To The Point
Ammonia Refrigeration

CHUBB®

Developing an Effective Risk Management Program

Anhydrous ammonia is a widely used refrigerant for commercial refrigeration applications. It can be found in meat and poultry processing facilities, dairies, wineries and breweries, cold storage warehouses, petrochemical plants, and ice skating rinks.

Ammonia is a refrigerant of choice for many commercial applications because of its excellent heat transfer properties, relative low cost in comparison to fluorocarbon refrigerants, tolerance to water contamination, and availability. However, there are significant risk factors to property and personnel that must be carefully weighed when ammonia is to be used as a refrigerant. Ammonia releases have resulted in hundreds of injuries and more than 50 fatalities, plus millions of dollars in property damage and lost business revenues in the past 25 years.

A strong ammonia risk management program includes detailed hazard identification evaluations, management programs to minimize the potential hazards, a comprehensive emergency response plan, and business recovery plan.

Ammonia Refrigeration Hazards

There are many hazards associated with the accidental release of ammonia.

- Ammonia is a toxic and corrosive substance that can be both flammable and explosive when mixed with air between 16% and 25% at atmospheric pressure.
- The effects of ammonia inhalation by personnel can range from minor irritation to severe respiratory damage, with the possibility of fatality at higher concentrations. It readily migrates to moist areas of the body such as eyes, nose, and throat, as well as moist skin areas. The National Institute of Occupational Health and Safety (NIOSH) established an Immediately Dangerous to Life and Health (IDLH) level of 300 ppm for ammonia.

Risk Engineering Services

- A large ammonia release not only affects the location at which the leak occurred, but an ammonia cloud can migrate with wind conditions to adjacent businesses and neighborhoods, resulting in large scale evacuations.
- Food items including meats, vegetables, fruits, milk, dairy products, and juices in process or storage are all highly susceptible to ammonia contamination and spoilage.
- Dry storage inventories are also at risk from contamination. Powdered milk, sugar, grains, and other consumables are also highly susceptible to contamination.
- The strong odor of ammonia can be absorbed into paper and cardboard packaging materials, interior walls, ceiling panels, carpet, and other building materials.

Causes of Ammonia Leaks

The leading causes of accidental ammonia releases stem from inadequate building and refrigeration system design or installation, inadequate operating procedures and personnel training, and poorly maintained equipment including a lack of critical controls and safety device testing.

Ammonia releases are commonly caused by:

- Piping failures due to excessive vibration or liquid slugging and/or poor weld quality.
- Piping or pressure vessel failures caused by electrolytic corrosion between dissimilar metals.
- External impact of unprotected ammonia piping and evaporator coils by forklift truck operators.
- Faulty, inoperative, or improperly set controls and pressure relief devices.
- Improper response by operating personnel to a refrigeration system upset.
- Failure to use human element programs such as lockout/tagout and hot work permits when performing routine maintenance, repairs, or alterations to refrigeration systems.

Safeguards that prevent or reduce the severity of a release include early warning ammonia detection, emergency ventilation systems, portable ventilation equipment, over pressure relief valves on ammonia vessels, and emergency equipment shutoff switches located outside the machine room.

Also update security protocols to help protect the ammonia tanks from potential theft or vandalism. Vandalism acts (or theft of ammonia for illicit drug manufacturing) pose a risk for serious injuries to individuals, emergency response personnel, and to some degree, shelter-in-place conditions for local residents or workers.

Leak Prevention

Ammonia can be safely used as a refrigerant when the building and systems are properly designed, constructed, operated, and maintained. There are federal requirements and recognized industry standards that define a comprehensive management program approach to ammonia leak prevention. Fundamental considerations include but are not limited to the following:

- Locate ammonia refrigeration system machinery in a detached building or in a room properly cut off from the rest of the facility with one or more exterior walls equipped with doors leading to the outside.
- Use noncombustible construction for machinery rooms when possible. Machinery spaces of combustible construction should have sprinkler protection in accordance with NFPA 13 Standard for the Installation of Sprinkler Protection.
- Do not store combustible or flammable materials in ammonia refrigeration machinery rooms. Combustion equipment should not be located in an ammonia machinery room unless specific design considerations are met for combustion air supply and ammonia vapor detection.
- Install properly rated electrical distribution equipment in the machinery room. Depending on the extent of the room's design and ventilation, the use of Class 1, Division 2 Group D electrical components may be required in accordance with the NFPA 70 National Electric Code. Limit electrical equipment in the machinery room to only that which is required for the operation of the system in order to limit potential ignition sources.
- Segregate as many areas of your facility as possible using vapor tight separation in order to minimize the spread of an ammonia leak in the facility. Mechanically operated gasket-sealed doors should be installed in large entry ways. Install tight fitting doors for walk-though entries and exits.
- Install barriers to protect exposed ammonia piping, valves, and coils from forklift truck impact. Include ammonia system awareness in your forklift operator training program.
- Develop a comprehensive operator training program that includes periodic continuing education. Include the use of written standard operating procedures and operating logs by all qualified operators. Limit access of machinery and control rooms to only properly trained personnel.
- Develop and maintain a refrigeration system written preventative maintenance program in accordance with manufacturer's recommendations. Maintenance programs must include the inspection, calibration, and testing of critical control systems and safety devices.

