INTRODUCTION

The purpose of this chapter is to provide a reference document containing suggested practices for the operation of an ammonia refrigeration system.

It is intended that this chapter be used as a general reference source and that in all cases, recommended practices issued by equipment manufacturers and suppliers take precedence over these recommendations when they afford greater protection.

GENERAL INFORMATION

Ammonia (NH₃) at normal temperatures and pressures is a colorless gas made up of one part nitrogen and three parts hydrogen. It is lighter than air and has a sharp, pungent odor that serves as a warning of its presence. While ammonia is a relatively toxic substance, it is not a cumulative poison. It is highly soluble in water and forms a solution known as ammonium hydroxide (NH₄OH) or aqua ammonia, commonly used as a household cleaner.

Commercially, ammonia is made by combining free nitrogen and hydrogen gases under high pressure and temperature in the presence of a catalyst. The process most commonly used is the Haber-Bosch method.

Anhydrous ammonia is the liquid form of pure ammonia gas, technically water-free, and the substance used universally as an industrial refrigerant.

The most important physical properties of anhydrous ammonia are:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Molecular Symbol</td>
<td>NH₃</td>
</tr>
<tr>
<td>Molecular Weight</td>
<td>17.03</td>
</tr>
<tr>
<td>Boiling Point (at one atmosphere)</td>
<td>-28°F</td>
</tr>
<tr>
<td>Freezing Point (at one atmosphere)</td>
<td>-107.9°F</td>
</tr>
<tr>
<td>Latent Heat of Vaporization (@ 70°F)</td>
<td>508.6 Btu/lb</td>
</tr>
<tr>
<td>Vapor Density (@ 32°F at one atmosphere)</td>
<td>0.597</td>
</tr>
<tr>
<td>Liquid Density (@ 70°F)</td>
<td>5.08 lb/gal</td>
</tr>
</tbody>
</table>

For transport purposes, anhydrous ammonia is classified as a non-flammable gas by the U.S. Department of Transportation (DOT); and anhydrous ammonia containers with a capacity of less than 165 lbs. are not required to be equipped with overpressure protection devices. The nitrogen component of the substance is inert in the combustion reaction and accounts for the limited flammability of anhydrous ammonia. The flammable limits at atmospheric pressure are 16% to 25% (by volume) of ammonia in air. Ammonia's high lower limit of flammability and low heat of combustion substantially reduce its combustion-explosion and fire hazards. A National Fire Protection Association (NFPA) fire record analysis shows that in a 40 year period (1929 through 1969) there were only 36 incidents in which released NH₃ gas or liquid were ignited, and only 28 resulted in a combustion-explosion.

USES OF AMMONIA

Ammonia, as the base for nitric acid, is an important “building block” in the manufacture of many chemical compounds such as cleaning fluids, catalysts used in the manufacture of plastics, and process constituents in the synthetic fibers industry.

Anhydrous ammonia is most commonly used as a fertilizer. It contains about 82% nitrogen and, therefore, produces the replacement for the nitrogen absorbing cycle in plant growth.
Industrial grade anhydrous ammonia serves as an economically abundant and efficient heat transfer medium for industrial refrigeration processes. Its pungent odor serves as a self-alarming characteristic.

**AMMONIA VAPOR COMPRESSION IN MECHANICAL REFRIGERATION**

Mechanical refrigeration is a process for exchanging heat to effect a desired temperature in an environment and/or an end product. The state-of-the-art in current mechanical refrigeration technology involves the transfer of the refrigerant through its liquid and vapor states by mechanical compression, condensation, and evaporation. This guideline for safety relates specifically to the mechanical functions and the associated equipment incorporated in the typical ammonia vapor-compression system.

Figure 1 is a flow diagram of a typical single-stage ammonia system, showing its basic components.

