ANHYDROUS AMMONIA SAFETY

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Images on the cover reflect ongoing training using simulated ammonia release events.
These mock-release events assist in emergency response training should an accident occur.

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A Basic Understanding of Anhydrous Ammonia

Ammonia (frequently called anhydrous ammonia) is one of the most valuable and versatile chemical compounds in today's modern world. For example, it finds wide application in food production and processing, textile and chemical manufacturing, refrigeration, metal treating and pollution abatement.

The ever-increasing use of ammonia has been accompanied by the need for the dissemination of knowledge regarding ammonia safety. Individuals that work with ammonia under normal conditions or those who may be exposed to ammonia in emergency conditions should have basic safety awareness training. Recognizing this need, Airgas Specialty Products prepared this booklet with a selected collection of helpful information and suggestions for the ammonia user and for the safety personnel. These suggestions are offered as an aid in the preparation of a comprehensive safety program and should be altered or augmented in accordance with individual requirements. Anyone using this publication should research original and current sources of authority.

Anyone working with ammonia has a responsibility not only to be thoroughly familiar with basic ammonia safety principles, to observe all necessary precautions, and react promptly and appropriately in the event of an emergency. Readers of this booklet will find answers to questions most often asked regarding general properties, potential hazards, exposure effects, personal protective and safety equipment, first aid procedures and methods of dealing with emergencies involving ammonia. Information regarding the manufacture, transportation, and or application of ammonia is not detailed.

Persons requiring any information regarding ammonia not covered in this booklet are urged to consult with Airgas Specialty Products (www.airgasspecialtyproducts.com) or with the Compressed Gas Association, Inc., Arlington, Va., or The Fertilizer Institute, Washington, D.C., for assistance. Also refer to 29CFR1910.111 and ANSI K61.1 for regulations and additional guidelines for ammonia handling and storage.

Anhydrous Ammonia Safety

General

The term "ammonia" in this booklet means "anhydrous ammonia" which has the molecular formula NH_3. Ammonia is formed by the combination of nitrogen and hydrogen at high temperature and pressure in the presence of a catalyst. Anhydrous means without water. Premium, metallurgical, and refrigeration grade anhydrous ammonia contains no more than 33 ppm water, while commercial-grade anhydrous ammonia contains 0.2- 0.5% water. Ammonia (anhydrous ammonia) should not be confused with the synonymous terms (ammonium hydroxide, aqua ammonia or aqueous ammonia), which refer to solutions of ammonia in water.

Commercial ammonium hydroxide solutions generally contain 19-30% ammonia in water, while household ammonia typically contains only 2-4% ammonia in water. These solutions are commonly known as ammonia, but should never be confused with liquid anhydrous ammonia, which has a much greater hazard potential.

Ammonia is a pungent, colorless gas at ambient temperature and pressure and is only about 40% as dense as air. Ammonia gas condenses to a colorless liquid when compressed and condensed. Liquid ammonia boils at -28 ºF (-33 dC) at atmospheric pressure and has a density of 5.69 lb/gal at that temperature. Liquid ammonia coexists with ammonia vapor in storage vessels. Temperature affects both the vapor pressure and density of liquid ammonia (see Table 1). The vapor pressure increases and the density decreases as the temperature of the liquid rises. It should be noted that the pressure observed within a storage vessel is NOT an indicator of the quantity of liquid in the vessel.

Liquid ammonia expands when its temperature increases. Thus, OSHA at 29CFR1910.111(b)(11)(i and ii) limits the filling of ammonia vessels to 87.5% provided the temperature of the anhydrous ammonia being charged is not lower than 30 ºF.

The filling limit is critical since a vessel filled with liquid to 87.5% full at 30 ºF would become 100% full of liquid if the temperature of the liquid ammonia reached 124 ºF. Any additional temperature rise above 124 ºF would cause the vessel to bulge and it could rupture due to the internal hydrostatic pressure caused by the expanding liquid. Ammonia storage vessels must not be exposed to excessive heat because of the expansion characteristics. Ammonia storage vessels, except cylinders, are equipped with Pressure Relief Valves to prevent excess pressure which could lead to catastrophic rupture of the vessels.

