; and (5) overpressure in ammonia storage vessels from overheating caused by exposure to fire, or from unrelieved overfilling.

Equipment causes of accidental releases result from: hardware failures such as failure of feed control systems from a loss of power, clogged lines, jammed valves, or instrument failure; excessive stress caused by improper fabrication, construction, or installation; failure of pressure relief systems; mechanical and thermal fatigue and shock; corrosion of equipment constructed of high alloys; and brittle fracture or creep failure. A significant concern for anhydrous ammonia is use of the proper alloy grade of steel. Certain grades of steel are prone to catastrophic failure due to cracking or embrittlement from anhydrous ammonia.

Operational causes of accidental releases result from incorrect procedures and human error, including: (1) overfilled storage vessels; (2) improper process control system operation; (3) errors in loading and unloading; (4) poor quality control of replacement parts; (5) inadequate maintenance, especially of pressure relief systems and other preventive and protection devices; and (6) lack of inspection and nondestructive testing of vessels and piping to detect corrosion weakening.

Hazard Prevention and Control

Prevention of accidental releases relies on the proper design, construction, and operation of facilities where ammonia is stored and used and on the protective systems that guard against accidental release.

Process design involves the basic chemistry of a process and how this chemistry is affected by the variables of flow, pressure, temperature, composition, and quantity. Any aspect of a process may be modified to enhance the integrity of the system. Such changes could involve the quantities of materials, process pressure and temperature conditions, the sequence of operations, process control strategies, and the instrumentation used.

The most important consideration for systems containing ammonia is the prevention of overheating and/or overpressuring. In addition to overpressure, overheating can also weaken process equipment and increase the probability of leaks developing at joints and valves.

Physical plant design covers equipment, siting and layout, and transfer/transport facilities. Dry ammonia is noncorrosive to most common metals; however, moist ammonia corrodes copper, tin, zinc, and many alloys, especially copper alloys. Only specific grades of steel, recommended for ammonia service, should be used due to the possibility of cracking or embrittlement. Certain aluminum alloys can be used in parts of ammonia systems. Metallic and nonmetallic gasket materials (e.g., compressed asbestos, graphited asbestos, carbon steel or stainless steel spiral-wound asbestos, and aluminum) are considered suitable for ammonia service based on current industrial practice.

The siting and layout of any facility handling ammonia and of individual equipment should be designed to reduce personnel exposure in the event of a release. Siting should allow ready ingress and egress and take advantage of barriers that reduce release exposures. Considerable distance between large inventories and sensitive receptors is desirable. The ground under process equipment and storage vessels should be sloped so that fire water and liquid spills flow away from equipment into drains. Storage facilities should be located in cool, dry, well-ventilated areas.

Because heat causes significant thermal expansion of ammonia, piping, storage vessels, and other equipment should not be located adjacent to piping containing flammable materials, hot process piping, equipment, or other sources of direct or radiant heat. Special consideration should be given to the locations of furnaces and other permanent sources of ignition in the plant.

Enclosures and scrubbers are protection technologies for containment and neutralization. Enclosures would capture any ammonia spilled or vented from storage or process equipment, containing the spilled liquid or gas until it could be transferred to other containment and discharged at a controlled rate or to water scrubbers for absorption.

Scrubbers can also be used for controlling ammonia releases. Because of its high solubility, ammonia discharges can be absorbed in water in scrubbing devices such as spray towers, packed bed scrubbers, and venturis.

If an accidental release occurs, mitigation technologies can reduce the consequences. Such measures include physical barriers, water sprays and fogs, and foams that will divert, limit, or disperse the released chemical to the atmosphere. In spite of the lower specific gravity of pure ammonia vapor relative to air, large accidental releases of ammonia have often formed ammonia/air mixtures that are denser than the surrounding atmosphere. The primary means of dispersing and removing ammonia vapor from the air is with water sprays or fogs. A capture zone can be created downwind of the release into which the ammonia vapor will drift and be absorbed.

Since accidental releases of toxic materials result not only from deficiencies of design but also from deficiencies of operation, safe operation of plants using ammonia requires competent, experienced managers and staff trained in handling and storing ammonia.

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The complete report, entitled "Prevention Reference Manual: Chemical Specific, Volume 4. Control of Accidental Releases of Ammonia (SCAQMD)," (Order No. PB 87-231 254/AS; Cost: $18.95, subject to change) will be available only from:

National Technical Information Service
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