

Chemical Safety Data Sheet SD-13

PROPERTIES AND ESSENTIAL INFORMATION

FOR

SAFE HANDLING AND USE

OF

AQUA AMMONIA

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Chemicals in any form can be safely stored, handled or used if the physical, chemical and hazardous properties are fully understood and the necessary precautions, including the use of proper safeguards and personal protective equipment, are observed.

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MANUFACTURING CHEMISTS ASSOCIATION

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Chemical Safety Data Sheet

AQUA AMMONIA

Adopted July 1947

1. NAME

Chemical Name: Ammonium Hydroxide
Common Names: Aqua Ammonia, Ammoniacal Liquor, Ammonia Liquor,
Ammonia Water
Formula: NH_4OH

2. PROPERTIES

- 2.1 Grades and Strengths. Grade A: 29.4% NH_3
Grade B: 25 % NH_3 Minimum
Grade C: 15 % NH_3 Minimum
USP : 27 to 29% NH_3
CP : 28 % NH_3

Anhydrous Ammonia is covered in Chemical Safety Data Sheet SD-8.

2.2 Important Physical and Chemical Properties

Color:

Liquid—Colorless.

NH_3 Gas—Colorless.

Odor: Pungent.

Density of 29.4% NH_3 at 15.5°C (60°F) (Water = 1): 0.8974 (26°Be)

Corrosive: To copper, copper alloys, aluminum alloys and galvanized surfaces.

Affinity for water: Gaseous ammonia is very soluble.

Light sensitive: No.

Explosive limits of NH_3 gas (per cent by volume in air): 16 to 25

Ignition temperature of NH_3 gas (Underwriters' Laboratories Report MH 2375):

651°C (1204°F)

Melting Point of 29.4%: About -72.4°C (-98°F)

TOTAL VAPOR PRESSURE OF AQUA AMMONIA

Pounds per Square Inch Absolute Pressure

% NH_3 by wt.	Temperature °F					
	32	50	80	100	120	140
10	0.6	1.1	2.5	4.2	6.7	10.1
15	1.1	1.8	3.9	6.3	9.8	14.9
20	1.7	2.7	6.0	9.7	14.8	22.2
25	2.3	4.8	9.9	15.6	23.0	34.0
30	4.6	7.4	15.2	23.1	34.5	50.3
40	11.2	17.2	32.7	48.4	69.5	97.1

Note: (a) To convert °F to °C: $(°\text{F} - 32) 5/9 = °\text{C}$

(b) To convert to lbs./sq. in. gauge pressure subtract 14.7 lbs.

2.3 Hazardous Properties

2.3.1 HEALTH HAZARDS (See 8. Health Hazards and Their Control)

Ammonia, as a gas or in aqueous solution, is a strongly irritant chemical, capable of exerting severe corrosive action locally. If handled improperly, it may cause irreparable damage or death.

Aqueous solutions of ammonia may severely injure the eyes, skin or mucous membranes on contact. Ammonia gas may cause varying degrees of irritation of the skin or mucous membranes, and may injure severely the respiratory mucosa, with possible fatal outcome.

For detailed description of health hazards and their control, see Section 8.

2.3.2 FIRE HAZARD (See 6.2)

Keep out of sun and away from heat. The vapor above the solution, when mixed with air, may be flammable within certain limits (16 to 25 per cent gaseous ammonia by volume). Such concentrations are seldom encountered in practical handling and, accordingly, the relative fire and explosion hazards are small.

Lighting fixtures and electrical equipment should be vapor-proof. If portable electric lights are necessary, they should be vapor-proof, grounded, and be equipped with a single piece of water-proof cable. They should be plugged in at a location free from ammonia gas.

Tanks, lines, and equipment should be purged or washed free of ammonia before welding. Blank off lines; do not depend on shut-off valves (see 5.7.3).

The presence of oil, or a mixture of ammonia with other combustible materials, will increase the fire hazard, and the explosive range is broadened by:

- (a) Admixture of oxygen replacing air,
- (b) Temperature and pressure higher than atmospheric.

Extinguishers: Aqueous. Ammonia is soluble in water. Hose streams are comparatively effective in removing gas from the atmosphere.