Due to these characteristics, ammonia containers should not be exposed to excessive heat. (See THERMAL EXPANSION and FIRE

TABLE 1. VAPOR PRESSURE AND VOLUMES OF LIQUID AMMONIA AT VARIOUS TEMPERATURES

Temperature ºF	Vapor Pressure psig	Volume gal/CWT	Density lb/gal
-28	0.0	17.57	5.69
0	15.7	18.10	5.52
30	45.0	18.72	5.34
60	92.9	19.43	5.15
90	165.9	20.25	4.94
115	251.5	21.04	4.75
130	315.6	21.58	4.63

Data derived from U.S. Bureau of Standards Circular No. 142

EXPOSURE.)

Under equilibrium conditions, the vapor pressure and volume of liquid ammonia vary with temperature as shown in Table 1.

Ammonia is frequently shipped and stored as a liquefied compressed gas under pressure at ambient temperature via truck (up to about 20 tons) or in 80 ton railcars. It is shipped in Department of Transportation (DOT) approved pressure vessels and stored in ASME pressure vessels as a liquefied compressed gas at ambient temperature. Very large quantities (thousands of tons) are transported in pipe lines as a liquefied compressed gas at ambient temperature and high pressure. Large quantities are also shipped via barge or tanker as a refrigerated liquid at -28 ºF and atmospheric pressure. When stored in very large quantities (thousands of tons/vessel) at terminals, ammonia is stored in refrigerated vessels often at -28 ºF and very little pressure.

Common Hazards

Ammonia is corrosive to human tissue in varying degrees depending on concentration and exposure time.

The odor of ammonia is detectable by many people at concentrations as low as five ppm in air. Its pungent and distinctive odor at concentrations of 10-20 ppm range would be very noticeable by nearly all individuals. Most people would be uncomfortable in ammonia atmospheres of 30-50 ppm, though ammonia vapor is generally not hazardous at concentrations below 50 ppm. No reasonably prudent person would voluntarily remain in hazardous concentrations of ammonia (See Table 2).

At the time of this printing, U. S. Department of Transportation requires shipping containers to be marked “INHALATION HAZARD” and that statement must also be included in the shipping name. Ammonia is classified as a “Non-Flammable Gas” by the U.S. Department of Transportation. However, ammonia will ignite within the limited range of 15-28% ammonia in air by volume at about 1200 ºF. Ignition is not spontaneous and an external source of ignition is required. Conditions favorable for ignition are seldom encountered in normal outdoor storage and handling. In addition, the heat generated by combustion of ammonia is not sufficient to sustain combustion, thus ammonia will cease to burn when the ignition source is removed.

Other Hazards

CHEMICAL **-** Ammonia is a very stable chemical compound at normal temperatures. It only begins to dissociate into nitrogen and highly flammable hydrogen at about 840 ºF.

Ammonia will not corrode most common metals. However, in the presence of water ammonia will attack copper, zinc and alloys containing copper or zinc. For this reason, materials of construction used for ammonia containers, fittings, piping and equipment are limited to steel and iron or certain non-ferrous alloys resistant to attack by ammonia. See 29CFR1910.111(b)(7)(iv) for piping requirements on non-refrigerated systems.

Ammonia is a highly reactive chemical, and reacts with inorganic and organic acids to form salts with the release of significant heat. Ammonia is known to react with bromine, chlorine, fluorine, or iodine to form compounds which explode spontaneously. Also, ammonia has been reported to react with gold, silver or mercury to form fulminate-like compounds which are explosive.

THERMAL EXPANSION **-** Liquid ammonia exhibits a high coefficient of cubic expansion. A given quantity of liquid ammonia expands considerably in volume with a rise in temperature (See Table 1). For this reason, facilities must be installed with hydrostatic relief valves to prevent hydrostatic rupture of containers, piping and other equipment.

