Ammonia Refrigeration

from Liberty Mutual **Property**

Ammonia is commonly used as a refrigerant, due to its excellent heat transferring properties, availability and low cost for large commercial operations. However, ammonia (NH_3) is classified as a toxic gas, is a moderate fire risk and may cause an explosion when mixed with air in the 16% – 25% range. Many underestimate the danger presented by ammonia refrigeration systems and the potential for serious property damage when these systems do not have adequate safeguards against leaks and fire or if contingency planning is lacking.

Food stocks are highly susceptible to contamination from ammonia leaks. Packaging such as corrugated cardboard can trap ammonia and lead to contaminated food products. In addition, if the refrigeration system is shut down because of an ammonia leak, food stocks can spoil. Therefore, contingency plans should be in place to limit losses in the event of a leak.

This Risk Management Guide will explain components of ammonia refrigeration that can help prevent and mitigate losses.

REFRIGERATION SYSTEMS

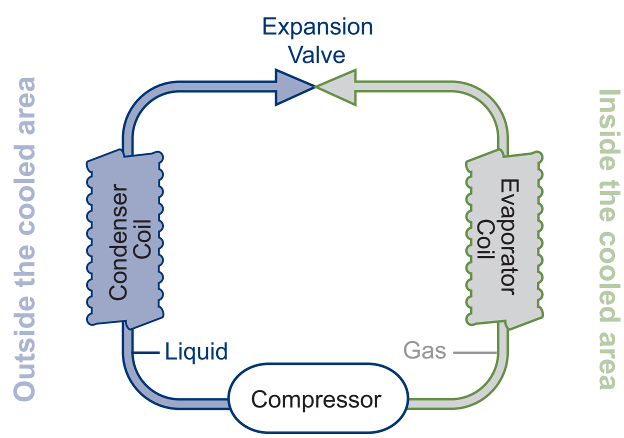
Ammonia refrigeration systems use a vapor compression cycle and three main pieces of equipment: a compressor, a condenser and an evaporator. Mechanical compressors may be reciprocating, centrifugal or rotary-screw types. When compressed, the ammonia gas liquifies. It passes through condenser coils that dissipate the heat from the liquid. It then passes through evaporator coils and returns to a gaseous state as it absorbs heat from the space being cooled.

Direct-piped ammonia refrigeration systems have evaporators in direct contact with the area to be cooled. Indirect-piped ammonia refrigeration systems have secondary coolants, such as glycol/water mixtures or brines, in contact with the evaporator coils for heat transfer. This means that the secondary coolant, rather than the ammonia, is transported through the facility. This system is safer because it requires less refrigerant and has a reduced risk of leaks and contamination, since the refrigerant is separate from the product.

AMMONIA HAZARDS

Because ammonia may cause an explosion when mixed with air, proper safeguards should be taken to minimize accidental release of the gas. Leaks create a serious fire and life safety hazard. Leaks can be caused by:

- Pipe failure due to vibration or mechanical damage
- Pipe failure due to electrolytic corrosion between dissimilar metals
- Valve failure due to impurities lodging in valves
- Compressor failure due to non-compressible liquids in the compressor suction
- Faulty valves allowing higher than normal operating pressure



CONSTRUCTION AND DESIGN SAFEGUARDS

Ammonia refrigeration machinery should be located in a detached building (preferred) or a cutoff room having one or more exterior walls with doors leading directly outside. Non-combustible construction is preferred, and combustible materials should not be stored in the machine room.

Detached building with condenser

The exterior walls of the machine room should contain vent relief panels using fasteners designed for explosion-venting wall systems according to NFPA 68, *Guide for Venting of Deflagrations*. Any interior walls that adjoin other occupancies should be vapor tight with a one-hour fire resistance rating and designed to be pressure resistive so the walls do not explosively vent.

To maintain the integrity of the rated walls, the door and frame assemblies should have the same fire and pressure rating as the walls. Rated doors should be self-closing, tight fitting and open into the machine room. To prevent leaks, the doorjamb should have a minimum 5/8 inch overlap and all penetrations through interior walls, floors and ceilings should be sealed with a listed fire resistant vapor-tight sealant.

Separate ventilation intake louvers and exhaust devices (fan or roof openings) should be located to promote mixing and airflow. All exhausts should vent directly to the outdoors. As ammonia is lighter than air, the exhaust should be close to the ceiling level and the fresh air intakes should be at floor level.

ELECTRICAL SAFEGUARDS

Ammonia machine rooms are classified as hazardous locations per NFPA 70, *National Electric Code (NEC),* requiring that all electrical equipment in machine rooms be listed for installation in Class I, Division 2 Group D atmospheres per NEC, Article 500. Natural ventilation at the ceiling is acceptable if Class 1, Division 2-rated electrical equipment is provided.