3. USUAL SHIPPING CONTAINERS

Aqua ammonia is not regulated by the Interstate Commerce Commission, but is usually shipped in ICC specification containers.

3.1 Type and Size

Tank Cars, ICC Spec. 103 or 103A.
Steel Drums, ICC Spec. 5 or 5A, 55 gallon (approx. 375 lb) or 110 gallon (approx. 750 lb) maximum.
Carboys, 13 gallon (approx. 90 lb) maximum.
Glass Bottles, 5 pint maximum, packed in outside wooden cases.

3.2 Label or Identification

3.2.1 Each container (including tank cars) should carry an identifying label or stencil.

3.2.2 The Manufacturing Chemists' Association recommends the following in addition to, or in combination with, any label warnings required by statutes, regulations, or ordinances. (See page 5).

3.3 Disposal and Return Precautions

3.3.1 Before returning shipping containers to suppliers, observe usual precautions regarding complete drainage of contents and properly close all openings. Never refill with ammonia or use containers for any other product.

3.3.2 Before returning empty tank cars, the dome cover should be tightly closed.

3.3.3 Return empty tank cars as promptly as possible, in accordance with instructions received from the shipper. Shipper's routing instructions should always be followed strictly.

3.3.4 When drums or carboys are empty, the openings should be closed properly and the containers returned promptly to the supplier.

4. UNLOADING AND EMPTYING

4.1 Health Hazards (See 8. Health Hazards and Their Control)

4.2 Fire Hazard (See 6.2 Fire Hazard)

4.3 Tank Cars

4.3.1 Unloading operations should be conducted by carefully instructed, reliable employees under adequate supervision. (See 6.3). They should be provided with proper personal protective equipment. Eye protection is extremely important because ammonia may squirt out when a closure is removed unless the container is first vented carefully. (See 6.4 and 8.3).

Drum Label

AMMONIA, AQUA

**WARNING! LIQUID CAUSES BURNS
VAPOR EXTREMELY IRRITATING**

Loosen closure cautiously before opening.
Avoid breathing vapor.
Avoid contact with eyes, skin and clothing.
In case of contact, immediately flush skin or eyes with plenty of water
for at least 15 minutes; for eyes, get medical attention.

DRUM HANDLING AND STORAGE

Keep plug up to prevent leakage.
Keep drum out of sun and away from heat.
Relieve internal pressure when received and at least weekly thereafter
by slowly loosening plug. Retighten immediately.
Drums should be grounded when being emptied.
Do not drop or slide across sharp projection.
Never use pressure to empty. Drum is not a pressure vessel.
Keep lights, fire, and sparks away from drums.
Drum must not be washed out or used for other purposes.
Replace plug after each withdrawal and return with empty drum.
In case of spillage, flush with plenty of water.

Carboy Label

AMMONIA, AQUA

**WARNING! LIQUID CAUSES BURNS
VAPOR EXTREMELY IRRITATING**

Loosen closure cautiously before opening.
Avoid breathing vapor.
Avoid contact with eyes, skin and clothing.
In case of contact, immediately flush skin or eyes with plenty of water
for at least 15 minutes; for eyes, get medical attention.

CARBOY HANDLING AND STORAGE

Before moving carboy be sure closure is securely fastened.
Avoid rough handling or dropping.
Loosen closure carefully.
Keep carboy out of sun and away from heat.
Never use pressure to empty. Carboy is not a pressure vessel.
Completely drain carboy before returning.
In case of spillage, flush with plenty of water.

4.3.2 See that the car is spotted accurately and that the track is level.

4.3.3 It is considered good practice that derrails be placed at one or both ends of the unloading track approximately one car-length from the car being unloaded, unless the car is protected by a closed and locked switch or gate.

4.3.4 The hand-brake should be set and standard rail clamps should be installed to block the wheels at the time of unloading. Metal "caution" signs should be fastened to the track. Signs should be 12" x 15", painted light blue. Use the legend "STOP TANK CAR CONNECTED", with the letters in "STOP" four inches high. Signs are available from safety equipment dealers.