![Flow Diagram of Ammonia Compression Refrigeration System](image)

**AMMONIA’S EFFECTS**

**Effects on the Human Body**

Ammonia itself is not a cumulative poison. Ammonia ions are a naturally occurring body chemical and are produced in the kidneys and by the metabolism of proteins. The liver converts ammonia ion rapidly to harmless urea, which is used in the body process or is excreted in the urine. There are no serious chronic or long term effects from ammonia, but it can present definite acute, or short term health hazards as indicated in Table 1.
Table 1

EFFECTS OF AMMONIA VAPOR IN VARIOUS CONCENTRATIONS

<table>
<thead>
<tr>
<th>NH₃ Concentration (PPM)</th>
<th>Effects on Unprotected Workers</th>
<th>Exposure Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>Noticeable odor to some people</td>
<td>Recommended 8 hr. exposure level (ACGIH)</td>
</tr>
<tr>
<td>25</td>
<td></td>
<td>Recommended maximum exposure 15 minutes (ACGIH)</td>
</tr>
<tr>
<td>35</td>
<td>Detectable odor, moderately strong odor, moderately irritating to the nose</td>
<td>Permissible for 8 hour working exposure (NIOSH, OSHA)</td>
</tr>
<tr>
<td>50</td>
<td>Detectable odor</td>
<td>Permissible for 8 hour working exposure (NIOSH, OSHA)</td>
</tr>
<tr>
<td>100</td>
<td>Detectable odor, moderately strong odor, moderately irritating to the nose</td>
<td>Permissible for 8 hour working exposure (NIOSH, OSHA)</td>
</tr>
<tr>
<td>400</td>
<td>Causes major irritation of throat</td>
<td>Ordinarily no serious results following infrequent short exposures (less than 1 hour is hazardous)</td>
</tr>
<tr>
<td>1,720</td>
<td>Causes convulsive coughing</td>
<td>No exposure permissible (may be fatal after short exposure less than half an hour)</td>
</tr>
<tr>
<td>5,000</td>
<td>Causes respiratory spasm, strangulation, asphyxia</td>
<td>No exposure permissible (rapidly fatal)</td>
</tr>
<tr>
<td>15,000</td>
<td>Causes burns and blisters to unprotected skin</td>
<td>MOST AMMONIA MACHINE ROOMS, EVEN WELL VENTILATED, WILL HAVE CONCENTRATIONS AROUND 5 PPM.</td>
</tr>
</tbody>
</table>

Note: AMMONIA-AIR COMBINATIONS ARE FLAMMABLE BY SPARK IGGITION AT CONCENTRATIONS OF 16–25% BY VOLUME IN AIR, OIL CARRIED BY THE AMMONIA VAPORS LOWERS THIS LEVEL CONSIDERABLY, AND GENERALLY, 4% BY VOLUME IN AIR IS CONSIDERED THE SAFE LIMIT TO PREVENT EXPLOSIONS.

Ammonia, from a chemical standpoint, is a moderately strong base (caustic alkali), depending upon its concentration. As a substance which dissolves in water to form hydroxyl ions, it is corrosive and destroys body tissues. Aqueous Ammonia is a liquid with this property. Anhydrous ammonia in liquid or gaseous form has a very strong attraction to water and moisture. It readily combines with moisture on and in the body to form strong concentrations of aqueous ammonia.

Ammonia's Self-Alarming Characteristic

Ammonia is not normally considered a serious or life-threatening hazard, as its pungent odor is irritating, and in large concentrations, intolerable to humans. Since ammonia is a chemical that is readily recognized, people will seek relief from its effects before it becomes a true health hazard. Air containing a concentration of ammonia in which a person is willing to remain is not particularly dangerous, though care should be taken to prevent prolonged exposure, as with any irritating atmosphere. The true danger from ammonia occurs when a person is unable to leave a gaseous ammonia environment, and when the liquid comes in contact with the body, particularly the eyes.

The odor of ammonia is widely recognized. The odor threshold reported in literature varies. One study indicates subjects could detect ammonia odor at 0.037 ppm. Other references report the detectable odor...
to be about 50 ppm. Patty, an authority, indicates the odor is detectable at 5 ppm, easily noticeable at 20 ppm, and moderately strong at 100 ppm. Some of the variation may be accounted for by acclimation, or the exposure history of the individual.