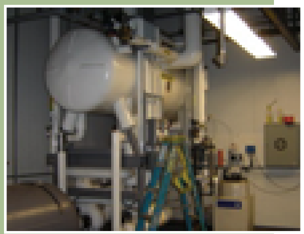
To consider the machine rooms "non-hazardous" requires compliance with all the following:

- A two-stage ammonia detection system with detectors installed according to the manufacturer's listing and arranged to sound the alarm in a constantly attended location
  - The detection system must sound continuously and automatically activate the emergency ventilation at 25% lower explosive limit (LEL)
  - The detection system must shut down all equipment and close valves at 50% LEL
- Continuous ceiling-level exhaust ventilation for the machine room, sized at a minimum of 1.0 cfm/ft^2
- Emergency ventilation providing 10 cfm/ft^2, with a minimum rate of 20,000 cfm regardless of room size
- A power source for ventilation systems (continuous or emergency) that is separate from the machine room power, so that shutting down power to the machine room does not affect the ventilation systems
- A means to activate emergency ventilation fans that is remote from the machine room

Refrigerated areas with direct-piped ammonia systems are acceptable without ventilation and explosion venting in two situations:

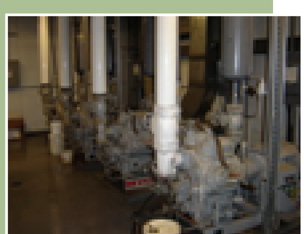
- The equipment in the refrigerated area is limited to piping
- All valves are located outside the refrigerated area

To limit sources of ignition, electrical equipment in the machine room should be limited to only that required for refrigeration operation.



Ammonia expansion tank in machine room with ammonia detection and alarms

Compressors for refrigeration system in machine room with ammonia detection and alarms



Room requiring ammonia detection

PROTECTION

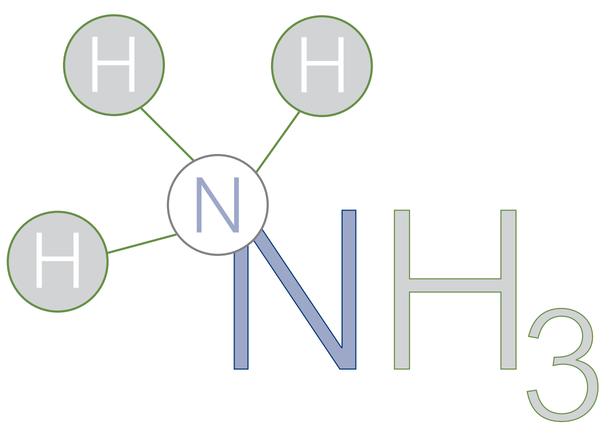
To protect against damage from ammonia leaks, an ammonia detection system should be installed in refrigerated areas containing materials and products subject to ammonia contamination. Ammonia detection and alarm systems should be tested according to the manufacturer's recommended testing frequency. If no frequency is recommended, the devices should be tested annually.

Early detection is essential for leak control. Leaks can be controlled by stopping the flow of ammonia and diluting or dispersing the ammonia gas. Shutting a valve is the fastest method of controlling a leak. Water, steam and air are also proven means of diluting and dispersing ammonia leaks.

It is important that accessible sectional valves are provided outside the cooled areas for emergency shutdown. Access to these sectional valves may be by a fixed ladder, a chain operation or a remote control. All piping should be protected against mechanical damage. Pressure-relief devices should be arranged to discharge to a safe outdoor location. Automatic shutoff valves should also be provided for liquid-level gauges.

Machine rooms of combustible construction should be equipped with automatic sprinklers designed for Ordinary Hazard Group 1 occupancy per NFPA 13, *Standard for the Installation of Sprinkler Systems*. Automatic sprinklers are not needed for the machine room if it is of non-combustible construction and no other combustible materials are present.

Refrigerated areas of combustible construction or areas containing combustible materials and products should be provided with properly designed automatic sprinkler systems.



EMERGENCY-RESPONSE PLANNING

Steps to address any ammonia leak should be included in an emergency-response plan. The emergency-response team should:

- Identify critical valves that control ammonia flow
- Understand ventilation systems and dispersion and diluting procedures
- Initiate product-recovery or damage-control plans
- Have easy access to a diagram with locations of all valves and components
- Have training in the use of all ammonia related equipment
- Have a supply of breathing apparatus and protective clothing for each team member
- Involve the fire department in prefire planning
- Arrange inspection and maintenance according to the manufacturer's recommendations for ammonia-related equipment

REFERENCES

NFPA 68. *Standard on Explosion Protection by Deflagration Venting.*

NFPA 70. *National Electrical Code.*

NFPA 13. *Standard for the Installation of Sprinkler Systems.*

IAAR Green Paper. *Ammonia: The Natural Refrigerant of Choice.*

ANSI/IIAR 2-199. *American National Standard for Equipment, Design, and Installation of Ammonia Mechanical Refrigerating Systems.*

IIAR Bulletin No 112. *Guidelines for Ammonia Machinery Room Design.*

Lewis, Richard Sr. *Hawley's Condensed Chemical Dictionary. (12th ed).* New York: John Wiley & Sons, INC, 1997.

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For more information on our
Risk Management Guides, contact us at:

Liberty Mutual

Liberty Mutual **Property**

20 Riverside Road
Weston, MA 02493

TEL: 781-891-0230
EMAIL: propertyengineering@libertymutual.com

www.libertymutualproperty.com