4.3.5 Shipper's detailed instructions and diagrams for unloading should always be followed and all caution markings on both sides of the tank or dome should be read and observed.

4.3.6 Ammonia corrodes copper and certain alloys (see 2.2), therefore, special pipe, valves and other fittings are required. Direct contact with mercury should be avoided, because explosive compounds may be formed.

4.3.7 In the event of a leak in the tank car or fittings which cannot be repaired by simple adjustment or tightening, telephone or wire the supplier for instructions.

4.3.8 Aqua ammonia may be unloaded by gravity flow or pump through the bottom outlet valve; or by pump through the liquid discharge fitting located on the dome of the car.

4.3.8.1 The connection between the liquid line on the tank car and the unloading line to the storage tank may be made by a rubber hose (suitable for 125 pound steam service) equipped with suitable union type couplings for ammonia service (see 4.3.6). This will allow flexibility in spotting the car.

4.3.9 Tightly close the dome cover before releasing the empty car, and return the car to the shipper in accordance with his routing instructions.

4.4 Drums

4.4.1 Certain instructions, such as those for Handling, Storing, Venting, and Removal and Replacement of Body Plug in MCA Manual Sheets D-30 (for Shippers) and D-31 (for Consignees) are applicable to the drums used for aqua ammonia.

4.4.2 Drums should not be subjected to rough handling or to abnormal mechanical shock such as dropping or bumping.

4.4.3 Protective clothing, safety shoes, and goggles or face shield should be worn. (See 6.4 and 8.3)

4.4.4 Drums should be opened carefully to permit the venting of any ammonia gas which may have formed in the container. Use a wrench with a long handle, stand to one side, and face away during the operation. After plug starts, give one full turn. If accumulated pressure vents, allow it to reduce to atmospheric pressure; then only should the plug be loosened further or removed.

4.4.5 Drums should be emptied by gravity only with the use of a faucet or safety siphon fabricated of material resistant to ammonia. Application of pressure to the drum for unloading is dangerous and should not be attempted.

4.4.6 Wash away spilled aqua ammonia with large quantities of water.

4.5 Carboys

4.5.1 The instructions for handling carboys in MCA Manual Sheets C-1 (for Shippers) and C-2 (for Consignees) should be followed.

4.5.2 Protective clothing, rubber gloves, chemical safety goggles, rubber apron, and safety toe-cap boots or shoes should be worn.

4.5.3 Carefully inspect all carboys on receipt and set aside any damaged ones for special handling.

4.5.4 Be sure closures are securely fastened before moving either filled or empty carboys.

4.5.5 Place a cap or boot over the neck of the carboy before moving it.

4.5.6 Use specially designed hand-trucks for transporting individually boxed carboys about the plant. Do not use hooks.

4.5.7 Never handle carboys by the closure or neck of the bottle.

4.5.8 Never "walk" a carboy on the edge of the box.

4.5.9 When removing full or empty boxed carboys from storage tiers, trucks, or cars, and when stacking full or empty carboys, the neck of the bottle should never be tilted toward the workman.

4.5.10 Filled boxed carboys of aqua ammonia should not be tiered more than three carboys high. Empty boxed carboys should be stored on their flat sides, not over four tiers high, in such manner that the necks will not protrude into aisles or passageways.

4.5.11 When opening carboys, always keep the hands and face to the side and never over the neck of the carboy. The recommended method of removing the wire holding the stopper in place is to use a wire cutter, (preferably the face type). Never attempt to remove the wire by twisting or prying; to do so will frequently break the neck of the bottle and injure the workman.

4.5.12 Never use air pressure to empty carboys. Use a regular carboy tilter or a safety siphon fabricated of material resistant to ammonia.

4.5.13 Empty boxed carboys should be completely drained before presentation to the transportation company. Do not wash them out.

4.6 Glass Bottles. Employees handling glass bottles should be equipped with proper personal protective equipment (see 6.4 and 8.3). Handle the bottles carefully to avoid breakage. Bottles should be opened carefully to permit the venting of any ammonia gas which may have formed in the container.