The vapor pressure of ammonia also increases with temperature. The vapor pressure is 138 psig at 80 ºF, 271 psig at 120 ºF and 428 psig at 150 ºF. Thus, pressure relief valves must be provided to prevent vessel rupture in the event of excess pressure due to heat. (Facilities must be installed in accord with 29CFR1910.111). Storage tanks must be protected from external heat sources.

TABLE 2. AMMONIA EXPOSURE GUIDELINES

Effect	PPM Ammonia in Air by Volume
Least perceptible odor	5 ppm
Readily detectable odor	10-20 ppm
OSHA PEL: TWA*	50 ppm
IDLH**	300 ppm

* Permissible Exposure Limit (PEL): Time weighted average (TWA) concentration that must not be exceeded during any 8 hour work shift of a 40 hour workweek.

**Interpretation of NIOSH definition: IDLH is the maximum concentration in which a person can exist for 30 minutes without respiratory protection and not sustain acute or permanent health damage or loss of ability to escape. IDLH (Immediately Dangerous to Life or Health) value listed as designated in the NIOSH Pocket Guide to Chemical Hazards (www.cdc.gov/niosh/npg/npg.html, 9/10/04).

Human Physiological Effects

Ammonia is NOT a cumulative metabolic poison; rather ammonium ions are important constituents of living systems. The effects of exposure to ammonia are exposure-time and concentration dependent. No effects, or only mild irritation, occur when exposed to low concentrations (OSHA PEL = 50 ppm) or even somewhat higher concentrations for short periods of time.

Exposure to high concentrations of ammonia can cause significant health problems and be fatal in extreme cases. Exposure to intermediate concentrations of ammonia for limited periods can cause mild irritation to skin, eyes and respiratory system. High concentrations (IDLH = 300 ppm, see Table 2 for explanation of IDLH) can cause obstruction of breathing from laryngeal and bronchial spasm, edema and severe damage of the mucous membranes of the respiratory tract with possible fatal results.

Liquid ammonia boils at -28ºF at atmospheric pressure, acting as a refrigerant to remove heat from any warmer object it may be contacting. Accordingly, liquid ammonia in contact with the skin can cause frostbite and severe freezing.

Ammonia vapor concentrations which are tolerated by some individuals may produce adverse reactions in others. Those having chronic respiratory disease or have shown evidence of undue sensitivity to ammonia should not be exposed to ammonia. Table 2 indicates exposure guidelines to various concentrations of ammonia in air upon inhalation.

Exposure Limits

Occupational Safety and Health administration (OSHA) regulations require that an employee's permissible exposure limit (PEL) for ammonia is not to exceed a time-weighted average of 50 ppm in an eight-hour workday 29CFR1910.1000; Table z-1.

Personal Protective Equipment

Individuals working with ammonia (operations or maintenance) should wear chemical splash-proof goggles plus a full face shield. The face shield should be worn over the goggles for additional protection of eyes, respiratory system and face, but never as a substitute for the goggles. In addition, those individuals should also wear rubber or plastic gauntlet gloves impervious to ammonia to protect hands and arms. Airgas regards these items to be minimal, and additional protection, such as rubber aprons or slickers, may be justified to protect critical body areas vulnerable to contact with ammonia.

Emergency Protective and Safety Equipment

Each location having an ammonia installation should have readily available and freely accessible emergency protective and safety equipment as required by federal, state and

local governmental regulations as well as good management practice. The location of such protective and safety equipment should be clearly identified by appropriate signs.

Emergency protective and safety equipment should include the following:

WATER SHOWER – Body parts that have come in contact with ammonia must be flooded immediately with large quantities of water. An emergency safety shower, eye wash fountain or other source of clean water can be used for this purpose. Water supplies should be protected from freezing.

RESPIRATORY DEVICES –

1. Stationary storage installations must have at least two suitable gas masks in readily accessible locations as per 29CFR1910.111(b)(10)(ii). Full face masks with ammonia canisters that have been approved by NIOSH under 42 CFR part 84 are required. These approved masks are suitable for emergency action involving most outdoor anhydrous ammonia leaks, as well as some indoor leaks. (See 29CFR1910.13 for detailed RESPIRATORY PROTECTION requirements.) Individuals expected to use gas masks must be clean shaven and trained in the use of gas masks. Masks with canisters must not be used in IDLH atmospheres except for escape purposes.