Ammonia does have a relatively uncommon and strong, nearly intolerable, odor at levels considered to be harmful. Therefore, it is generally accepted as having adequate warning properties, before serious harm or death occurs. A rule of thumb would be: if you can tolerate the concentration of gas, it will not be harmful to you.

**Effects of Exposure of Ammonia Gas**

Anhydrous ammonia gas, as mentioned earlier, does react with moisture on and in the body to form a basic, or caustic, solution, which irritates body tissue at higher concentrations.

A five minute exposure of 50 ppm of ammonia in air results in complaints of dryness of the nose and throat. Exposure above 100 ppm produces noticeable irritation of the eyes and mucous membranes. At 400 ppm, mucous surfaces may be destroyed after prolonged contact.

Eye irritation becomes significant at 700 ppm. Higher exposure becomes intolerable. Convulsive coughing is reported at 1,720 ppm. Exposure above 2,500 ppm becomes dangerous in as short a time as 30 minutes. The most serious effects may not be immediate. It may take several days before pulmonary edema develops (water in the lungs). Above 5,000 ppm, no exposure to ammonia gas is permissible without full-face respiratory protection.

Even after workers have full-face respiratory protection (which includes eye protection), additional problems develop over 15,000 ppm (1.5%). Ammonia gas will combine with perspiration on the skin (arm pits, belt line, etc.) to form a caustic solution that attacks the skin.

Concentrations of ammonia exceeding the recommended limit may originate from unsuspected sources, such as decomposition of organic materials in chicken houses, hydrolysis of cyanide emitted from electroplating solutions, and the thermal decomposition of plastics. Personnel should report any unaccounted for ammonia odor to responsible supervisory persons for further investigation.

Dobbs estimated that lethal concentrations existed 100-200 ft. from the point of ammonia discharge in a tank car accident. The air temperature was 7°F (-14°C), a gentle breeze was blowing at 3-5 mph, and a temperature inversion existed. Storage areas and containers of ammonia should be located with due consideration for potential dispersion, and should meet the requirement of 29 CFR 1910.111, as amended.

**Effects of Exposure to Pure Liquid Ammonia**

The most likely serious hazard, because of its higher potential, is eye damage, which results when liquid ammonia contacts the eye. Unless the eye can be flushed promptly (in less than 20 seconds) permanent damage, including blindness, is likely. Therefore, eye protection and eye wash equipment are essential.

Contact of liquid ammonia with the skin must also be eliminated. As a caustic material, it will destroy tissue, resulting in blisters and chemical burns. In addition, thermal "freeze" burns are possible, due to the low temperature of liquid anhydrous ammonia and uninsulated equipment.
OPERATION OF AMMONIA REFRIGERATION SYSTEMS
International Institute of Ammonia Refrigeration

OPERATOR RESPONSIBILITIES

What Operators Must Know

The basic fundamentals of refrigeration, particularly the relationship between the temperature and pressure of ammonia, should be fully understood by every operator. This is not to imply that the operator needs to have the capabilities necessary to design a system, but rather that he/she should have sufficient knowledge:

a. To operate the system safely
b. To understand the operation and function of each component
c. To be aware of the relationship between the various components in the system

The operator should be thoroughly familiar with the following specific components and operations:

The Compressor

Each compressor manufacturer has a number of limitations relating to any particular model. Together, these limitations give a field of application within which that compressor may be operated safely. The most important limits are protected by safety controls and the operator must make himself familiar with the operation, set point and function of the following:

a. Low (suction gas) pressure cut-out
b. High (discharge gas) pressure cut-out
c. Low differential oil pressure cut-out
d. High oil temperature cut-out
e. High discharge temperature cut-out
f. Any additional safety controls which may be fitted

Automatic Control Valves

The basic function of control valves is to regulate automatically the pressure, temperature, level and feed rate of refrigerant in the system. It is the responsibility of the operator to know:

a. How a valve functions
b. What the valve regulates
c. How to adjust the valve
d. What happens when the valve is opened or closed
e. What happens when the valve is bypassed or isolated
f. What happens during a power failure
Isolating Valves