5. STORAGE

5.1 Hazards

5.1.1 **HEALTH HAZARDS** (See 8. Health Hazards and Their Control)

5.1.2 **FIRE HAZARD** (See 6.2 Fire Hazard)

5.1.3 **CORROSION.** Ammonia corrodes copper and certain alloys (see 2.2), therefore, special pipe, valves and other fittings are required. Direct contact with mercury should be avoided.

5.1.4 Avoid mechanical injury or overheating of storage tanks, drums and carboys. Store away from steam pipes and heating devices, preferably in a fire resistive structure. If combustible buildings are necessary, or other combustibles are adjacent, automatic sprinklers are recommended.

5.1.5 Avoid the direct rays of the sun on storage tanks, drums or carboys. (See 2.2 Table, Total Vapor Pressure of Aqua Ammonia.)

5.2 Conditions of Storage

5.2.1 Aqua ammonia is quite volatile at atmospheric temperature and pressure and for that reason must be stored in closed containers.

5.2.2 Storage should be dry and cool.

5.2.3 If storage tanks, drums or carboys are housed in a building, or protected by sun shades, ventilation should be provided at the top of the structure so that full advantage of natural ventilation may be obtained. (See 2.2 Vapor Density.) If natural ventilation is not sufficient, then storage area should be equipped with a suitable type of mechanical ventilation. *Avoid pocketing of ammonia gas under floors, roofs, and similar structures.* (See 6.6 and 8.2.1)

5.2.4 All lighting fixtures should be vapor-proof type and all other electrical devices protected to prevent sparks within the storage area.

5.2.5 Each ammonia storage tank should be equipped with a vacuum breaker to prevent possible collapse.

5.2.6 Each storage tank should be electrically grounded for protection against electric storms.

5.2.7 Industrial gas masks approved by the United States Bureau of Mines with green canisters approved for use in ammonia should be located outside of the storage building or ammonia storage space. These masks are suitable for use only in concentrations of ammonia gas not exceeding 3 per cent and for relatively brief exposure periods, provided also that there is no atmospheric oxygen deficiency. (See 6.4 and 8.3 Personal Protective Equipment.) If the unloading site and the storage are adjacent, one set of two masks should be sufficient.

5.2.8 In laying out new storage facilities or studying existing storage, consult suppliers of ammonia and of equipment, and comply with all local, state, or other regulations.

6. HANDLING

6.1 **Health Hazards** (See 8. Health Hazards and Their Control)

6.2 **Fire Hazard.** Ammonia gas is flammable in air only at comparatively high concentrations. The explosive or flammable limits of the gas (see 2.2) are from 16 to 25 per cent by volume in air. Such concentrations are seldom encountered in practical handling. They may, however, exist in process operations, so proper design and precautions are necessary to prevent explosion and fire. The presence of oil or other flammable gases or liquids will increase the fire hazard.

6.3 Employee Education and Training (See 8.2.7)

6.3.1 Safety in handling aqua ammonia (and other hazardous or corrosive chemical products) depends upon the effectiveness of employee education, training, and supervision.

6.3.2 The education and training of the employees to work safely and to use the personal protective equipment or other safeguards provided for them is a responsibility of supervision.

6.3.3 Employee education and training should emphasize the need of handling aqua ammonia according to the methods outlined in this manual.

6.3.4 Before being placed on the job, new employees should be instructed thoroughly in the proper handling of aqua ammonia. Older employees should be reinstructed periodically.

6.3.5 Each employee should know the location, purpose, and maintenance of personal protective equipment and be thoroughly trained when and how to use it (see 8.3).

6.3.6 Each employee should know the location of safety showers, bubbler drinking fountains for flushing the eyes, and hose lines. (See 6.4.2)

6.3.7 Only reliable, dependable, and properly trained employees should be given the responsibility of operating valves which control the movement of aqua ammonia to and from storage tanks, tank cars, and containers.

6.3.8 Employees should be trained to report to the proper authority all suspected leaks or equipment failures, and any signs of illness or skin difficulties.

6.3.9 Each employee should know what to do in an emergency and in first aid measures (see 8.4), and should realize the necessity for the prompt application of first aid in case of contact with aqua ammonia or exposure to the gas.