Any individual wearing a gas mask must leave a contaminated area immediately after detecting the odor of ammonia or experiencing breathing difficulty. These are indications that the mask or canister is not functioning properly, that the ammonia concentration is excessive, or that adequate oxygen is not available.

2. SELF-CONTAINED AIR BREATHING APPARATUS (SCBA) of an approved pressure demand type must be used when entering areas where ammonia concentrations are unknown, exceed the IDLH level of 300 ppm or are oxygen deficient atmospheres (See 29CFR1910.134(d)(2).

The SCBA, which consists of a sealable full-face shield, a pressure and flow control and a high pressure cylinder of air, provides breathing protection for a period of time which varies with the amount of air carried and the extent of exertion by the user. The user must have a clean-shaven face and have training required by OSHA in the use of respirators (See 29CFR1910.134 and 29CFR1910.120). The buddy system must always be employed when using SCBA (29CFR1910.134(g)(3).

Respiratory devices must be used and maintained in accordance with the manufacturer's instructions. Individuals expected to use respiratory masks with canisters or air supply must be well trained to function safely in tense emergency situations.

PROTECTIVE CLOTHING – Emergency or rescue personnel required to work in high ammonia concentrations should wear protective gloves, boots, pants and jacket (or slicker) impervious to ammonia. A hard hat should be worn as required by plant practice or dictated by special hazards. Class A totally encapsulated suits with SCBA will be required in severe ammonia atmospheres that can severely damage the skin.

RESCUE HARNESS – A safety belt and lifeline should be worn by an individual using respiratory equipment and entering contaminated air in a confined location. Another person also wearing respiratory equipment and protective clothing should be located outside the contaminated area to act in case of emergency. See 29 CFR 1910.120 and 134.

WATER SYSTEM – Ammonia installations should have adequate water available for fire fighting, and for suppression of ammonia vapor clouds resulting from ammonia leaks.

STRETCHER AND BLANKETS – Inadequate facilities for transporting a seriously injured person from the scene of an accident to a first aid station can add to the seriousness of the injury. A stretcher provides the most acceptable method of hand transportation and it may be used as a temporary cot at the first aid station or during transit in a vehicle.

First Aid Procedures

Ammonia is one of the most water-soluble of all gases. Accordingly, the best means of providing first aid for an injury caused by ammonia contact with the eyes or skin is to flush immediately with large quantities of potable water. Promptness in initiating treatment, using adequate quantities of water and continuous application for at least fifteen minutes, or longer if necessary, are all essential in successful first aid management of an eye or skin injury resulting from contact with ammonia. Seek medical attention immediately.

PRIOR TO MEDICAL AID BY THE PHYSICIAN, FIRST AID PROCEDURES SHOULD BE EMPLOYED. THOSE PRESENTED HEREIN ARE BASED UPON WHAT IS BELIEVED TO BE COMMON PRACTICE IN INDUSTRY. THEIR ADOPTION IN ANY SPECIFIC CASE SHOULD, OF COURSE, BE SUBJECT TO PRIOR ENDORSEMENT BY A COMPETENT MEDICAL ADVISOR.

As a guide in case of injury caused by ammonia, the following first aid procedures are suggested:

INHALATION – Any conscious person who has incurred irritation due to inhalation of ammonia should proceed at once to a location free of ammonia and breathe fresh air. Seek medical attention if needed.

A person overcome by ammonia must be carried to a location free of ammonia and the services of a physician obtained promptly. Successful resuscitation requires SPEED and EFFICIENCY. DELAY AND INEXPERIENCE MAY RESULT IN A FATALITY.

If there is an obstruction to the patient's breathing, the airway must be cleared by appropriate methods which may include proper positioning of the patient's head, pulling the tongue forward and clearing any blockage from the mouth such as dentures or vomit. If spontaneous breathing does not resume after the airway has been cleared, artificial respiration should be started immediately by mouth-to-mouth resuscitation (expired-air ventilation, rescue breathing), preferably by an individual trained in the procedure.