These valves are installed in a system in order to isolate certain components or to stop the flow of refrigerant. They may be manually operated, electrically operated or pneumatically operated. Each operator must know:

a. Where each valve is located
b. What the effect is of opening or closing each valve
c. Whether a valve should normally be in the open or closed position
d. How to determine whether a valve is opened or closed

Pressure Relief Valves

In order to prevent unduly high pressures from causing rupture of components within the system, a number of spring-loaded pressure relief valves are normally provided. The performance of these pressure relief valves should be checked annually. Each operator should know:

a. The location of each pressure relief valve
b. The correct relief setting for each valve
c. What part of the system the valve is designed to protect
d. What action to take should the relief valve operate or fail to operate

Electrical Controls

A modern refrigeration system incorporates many electrical controls, such as disconnects, fuses, safety switches, capacity control switches, relays, timers, etc. Several of these may be grouped together in a control panel. It is the responsibility of each operator to fully understand:

a. The purpose of each control
b. What each control is designed to protect
c. What to do in case of power failure
d. What happens to the system on prolonged shut down
e. What sequence of action to take to shut down the plant
f. What sequence of action to take to start up the plant
g. How to relieve excess pressure buildup during electrical failure
Temperature or Pressure Changes

Many factors such as mechanical malfunction, ambient temperature, or product load can have an effect on the normal operating temperatures/pressures of the refrigeration system. Every plant operator should understand:

1. The normal operating pressures and temperatures of the system
2. The causes and effects of a change in temperature or pressure in:
   a. the low pressure (low side) part of the system
   b. the intermediate pressure part of a two-stage system
   c. the high pressure (high side) part of the system
3. what action to take upon a change in temperature or pressure in order to restore the system to normal

Pump Out

A well-designed refrigeration system includes facilities to permit the transfer of refrigerant from one part of the system to another for the purposes of servicing. Each operator should be thoroughly familiar with the total system and be capable of performing a pump-out operation at short notice. In addition, each operator should know:

a. What action to take in the event of pressure buildup
b. What action to take in the event of a leak
c. How to pump out the system or maintain a vacuum on different components in the system for repair purposes.

Preventive Maintenance

The most important factor contributing to a safe operation may be the operator's knowledge of preventive maintenance. Each component of a system requires routine checking, cleaning and possible replacement. The following operations should be performed on a regular basis:

Compressors should be inspected annually according to manufacturer's recommendations.

Oil should be inspected and replaced periodically in accordance with compressor manufacturer's recommendation.

Filters should be cleaned or replaced periodically.

Safety controls should be inspected and operated manually to insure that they are functioning properly. Replacements should be made immediately where necessary.

Shut-off valves should be checked by operating each valve. The valve stem should be free of paint or rust and the packing must not leak.

Electrical control valves should be checked by operating manually. Defective components, such as coils, pilot lights, and gauges should be replaced. Strainers in the line feeding the valve in question should be checked and cleaned, especially if the system has a loss of capacity.
Oil drains should be checked frequently and excess oil removed. All caps or plugs should be refitted after completion of the oil draining operation.

Expansion valves should be checked for proper setting. If thermostatic expansion valves are used, make certain that there is no damage to either the bulb or the capillary, and that the bulb is clamped firmly in its correct position.

Pressure gauges and thermometer should be checked and recalibrated or replaced where necessary.

Sight glasses should be clean and unobstructed; clean when necessary. Protective shields should be properly placed.

Float controls and level alarms should be inspected visually and checked operationally to insure that they are functioning properly.

Refrigerant pumps should be checked for performance. The packing should be checked for leakage and the belts or couplings checked for tension, alignment, and possible wear. All pumps should be lubricated periodically in accordance with the manufacturer's recommendations.

Safety equipment such as gas masks, air packs, water sprays, eye wash stations, and emergency lighting must be inspected regularly.

Emergency procedures: All personnel must be aware of emergency procedures and a list of who to call and where to locate them should be readily available for use in case of emergency.