6.4 Personal Protective Equipment (See 8.3)

6.4.1 For emergency use, protective clothing should consist of brimmed felt hat or treated fiber hat, suitable gas-tight chemical safety goggles, rubber gloves, rubber suit, and rubber safety-toe cap shoes in good condition. (See 8.3.4). Respiratory equipment as outlined in 8.3.2.2, should be used in an emergency. Industrial gas masks with canisters (see 8.3.2.1) are

not suitable for emergencies since the ammonia concentration and the oxygen deficiency are not known.

6.4.2. Clean water in ample quantities should be immediately available at unloading stations. Standard deluge type safety showers and bubbler drinking fountains for flushing the eyes are recommended. They should be located so leaks will not render them inoperative.

6.5 Engineering Controls

6.5.1. For each installation, a written set of operation instructions should be prepared and posted adjacent to operation. The procedure should be checked frequently by the supervisor in order to maintain proper controls. Suppliers will be glad to check and advise on proper operating procedures.

6.5.2 In handling or operating any type of ammonia system, always be sure that all valve connections and pipe lines are in proper order and in good condition before starting the operation. Keep pumps and motors clean and in good repair.

6.5.3 The rate at which gaseous ammonia is given off from aqua ammonia depends upon the temperature of the surrounding atmosphere and the surface area of the ammonia liquor.

6.5.4 When drums or carboys are empty, fasten the closures securely.

6.6 Ventilation. (See 8.2.1). Under normal conditions good natural ventilation should be sufficient. Ammonia gas is lighter than air and therefore tends to rise. If good natural ventilation is not available, provide mechanical ventilation such as fans, hoods, and ducts. The maximum allowable concentration is 100 ppm by volume in air for an eight hour working exposure.

6.7 Tank and Equipment Repairs

6.7.1 The hazardous nature of tank inspection or repairs requires that the foreman and crew be selected, trained, and drilled carefully. They should be fully familiar with the hazards, and the safeguards necessary for the safe performance of the work.

6.7.2. Wherever possible, enclosures should be cleaned from the outside, using clean-out doors.

6.7.3 All pipe lines into or out of the tank or other apparatus should be disconnected, preferably by removing a complete small section and

providing a blank flange on the open end to protect against human error and unsuspected leaks. Valves, cocks, and blank flanges in the pipe line should not be relied upon.

6.7.4 Danger signs should be placed suitably to indicate when workmen are in the tank or other apparatus.

6.7.5 Be sure the tank can be left by the original entrance.

6.7.6 Lock all electrical switches in the off position, remove belts, and completely safeguard against accidental starting of any agitating equipment or other moving parts located inside or adjacent to the tank entrance.

6.7.7 Before entering a tank and during the course of the work, tests should be made by a qualified person to determine if further washing is necessary; to make sure that no oxygen deficiency exists and that no harmful gases are present. Before directing men to enter a tank, an inspection of the interior should be made by the foreman equipped with a hose-type gas mask, life belt, and life line; another person should be on guard during the inspection.

6.7.8 Proper personal protective equipment should be worn by anyone entering a tank for inspection or repairs (see 6.4 and 8.3).

6.7.9 One man on the outside of the tank should keep the men in the tank under constant observation, and at least two men should be available to aid in rescue if any of those in the tank are overcome.

6.7.10 A supplied air respirator or self-contained breathing apparatus, together with rescue harness and life line, should always be located outside the tank entrance for rescue purposes, regardless of the type of respiratory equipment or air supply which is provided for employees inside the tank.

6.7.11 In addition to protecting the workmen actually engaged in cleaning and repairing the tank, attention should be paid to the protection of workers in nearby areas.