Oxygen therapy may be indicated once the patient's breathing has been restored or if it continues to be labored. Such therapy should not replace immediate mouth-to-mouth resuscitation and should only be applied during a sustained resuscitation period or if the patient is to be moved. CAUTION: It may not be advisable to administer oxygen under positive pressure if the patient is in shock or there is impending or existing cardiovascular failure. Oxygen therapy equipment should be used only by qualified and experienced personnel.

Treatment with oxygen may be discontinued if breathing becomes easy, the color is good and there are no signs of lung congestion. During treatment, the patient should be placed in a reclining position. He should be kept quiet, at rest and comfortably warm, but not hot. Seek medical attention.

EYES – If ammonia enters the eye, flood the eye immediately with large quantities of potable water for at least 15 minutes. Speed is essential. Contact lenses should never be worn in the presence of ammonia, since the lens could trap ammonia in the eye and interfere with treatment. Water in a squeeze bottle which can be carried in the pocket is helpful for emergency irrigation purposes. An eye-wash fountain should be used, but if not available, water from any source may be poured into the eyes. In any case, the eyelids MUST BE HELD OPEN and irrigation continued for at least 15 minutes. Continue irrigation with 10 minute breaks and 5 minutes irrigation until Medical attention is obtained. MEDICAL ATTENTION must be received immediately, preferable from an ophthalmologist. Medication, of any type, should not be placed in the eyes unless ordered by a physician.

SKIN AND MUCOSA – If contacted by liquid ammonia or high concentrations of ammonia vapor, immediately flood the affected body parts with water. If a safety shower is not available, use any available water supply. Water will thaw any clothing that may be

frozen to the skin. After thawing, remove contaminated clothing and continue flooding the contaminated skin with water for at least 15 minutes to remove ammonia from the skin. SEEK MEDICAL ATTENTION IMMEDIATELY. Do not apply medication to the burned areas without medical advice.

INTERNAL – Swallowing of liquid ammonia is very unlikely. However, if ammonia has been taken internally and if the patient is CONSCIOUS and able, have him drink large quantities of water immediately. NEVER GIVE ANYTHING BY MOUTH TO AN UNCONSCIOUS PERSON. Should the patient vomit, place his face down with head lower than hips to prevent it from entering the lungs. Transport patient to a physician promptly and apply other first aid treatment as the doctor may prescribe.

Emergency Measures

Every facility is susceptible to emergency situations which can result in property damage and/or bodily harm to employees, visitors or neighbors. A facility using ammonia bears responsibility for the development and implementation of effective Emergency Action (or response) plans as per 29CFR1910.38 to be prepared to deal with emergency situations. Facilities that have 10,000 pounds or more of anhydrous ammonia must also develop Process Safety Management (PSM) programs as per 29CFR1910.119 and Risk Management Programs (RMP) as per 40CFR68. Effective Emergency Action Plans, PSM and RMP programs help facilities avoid and be prepared for emergencies as well as comply with Federal regulatory requirements.

No one plan will serve the needs of all companies. Each organization must assess the various potential emergency conditions that might occur and develop a program to suit its own requirements. Where ammonia is stored and used, the following procedures and actions are suggested for incorporation into an emergency action or response plan upon the understanding that the publisher is not offering professional advice.

When an ammonia leak occurs, personnel trained for and authorized to handle such situations should take immediate steps to locate and control the condition. Respiratory equipment and protective clothing suitable for ammonia must be worn. All other persons must be kept away from the affected area until the leak has been stopped. Remain upwind of the leak when possible.

If ammonia vapor is released, the irritating effect of the vapor will generally force personnel to leave the area before they are overcome by harmful concentrations. Sufficient, well-marked and readily accessible exits must be provided to facilitate rapid evacuation from a building. Should an individual become trapped in an ammonia-contaminated atmosphere, breathing should be held to a minimum and eyes opened only as necessary.