**Observation of System to Prevent Incident**

An operator should be aware of and observe the operation of the overall system. A log book should be maintained, to record operating conditions and to detect deviations from normal. Both these and the following recommendations will help to prevent emergencies:

Refrigerant pipelines, hangers and valves should be checked for vibration, movement or breakage. A check should also be made for damaged insulation, broken or loose conduit, damaged wall or roof sleeves, water line leaks or roof leaks above or around ammonia piping and equipment.

Unrelated Items: Check to see that items not related to the ammonia system have not been attached to pipes or hangers, and that all obstructions have been removed from around safety equipment, valve stations, and control groups.

Leaks: Check the system for leakage. Traces of oil at flanged or screwed connections or on valve packing nuts are indicators of such a leak. Such joints should be tightened and rechecked for possible leakage.

Water systems should be checked for traces of ammonia in the water, using litmus paper (litmus will turn blue in the presence of ammonium hydroxide).

Safety valves: Check to make sure that all safety relief valves are in place and that the discharge piping from the valve outlet is correctly installed and that it is free of obstructions.

Control valves and safety switches should be inspected and checked to see that their covers are in place.

Pipeline identification: Make sure all piping is correctly identified.
WEATHER-EXPOSED PIPING should be checked for rust, deterioration, blisters, loss of paint protection, and deterioration of insulation and vapor barrier.

STEEL SUPPORT MEMBERS should be checked for deterioration.

TO SUM UP, an operator needs a good working knowledge of each system, and the ability to cope with emergencies, as well as daily routines. The prolonged safety of the system is basically the responsibility of the operator and management. Remember: Safety is a planned maintenance and operational function.

FIRST AID FOR EXPOSURE TO ANHYDROUS AMMONIA

Seconds count after exposure to anhydrous ammonia. Anhydrous ammonia, that is ammonia that is undiluted with water and is approximately 99% pure, can be damaging to body tissues in both its liquid and gaseous states.

It is especially uncomfortable and irritating to the eyes, throat, breathing passages, and skin.

EYES

Ammonia can be damaging to the eyes. The first step to take after excessive exposure to ammonia is to get into an uncontaminated area, and begin treating the eyes by flushing them with water. The eyes should be held open to assure contact with the water on the eyeball itself, and on the inner lid. The water can be splashed into the eyes, or the face can be immersed in water, and the eyes opened and closed to assure irrigation. It is very important to wash the eyes immediately with water; small water-filled squeeze bottles should be available, so that the eyes can be irrigated even en route to a larger water supply.

Flood the eyes with water for at least fifteen minutes before traveling to get the assistance of an ophthalmologist. In case of mild exposure, after the initial fifteen minutes of irrigating the eyes, use a 2% boric acid solution to flush the eyes, or two or three drops of a 0.5% Pontocaine solution or other aqueous topical anesthetic. Never put an oily preparation in the eyes following exposure to ammonia. The oil would tend to hold the ammonia in the eye and retard the eye’s natural ability to gradually expel the foreign substance. Contact lenses, if retained in the eye, would cause additional damage, since they too would hold the caustic substance on the eye. It is usually recommended that contact lenses not be worn by people working with ammonia.

In most all cases of eye exposure to ammonia, the patient should see an eye doctor (ophthalmologist) as soon as possible.

INHALATION

Because ammonia has a suffocating odor, and is very irritating, it is natural to try and get away from it. Of course, a certain amount would be inhaled. If escape should be delayed (perhaps if the victim fell unconscious before getting free of the contaminated area) and the gas were inhaled deeply, laryngeal and bronchial spasms, congestion of the lungs, and edema could occur.

After inhaling ammonia, a person should be moved to an uncontaminated area. If they experience chest or breathing passage pains, or a persistent cough, medical attention should be sought.

Oxygen is usually beneficial for the patient who has inhaled ammonia, but should not be administered by anyone but a person trained in its use. A pulmotor or other means of mechanical respiration should never be used.