6.7.12 Cleaning or making repairs inside a tank may be hazardous even though the tank contained a non-toxic, non-flammable material. In addition to the precautions generally recommended for tank work, such as procurement of written approval of supervision, testing for oxygen deficiency, use of rescue harness or life belt and life line, provision of grounded equipment in good condition for portable electric lights and power tools, and stationing of thoroughly trained "watchers" outside of the tank entrance, additional precautions are recommended as follows:

- (a) Wash tank thoroughly with water.
- (b) Fill tank completely with water and drain out. Repeat if any ammonia gas remains.
- (c) If residual oil is found in the tank and must be removed, it should be done by steaming and draining.
- (d) Flush all lines completely with water until no ammonia gas remains.
- (e) No welding or cutting of any type should be conducted on tanks or lines until they are completely free of ammonia gas.
- (f) The previous addition of water to the tank will depacify the tank lining; consequently, if purity of product is to be maintained, it should be repacified. Details on this treatment can be obtained from the supplier.
- (g) On refilling the tank with aqua ammonia, the tank should be vented to a sewer, or absorber. The ammonia should be added carefully allowing the ammonia gas-air mixture to vent.

6.8 Exits. Areas in which ammonia hazards exist should have an adequate number of well-marked exits through which personnel can escape quickly in case of emergency. Doors should open outward and lead to outside galleries or platforms, fire escapes, or other unobstructed passageways.

7. WASTE DISPOSAL

7.1 Waste disposal of ammonia and materials containing ammonia depends to a great extent upon local conditions. Be sure that all Federal, state, and local regulations regarding health and pollution are followed. The supplier will be able to furnish good advice.

7.2 If not prohibited, waste may be disposed of by diluting with large quantities of water and washing into sewers.

8. HEALTH HAZARDS AND THEIR CONTROL

This section includes not only recognized first aid procedures and information of interest to the layman, but also suggestions which may be of value to the attending physician.

8.1 Hazards

8.1.1 GENERAL. Since ammonia has a penetrating, intensely pungent, suffocating odor, and is strongly irritant, there is little likelihood that one will remain dangerously long in an atmosphere seriously contaminated with ammonia if one is conscious and able to escape. However, serious injury may result if escape from the vapor or gas is impossible, or if one is subjected to the action of the aqueous solution (ammonia water or ammonium hydroxide). Ammonia exerts mainly a local corrosive action and is rarely absorbed into the blood stream. Its greatest danger arises from the fact that it is frequently used in combination with other chemicals as a familiar part of a process and is, therefore, not considered seriously as a hazardous agent. That ammonia may cause severe injury if it is employed improperly should be evident from the information given in the sections which follow.

8.1.2 AMMONIA—AQUEOUS SOLUTION (Ammonia Water)

Aqueous ammonia exerts a local irritant action; strong solutions cause tissue destruction on contact, whether acting on eyes, skin, mucous membrane, gastro-intestinal mucosa, or pulmonary tissue. When liquid ammonia is ingested in large quantities, there is corrosive destruction of the mucosa of the pharynx, esophagus and stomach, frequently with signs and symptoms of nausea; vomiting; pain in the throat and upper abdomen; cold, clammy skin; rapid, weak pulse; convulsions, and collapse. The swallowing of as little as a teaspoonful of concentrated ammonium hydroxide has caused death; on the other hand, recovery has followed the taking of as much as a fluid ounce.

Concentrated solutions of ammonia remaining in contact with the eye for even a short time may cause serious ocular damage, which may result in prolonged, severe visual disturbances or permanent scarring of the cornea.

When concentrated solutions of ammonia are mixed rapidly with sulfuric acid or other strong mineral acids, the mixture becomes boiling hot instantly and may result in an explosion, causing severe burns.

The consequences of skin contact with ammonia water vary from a relatively mild dermatitis to severe burns, depending upon the strength of the solution, length of contact, and individual skin sensitivity.

Ammonia gas, readily given off by aqueous solutions of ammonia, may cause severe irrita-

tion of the skin, eyes and respiratory mucosa (see 8.1.3).

8.1.3 AMMONIA—GAS

Ammonia gas in concentrations of 0.6 per cent to 1 per cent by volume is lethal within a few minutes. Irritation of the eyes, respiratory tract, and throat results from concentrations as low as 0.05 per cent to 0.1 per cent; a concentration of 0.2 per cent produces convulsive coughing and may be fatal after a short exposure, i. e., less than half an hour. The maximum concentration tolerated by the skin for more than a few seconds is 2.0 per cent (i. e., when suitable respiratory protection is worn).