- Install ammonia detection sensors in all areas where substantial leaks could occur, and connect into a local alarm system with monitoring by a central station alarm service. Calibrate and test ammonia sensors in accordance with manufacturer's recommendations. Ammonia ventilation systems should be controlled by the activation of ammonia detection sensors.
- Conduct periodic visual inspections of all accessible ammonia system piping and vessels for signs of corrosion, leakage, or excessive ice accumulations. Consider the use of nondestructive examination methods where appropriate. Repair or replace all deteriorated piping and valves. Remove excessive ice accumulations and investigate and make corrections in the operation of the hot gas defrost cycle.
- Institute human element programs including lockout/tagout and hot work permits to ensure that ammonia releases and potential fires/explosions do not occur during maintenance and repair activities.
- Investigate all reported ammonia leaks and near misses. The incident investigation team findings should be reported back in a timely manner. Implement recommendations to eliminate or minimize the potential for an ammonia release.

Emergency Response

Minimizing the impact of an ammonia leak on a facility and personnel is dependent on prompt and effective preplanned action. For a formal emergency response plan to remain viable, every aspect of the plan should be tested and practiced, including realistic ammonia release drills. Ensure that the plan is periodically reviewed by management and key facility personnel.

Large ammonia systems exceeding 10,000 pounds of ammonia are subject to federal regulation under both the OSHA process safety management of highly hazardous chemicals (29 CFR Part 1910.119) and the Environmental Protection Agency (EPA) Chemical Accident Prevention Provisions (40 CFR Part 68). It is recommended that facilities with systems below 10,000 pounds of ammonia still review these guidelines and employ many of the requirements into a comprehensive ammonia refrigeration risk management program and emergency response plan.

The first and most important requirement of any response plan is to stop the supply of ammonia as soon as possible. This dictates that a manually operated main isolation valves be properly identified, maintained in good working condition, and accessible from the floor level. A master solenoid valve controlled remotely from the floor outside the containment area may also be used and is highly recommended. If hand valves are located more than seven feet above floor level, provide OSHA-approved access platforms and/or ladders, and chain-operated hand wheels accessible from the floor.

Important components of any emergency response plan include:

- Rapid identification and isolation of the leak source.
- Proper ventilation to control the spread of ammonia.
- Identification of the direction of ammonia release from facility (wind socks).
- Sealing off unaffected areas to prevent further contamination.
- Decontamination procedures for personnel and property.
- Relocation of refrigerated goods to off-site storage to minimize spoilage.
- Use of personal protection equipment.
- Evacuation of nonessential personnel.
- Coordination with emergency response providers and governmental agencies as necessary.

Change management is a vital component of the emergency response plan. Emergency response plans must be reviewed and revised as necessary whenever any key changes to the facility or personnel are made. Ensure all internal and external emergency response team members are aware of any significant changes in personnel responsibilities in addition to changes to the facility and equipment.

Keep all piping and instrumentation diagrams (P&IDs), process flow diagrams, ladder diagrams, and single line diagrams current. A best practice is to post these diagrams in key areas of the facility along with signs and placards that provide multilingual instruction.

Business Recovery

The business recovery plan provides procedures to mitigate the loss and restore operations back to normal. The plan needs to address cleanup and deodorization of contaminated spaces, contaminated waste removal, salvage of product and materials in storage or process, alternate site agreements for cold storage and production, suppliers of rental equipment, repairs, critical spare parts inventory, logistics of goods in transit, restocking, quality control inspection practices for product exposure to ammonia, and customer communications. Once developed, the plan must be reviewed and updated periodically.

Resources

American Society of Heating, Refrigerating and Air Conditioning Engineers
www.ashrae.org/

ANSI/ASHRAE 15 - 2007 Safety Standard for Refrigeration Systems

ASME B31.5 - 2006 Refrigeration Piping and Heat Transfer Components
www.asme.org/

Environmental Protection Agency
www.epa.gov/

- EPA Chemical Accident Prevention Provisions (40 CFR Part 68)
- EPA Accident Prevention and Response Manual for Anhydrous Ammonia Refrigeration Operators
- EPA Hazards of Ammonia Releases at Ammonia Refrigeration Facilities

International Institute of Ammonia Refrigeration
www.iiar.org/index.cfm

National Fire Protection Association
www.nfpa.org/codes-and-standards

- NFPA 13 Standard for the Installation of Sprinkler Systems
- NFPA 70 National Electrical Code

Occupational Safety & Health Management
www.osha.gov/

- OSHA Process Safety Management of Highly Hazardous Chemicals (29 CFR Part 1910.119)
- OSHA Hazard Waste Operations and Emergency Response (29 CFR 1910.120)

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