Since ammonia vapor is lighter than air, a trapped person should remain close to the floor to take advantage of lower vapor concentrations while seeking an escape route, unless liquid ammonia has been spilled. If respiratory equipment is not available, some temporary protection may be afforded by holding a wet cloth over the nose and mouth.

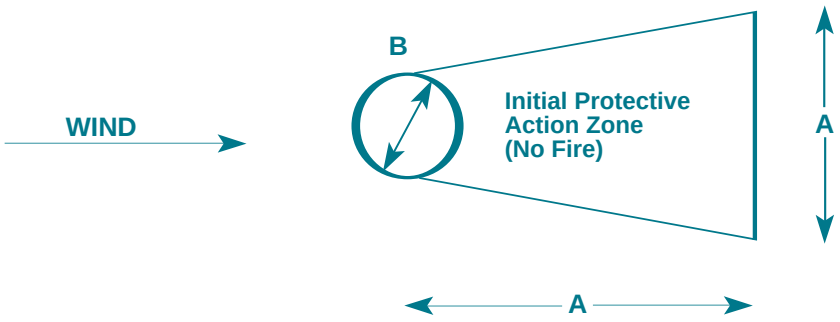
Significant ammonia releases MUST be reported to authorities immediately. Releases of 100 pounds or more of ammonia in any continuous 24-hours period must be reported to the Local Emergency Planning Commission (LEPC), Fire Department, State Emergency Response Commission (SERC) and National Response Center (NRC; phone 800-424-8802) immediately as per 40CFR355.40. Smaller releases that may have an offsite impact should be reported to the LEPC and Fire Department, and possibly the SERC.

Evacuation of the surrounding area may be required in the case of significant ammonia releases. Suggested evacuation distances are given in Table 3, starting with the circle as shown in the accompanying diagram.

With good ventilation or rapidly moving air currents, ammonia vapor, can be expected to dissipate readily to the upper atmosphere. Further action may not be required other than to stop the leak. If necessary, the concentration of ammonia vapor in the air can be reduced effectively by the use of an

TABLE 3. TABLE OF INITIAL ISOLATION AND PROTECTIVE ACTION DISTANCES

Small Spill	Large Spill
A) Downwind and Crosswind Distances: 0.1mi. Day Downwind and Crosswind Distances: 0.2mi. Night B) Isolation Zone Diameter: 100 ft.	A) Downwind and Crosswind Distance: 0.2mi. Day Downwind and Crosswind Distance: 0.5mi. Night



(Derived from "1996 North American Emergency Response Guidebook", U.S. Department of Transportation NAERG 96)

adequate volume of water applied through a spray or fog nozzle.

Under some conditions, ammonia in a container may be colder than available water supply. At such times, water must not be applied to the container walls since heat would be transferred to the ammonia thus causing increased pressure within the container resulting in increased leakage or relief valve discharge.

Water should not be applied to a liquid spill unless at least 100 parts of water to 1 part of ammonia are available. Runoff of a liquid spill should be diverted if the direction of flow will create an additional problem. UNDER NO CIRCUMSTANCES SHOULD AN ATTEMPT BE MADE TO NEUTRALIZE AN AMMONIA SPILL WITH AN ACID.

An up-to-date telephone listing of various emergency, rescue, medical and regulatory agencies should be maintained for use by designated personnel. The list should include numbers for fire and police departments, ambulance, rescue or paramedical services, doctors, hospitals, governmental authorities, material and equipment suppliers. The names and numbers for selected company supervisory and management personnel who are to be notified of an emergency situation should be included. Where appropriate, both day and night or alternate numbers should be shown.

If company or security personnel are not present at a facility during off-hours, the name(s) and telephone number(s) of a responsible individual(s) should be posted at a gate or entrance for purposes of notification by local authorities should an emergency arise.

Leak Detection

An ammonia leak is readily detectable by its characteristically pungent odor. The location of a small leak may often be determined by holding a moist strip of phenolphthalein or red litmus paper near the suspected leak source. The rapidity and intensity of the color change in the paper will give some indication of leak proximity or size. In the presence of ammonia, phenolphthalein paper will turn from white to pink or deep red, whereas the red litmus will become blue.