The following signs and symptoms result from exposure to gaseous ammonia: burning of the eyes, conjunctivitis, skin irritation; swelling of the eyelids and lips; dry, red mouth and tongue; burning of the throat; coughing; and, in more severe cases of exposure, difficult breathing (due, in part, to a reflex laryngeal spasm); tenacious, blood-stained sputum; signs and symptoms of pulmonary congestion (pulmonary edema); and ultimate death from suffocation (asphyxia), due primarily to the congestion of all tissues of the respiratory tract. Inadequately treated cases of severe exposure who have developed pulmonary edema may occasionally contract a secondary bronchopneumonia, which may be fatal.

8.2 Prevention and Control

8.2.1 VENTILATION (See 6.6)

It is of primary importance that adequate ventilation be provided and maintained to keep the concentration of ammonia gas below 100 ppm by volume in air. Higher concentrations are dangerous for the unprotected worker.

Although special ventilating systems will not be found necessary in most processes, rooms into which ammonia might escape should have ventilating ducts leading to the outside, so that escaping gas will not contaminate adjoining areas or bar the escape of persons who may be working in them.

8.2.2 LABELING, STORAGE, AND HANDLING. (See 3., 4., 5., and 6.) Ammonia containers of all types must be properly labeled and carefully stored and handled, as previously set forth, to avoid leakage, spillage, splashing, spattering, breakage of carboys, and escape of gaseous ammonia. Supervisors should assure the handling of chemicals in such a way that unsafe mixtures, such as ammonium hydroxide with a strong acid or with chlorine, bromine, or

<i>Gaseous Concentration (ppm)</i>	<i>Effects on Unprotected Worker</i>	<i>Exposure Period</i>
50	Least detectable odor	Permissible for 8-hour working exposure
100	No adverse effects for average, unprotected worker	
400	Causes irritation of throat	Ordinarily no serious results following infrequent short exposures (less than one hour)
700	Causes irritation of eyes	
1720	Causes convulsive coughing	No exposure permissible (may be fatal after short exposure—less than half an hour)
5,000 to 10,000	Causes respiratory spasm, strangulation, asphyxia	No exposure permissible (rapidly fatal)

iodine, will not be created. It is desirable that ammonia containers be stored in a cool, sprinklered building.

8.2.3 SAFETY SHOWERS, WASHING FACILITIES AND EMERGENCY EQUIPMENT

To facilitate the quick removal of ammonia from the body and to expedite the administration of first aid, the following equipment, its location clearly marked, should be readily available to workers in areas where an ammonia hazard exists:

- Safety showers, treadle type with quick opening valves, capable of supplying large quantities of water under moderately high pressure.
- Bubbler drinking fountains, foot operated (to facilitate flushing the eyes).
- Stretcher and blanket (necessary only if the work station is located at a considerable distance from the dispenser).
- Respiratory equipment (see 8.3.2).

8.2.4 *EXITS*. Areas in which ammonia hazards exist should have an adequate number of well-marked exits through which personnel can escape quickly in case of emergency. Doors should open outward and lead to outside galleries or platforms, fire escapes, or other unobstructed passageways.

8.2.5 *PERIODIC INSPECTIONS*. (See 6.5). There should be regular, stringent inspections of all equipment and procedures employed in processes in which ammonia is manufactured, used, or transported, to check the serviceability of equipment and safety devices and to evaluate potential hazards.

8.2.6 *PHYSICAL EXAMINATION OF EMPLOYEES*. Although most employees may be assigned with impunity to processes in which ammonia is used, it is recommended that those with chronic lung disease, e. g., tuberculosis, bronchiectasis, asthma, hay fever (pollinosis), be excluded from such work. Individuals who are known to be unusually sensitive to ammonia should also be assigned work in which exposure to ammonia in any form is not possible. Special periodic physical examinations are unnecessary.