If the victim stops breathing, artificial respiration should begin at once, and continue until the patient regains consciousness. An unconscious person should never be given liquid. He should be placed on his
back, in a relaxed position, covered with a blanket for warmth, and watched for signs of shock. A good "jingle" to remember when watching for or treating shock is, "Face is red, raise the head-Face is pale, raise the tail (legs)."

For the person who has a mild reaction to light ammonia exposure, but some discomfort, a 2% boric acid solution can be snuffed and used as a gargle to relieve nose and throat irritation.

**INGESTION (SWALLOWING) OF AMMONIA**

If a patient is conscious, he/she should swallow large quantities of water. If vomiting, they should be placed face down, with head lower than hips, to prevent vomitus from entering the lungs.

If the victim is in shock, or unconscious, or in pain, do not give water or induce vomiting.

Get the victim to a doctor immediately.

**SKIN CONTACT**

Liquid ammonia causes the water in the skin to freeze, expanding the cells to the point of rupture, producing burns. The skin should be flushed thoroughly with water for at least 15 minutes. If a large area has been exposed, the victim should get under or into a water source, fully clothed. Only after thorough rinsing should the clothes be carefully removed (after they have thawed).

Medications should not be applied to ammonia burns, unless applied by a physician. Some preparations will hinder the body's natural process of eliminating the ammonia from the skin.

Light burns can be treated, after long periods of flooding with water, with picric acid or a .5% solution of tannic acid, lemon juice, vinegar, or 2% solution of acetic acid. The burn will be soothed by keeping it moist with a boric acid solution until medical help arrives. Generally, treatment of these burns involves periodic saturation of the dressing with a mild oxidizing-reducing solution, like sodium thiosulfate for a twenty-four hour period.

**FIRST AID SUPPLIES**

Because ammonia is so water-soluble, and water is so important in first aid treatment, it seems only proper to mention it again in this category. In addition to a close, dependable water source, the articles shown in Table 2 should be stored in a First Aid Kit, accessible to the ammonia equipment workers, and each item labeled as to its use. No application other than water should be used except under medical supervision.

<table>
<thead>
<tr>
<th>Table 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FIRST AID SUPPLIES CHECKLIST</strong></td>
</tr>
<tr>
<td>Saturated Solution of Sodium Thiosulfate, or Sterilized Water</td>
</tr>
<tr>
<td>Sterile Compresses or Dressings</td>
</tr>
<tr>
<td>1/2 % Pontocaine Solution (with eye dropper)</td>
</tr>
<tr>
<td>Rubber bulb syringe</td>
</tr>
</tbody>
</table>
Personnel handling anhydrous or strong aqueous ammonia solutions, where skin or eye contact is likely to occur, shall wear gloves, shoe covers, and aprons impervious to ammonia. Unless eye and face protection is provided by a respirator hood or face piece, chemical goggles and face shields shall be worn. Eye and face protective equipment and its use shall conform to Federal Register 29 CFR 1910.133, as amended.

In addition to the respiratory protection specified in Table 3, personnel required to enter atmospheric ammonia concentrations likely to be more than 10,000 ppm, shall wear, under an impervious full-body suit, a self-contained breathing apparatus with a positive pressure in a full-face piece or a combination supplied-air impervious suit, continuous-flow type, with auxiliary self-contained air supply. When the worker is using the impervious suit over a self-contained breathing apparatus, staying time in the area shall be limited by the heat-stress factors involved.