Sulfur dioxide vapor reacts with ammonia to form a dense white cloud and may be used for leak detection. Care must be exercised to avoid breathing sulfur dioxide vapor as it is also highly irritating. It should be noted that a gas mask canister which is specific for ammonia will not offer protection against sulfur dioxide. If there is an appreciable

quantity of ammonia in the air, it may be difficult to pinpoint the leak source. Various types of devices are available to detect and measure the concentration of ammonia vapor in air. One such device, known as a Draeger tube, employs a colorimetric detector tube through which air to be tested is drawn by a special hand or battery operated pump. A comparison of the length of the color stain produced in the tube is made with a calibrated chart which gives an indication of the concentration. The use of electronic leak detection systems may be useful at facilities that are not staffed at all times.

Leak Control

EQUIPMENT OR PIPING – If a leak occurs in equipment or piping, shut off the ammonia supply and carefully vent all ammonia from the system before attempting to dismantle any part or make repairs. The appearance of frost on an external surface indicates the presence of liquid ammonia vaporizing in the system. Accordingly, the frost should be allowed to dissipate before breaking any connection. If welding is required, the system should be thoroughly purged until all ammonia and any oil residue has been removed. Cutting or welding must conform with applicable codes.

VALVE – A leak at a valve stem can usually be stopped by tightening the packing gland nut. A leak at a valve bonnet may be stopped by tightening the bonnet threads or the bolts holding the bonnet to the valve body. All tightening should be performed slowly and without application of excessive force. Packing gland nut and bonnet threads on some ammonia valves are left-handed. If tightening procedures fail to stop the leak, the valve should be closed. If the valve should fail to close completely, it should be plugged.

PRESSURE RELIEF DEVICE – A leak or discharge through a pressure relief device, such as a pressure relief valve, may occur if the pressure within the equipment, piping, tank or container exceeds the rated pressure setting of the device or if the device is faulty. Reducing the pressure within the system by removing ammonia as vapor to process or cooling the container with a water spray may permit the device to reseat. If reseating does not take place, it may be necessary to replace the device with one approved for ammonia service and of the proper pressure rating and capacity.

No attempt should be made to plug, cap or otherwise tamper with a pressure relief device under any circumstances (See 29 CFR 1910.111 (b)(9)(iii)). However, a pressure relief valve may be provided with a shut-off valve. This will allow the leaking device to be isolated for removal purposes while another pressure relief valve provides the full rate of discharge capacity required for safety. Unless returned to the manufacturer, a pressure relief device should not be repaired or adjusted in any manner. Pressure relief valves should be replaced at regular intervals as suggested by the manufacturer. Failure to observe these precautions could result in a serious weakening or catastrophic rupture of the equipment, piping, tank or container which was being protected by the device.

STORAGE TANK – A leak at a threaded or flanged storage tank opening may often be stopped by a careful tightening of threads or bolts. Should such efforts fail, it will be necessary to empty the tank of all ammonia before attempting further repair. If the leak is small, the tank can frequently be emptied by removing the ammonia as a vapor or liquid to process. If it is necessary to remove the ammonia, or if the tank is equipped with a vaporizer, Airgas should be contacted for advice and assistance at 800-295-2225.

Occasionally, a storage tank will develop a leak in a plate, weld or coupling. No attempt to repair such a leak should be made. Instead, call your tank or ammonia supplier promptly. Welding on an ammonia storage tank must be performed in accordance with ASME code procedures and only after complete purging.

SHIPPING CONTAINER – Ammonia is shipped in special containers which are fabricated, transported and maintained in accordance with the U.S. Department of Transportation regulations. Shipping containers include cylinders, portable tanks, tank trucks, rail tank cars, barges and tankers. If an ammonia leak occurs in a shipping container while at the user's facility, these

actions should be taken to limit and control the escape of ammonia:

(1) If liquid is leaking from a cylinder, position it so that vapor escapes instead of liquid. The rate of ammonia release from a vapor leak is considerably less than from a liquid leak through an opening of the same size.