Table 3

<table>
<thead>
<tr>
<th>Multiple of Ceiling (50 ppm)</th>
<th>Respirator Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than or equal to 2x</td>
<td>1) Chemical cartridge respirator with replaceable ammonia cartridge and half mask facepiece: or 2) Type C supplied air respirator, demand type (negative pressure), with half mask facepiece.</td>
</tr>
<tr>
<td>Less than or equal to 20X</td>
<td>Full face gas mask, chin type, with ammonia canister*</td>
</tr>
<tr>
<td>Less than or equal to 50X</td>
<td>1) Full face gas mask, chest or back mounted type, with industrial size ammonia canister,** or 2) Type C supply air respirator, demand or pressure-demand type (negative or positive pressure), with full facepiece, hood, or helmet with shroud.</td>
</tr>
<tr>
<td>Greater than 50X</td>
<td>1) Self-contained breathing apparatus with positive pressure in full facepiece; or 2) Combination supplied air respirator, pressure demand type, with auxiliary self contained air supply.</td>
</tr>
<tr>
<td>Emergency (no concentration limit)</td>
<td>1) Self-contained breathing apparatus with positive pressure in full facepiece; or 2) Combination supplied air respirator, pressure demand type, with auxiliary self contained air supply, or 3) Full face gas mask, back or front mounted type, with industrial size ammonia canister. Not for use in limited egress emergencies.</td>
</tr>
<tr>
<td>Evacuation or Escape (no concentration limit)</td>
<td>1) Self-contained breathing apparatus in demand or pressure demand mode (negative or positive pressure), 2) Full face gas mask, front sparing or back mounted type, with industrial size ammonia canister; or 3) Mouthpiece respirator with escape type ammonia canister (escape type gas mask).</td>
</tr>
</tbody>
</table>

*Maximum service life of 1 hour only
**Maximum service life of 2 hours only

NOTE: All respirators must be NIOSH approved.

The employer shall supply and maintain all protective clothing in a clean, sanitary, and workable condition.
Respiratory Protection

The employer shall provide appropriate respirators and ensure proper use when a variance has been granted under the provisions of the Occupational Safety and Health Act to allow respirators as a means of control of exposure in routine operations, while the application for variance is pending, or whenever atmospheric concentrations of ammonia exceed 50 ppm; for example, for non-routine operations, for occasional brief concentrations above the ceiling, or for emergencies. For these instances, a variance is not required, but the requirements set forth below continue to apply. Appropriate respirators, as described in Table 3, shall only be used pursuant to the following requirements:

1. For the purpose of determining the type of respirator to be used, the employer shall measure the atmospheric concentrations of ammonia in the workplace when the initial application for variance is made and thereafter whenever process, worksite, climate, or control changes occur which are likely to increase the ammonia concentration; this requirement shall not apply when only atmosphere-supplying positive pressure respirators are used. The employer shall ensure that no worker is being exposed to ammonia in excess of the standard because of improper respirator selection, fit, use, or maintenance.

2. A respiratory protective program meeting the requirements, as stated in the Federal Register 29 CFR 1910.134 as amended, shall be established and enforced by the employer.

3. The employer shall provide respirators in accordance with Table 3 and shall ensure that when required by circumstances the employee uses the respirator provided.

4. Any operator who may be required to wear a respirator must be deemed physically fit to do so by a physician.

5. Each area required to be posted in accordance with Section 3 (d) of the Code shall have emergency respiratory protection readily available in nearby locations which do not require entry into a contaminated atmosphere for access. Such respiratory protection shall consist of:

   a. Outdoor areas: At least 2 full-face gas masks, chest or back-mounted type, with industrial size ammonia canisters (maximum life 2 hours).

   b. Indoor areas requiring worker entry to control spills or leaking tanks: At least 2 full-face gas masks, chest or back-mounted type, with industrial size ammonia canisters.

   c. Indoor or outdoor confined spaces with limited egress, such as tanks, pits, etc., requiring worker entry: At least 2 self-contained breathing apparatus, pressure-demand type or positive-pressure.

   d. Respiratory protective devices described in Table 2 shall be those approved under the provisions of 30 CFR 11, published in the Federal Register, March 25, 1972, as amended.

   e. Respirators specified for use in higher concentrations of ammonia may be used in atmospheres of lower concentrations.

   f. The employer shall ensure that respirators are adequately cleaned, maintained, and stored when not in use, and that employees are instructed in the use of respirators assigned to them and how to test for leakage.
g. Canisters shall be discarded and replaced with fresh canisters after use. Unused canisters shall be discarded and replaced when the seal is broken, or after 3 years if seals are unbroken, or on manufacturer's recommendation, whichever is first.

Limitations of Respirators with Ammonia Canisters

In ammonia concentrations of 3% by volume (30,000 ppm), an ammonia canister will last for approximately 15 minutes. Canister respirators do not protect in atmospheres deficient in oxygen. Because emergencies involve exposures to unknown concentrations of ammonia, canister-type respirators are suitable for outdoor emergency use only. Self-contained breathing apparatus should be used in all other cases. If the odor of ammonia is noticeable while wearing a canister type gas mask, the ammonia concentration is too high for safety, or the canister is not effective. Shelf life of unopened canisters is limited, and unless the manufacturer recommends a shorter period, they should be replaced after 3 years. Used canisters should be promptly replaced.

SAFETY PROGRAMS AND PERSONNEL TRAINING

Informing Employees

At the beginning of employment, workers whose jobs may involve exposure to concentrations greater than 50 ppm, or who will work in areas required to be posted in accordance with Section 3 (d), shall be informed of the hazards, relevant symptoms of overexposure, appropriate emergency procedures, and precautions to ensure safe use and to minimize exposure. Employees should be examined by a physician and deemed physically fit to wear a respirator. First aid procedures will be included, with emphasis on the importance of prompt, copious irrigation of the eyes despite the initial lack of pain. The information shall be posted in the work area, and kept on file, readily accessible to the worker at all places of employment where ammonia is involved in unit processes and operations, or is released as a product, by-product, or contaminant.

A continuing educational program shall be instituted to ensure that all workers have current knowledge of job hazards, first aid procedures, proper maintenance procedures and cleanup methods and that they know how to correctly use respiratory protective equipment and protective clothing. Retention of this information by workers in areas required to be posted in accordance with Section 3 (d) shall be verified by drills simulating potential emergency situations appropriate to the work situation, held at intervals not exceeding 6 months. Drills should cover, but not be limited to, the following:

1. Evacuation procedures
2. Handling of spills and leaks, including decontamination
3. Location and use of emergency fire fighting equipment
4. First aid and rescue procedures
5. Use of protective clothing, and location, use, limitations and care of respiratory protective equipment
6. Location and use of shut-off valves
7. Locations, purposes, and use of safety showers, eye wash fountains, and other sources of water for emergency use
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8. Operating procedures

9. Prearranged procedures for obtaining emergency medical care

Deficiencies noted during drill shall form the basis for a continuing educational program to ensure that all workers have current knowledge. Records of drills and training conducted shall be kept and made available for inspection by authorized personnel as required.

Information as required shall be recorded on US Department of Labor Form OSHA-20 "Material Safety Data Sheet" or a similar form approved by the Occupational Safety and Health Administration, US Department of Labor. Periodic evaluations should be made of the work environment to determine ammonia levels. This information should be passed on to the employees for use in determining appropriate safety precautions in light of this program.

Safe Work Practices and Procedures

For all work areas in which there is reasonable potential for emergencies, procedures as specified below, as well as any other procedures appropriate for a specific operation or process, shall be formulated in advance and employees shall be instructed in their implementation.

Procedures shall include prearranged plans for obtaining emergency medical care and for necessary transportation of injured workers.

Training Requirements

Federal Occupational Safety and Health Standards, 29 CFR 1910.111, state that personnel required to handle ammonia should be trained in safe operating practices and in the proper action to take in the event of emergencies. It further states that employers shall ensure that ammonia unloading operations are performed by properly instructed persons. 29 CFR 1910.134 requires training in the use of respiratory protection. Other references (1, 2, 107, 111, 120) stress the importance of training and drills for emergency situations. Accordingly, a requirement for training and drills is recommended.

IDENTIFICATION CODES

The American National Standard Institute "Scheme For The Identification of Piping Systems" (ANSI A13.1) is a well-known reference for color coding all piping. It establishes colors according to classes of materials carried by the piping. Identification of pipe contents is made by using a marker or tape of prescribed background color, with printed letters also colored according to the code. Directional flow arrows are added where appropriate. It is recommended that ammonia refrigeration piping systems use the ANSI identification code.

Many operating plants also provide a valve identification tag system. It is particularly useful in operating remote equipment. There are no recognized standards for such systems.