(2) If possible, move the container to an area of reduced hazard.

(3) If no risk is entailed, attempt to reduce the pressure in the container by removing the ammonia to process as a vapor.

(4) Reduce the quantity of vapor in the atmosphere with a water spray applied to the leak area.

(5) Aside from trying to stop a leak from a shipping container by tightening a valve packing nut, closing a valve or possibly tightening a flange bolt, no other repairs should be attempted or authorized by the user.

(6) It is a violation of federal regulations to transport an ammonia shipping container which is leaking or damaged. If a shipping container is damaged or is leaking in a manner which cannot be handled by personnel at the site, the nearest office of the producer or supplier should be called for assistance. If the producer or supplier cannot be reached, contact the Chemical Transportation Emergency Center (CHEMTREC) by telephoning the toll free number (800) 424-9300 for advice or help day or night.

When calling for assistance, be prepared to provide the following information:

(a) Nature of emergency: when, where and extent.

(b) Type and condition of container.

(c) Name of shipper or supplier.

(d) Extent of injuries or property damage, if any.

(e) Description of surrounding area and prevailing weather conditions.

(f) Corrective measures being applied.

(g) Name of caller and location now and where telephone contact may be re-established with caller or other responsible party at the emergency site.

Regulations require immediate (within 15 minutes) reporting of ammonia releases over 100 lbs. to the following agencies: Fire Department, LEPC, SERC, and NRC (800-424-8802).

Fire Exposure

If possible, an ammonia container should be disconnected and removed immediately from the fire zone. If, for any reason, a container cannot be moved, it should be kept cool with water until well after the fire is extinguished. Firefighting personnel should be properly equipped with protective clothing and respiratory equipment.

Employee Safety Training

Safety in working with ammonia depends on more than just the availability of personal or emergency protective equipment and clothing. Employee training in safe operation procedures, in first-aid measures and in the use of suitable operating and protective equipment, properly maintained, must also be included as an essential element in any comprehensive safety program.

Such safety training is the responsibility of management and should be given to new and old employees at periodic intervals as needed to maintain high proficiency levels. Written and oral instructions should be provided followed by drills regarding the location, purpose and use of personal and emergency protective clothing, equipment, safety showers or other water sources, first aid supplies and shut-down equipment such as valves and switches.

Training should also stress the avoidance of body contact with liquid ammonia or inhalation of gas and the reporting of equipment failures to appropriate supervisory authority.

Additional copies of this booklet are available by forwarding a request to Airgas Inc. at (770) 717-2200 or info@airgasspecialtyproducts.com.

Material Safety Data Sheets are available by similar request.

Selected Ammonia Safety References and Training Aids

1. *Safety Requirements for the Storage and Handling of Anhydrous Ammonia, ANSI-K61.1*
   American National Standards Institute, Inc. (ANSI)
   1430 Broadway
   New York, NY 10018
   (212) 354-3300

2. *Anhydrous Ammonia, Pamphlet G-2*
   Compressed Gas Association, Inc. (CGA)
   1235 Jefferson Davis Highway
   Arlington, VA 22202
   (703) 979-0900

3. *Anhydrous Ammonia Safety Video*
   Airgas Inc.
   6340 Sugarloaf Parkway
   Duluth, GA 30097
   (770) 717-2200
   www.airgas.com

4. *For The Rest of Your Life*, 16mm color sound film
   National Society for the Preservation of Blindness, Inc.
   79 Madison Avenue
   New York, NY 10016
   (212) 684-3222

REGULATORY REFERENCES

CFR = Code of Federal Regulations

29CFR can be found at "http://www.osha.gov"

29CFR1910.111 Storage and Handling of Anhydrous Ammonia

29CFR1910.119 Process Safety Management of Highly Hazardous Materials

29CFR1910.134 Respiratory Protection

40CFR can be found at "http://www.epa.gov" under Laws, Regulations & Dockets

40CFR68 Chemical Accident Prevention Provisions (Risk Management Plan Requirements)

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