8.2.7 EMPLOYEE EDUCATION

Employees working where ammonia hazards exist should be instructed and trained in the following:

- Location of gas masks, other personal protective equipment, safety showers, bubbler drinking fountains, water hoses, exits, and first aid equipment.
- Proper use of respiratory protective devices and other personal protective equipment (see 8.3).
- The necessity for reporting at once

any unusual odor of ammonia and for removing spillage immediately by flushing contaminated areas with an abundance of water, having first taken adequate precautions to prevent personal injury.

- (d) Proper individual conduct in case of an emergency (see 8.2.8).
- (e) Methods of handling properly the several types of ammonia containers, including approved methods for moving and emptying carboys and approved procedures for cleaning pipes, storage tanks, tank cars, and pits.

8.2.8 CONDUCT IN AN EMERGENCY

When trapped in an atmosphere of ammonia and while seeking an escape to fresh air, refrain from breathing for as long a time as possible. Should it become necessary to breathe before respiratory equipment can be secured and adjusted, take only short, shallow breaths. Keeping the eyes closed as much as possible, opening them only in a squint for brief periods from time to time, will minimize eye irritation and injury.

If immediate escape is impossible, approved respiratory equipment should be donned at once. If it is not available, the effects of ammonia inhalation will be lessened slightly by tying a wet cloth over the mouth and nose (it must be clearly realized that this does *not* offer adequate protection but is merely a temporary expedient while means of escape are sought).

Since the specific gravity of ammonia is 0.597 (air = 1), it is usually safest to creep close to the floor while seeking an exit or personal protective equipment, unless, of course, an aqueous solution of ammonia has been spilled, in which case the spillage itself should be avoided.

8.3 Personal Protective Equipment

8.3.1 GENERAL. Personal protective equipment is not an adequate substitute for safe working conditions and carefulness on the part of the individual employees. Furthermore, if personal protective equipment is to be used effectively, each worker must be fully informed with respect to its proper employment and trained in its use.

8.3.2 RESPIRATORY EQUIPMENT. All respiratory equipment must be approved by the United States Bureau of Mines for the use to which it is to be put and must be used in strict

compliance with the instructions issued by the manufacturer.

8.3.2.1 Low Concentrations of Gas. Suitable respiratory protection is needed if even small concentrations of ammonia are to be encountered. For concentrations of ammonia gas not exceeding 3 per cent and for relatively brief exposure periods, an industrial gas mask with full face mask and green canister, approved by the United States Bureau of Mines, may be used, provided also that there is no atmospheric oxygen deficiency and that adequate skin and mucous membrane protection have been provided (see 8.3.4). Such respirators should be readily available at all points where such limited exposures may occur. They are not suitable for emergency, since, in emergency, the actual ammonia concentration is unknown.

8.3.2.2 High Concentrations of Gas; Prolonged Exposure; Emergencies

Where the gas concentration exceeds 3 per cent or is unknown, as in most emergency situations, or when exposure is prolonged, supplied-air respiratory equipment of appropriate design with full face masks, together with protective clothing as indicated, must be used by all persons entering the contaminated area. This is true also for oxygen-deficient atmospheres, such as those which exist frequently in storage tanks, tank cars, pits, and sewers handling ammoniacal waste.

Such supplied-air respiratory equipment consists of approved types of:

- (a) Hose masks, with or without air pump, as may be required to maintain an adequate air supply (hose inlet must be in a vapor-free atmosphere).
- (b) Air line masks with compressed air supply, equipped with a suitable filter and a proper reducing valve or other device designed to effect delivery of air to the face piece under optimum pressure.

NOTE: Hose or air line masks are suitable for use only where conditions will permit safe escape in case of failure of the air supply.

- (c) Self-contained breathing apparatus with proper reducing valve and filter, containing an adequate supply of stored oxygen or air (such equipment allows greater mobility but usually requires more training for its proper employment).

8.3.2.3 Inspections. Gas masks and other respiratory protective equipment must be in-

spected at regular intervals and should be cleaned and serviced after each use. It is particularly important that canisters and oxygen cylinders be replaced before they become exhausted.

8.3.3 RESCUE HARNESS. A safety belt and life line should be used in every case where the wearer of respiratory equipment enters a confined, irrespirable atmosphere (see 6.7). A man should be stationed outside the contaminated area to act in case of an emergency; this attendant should also be provided with adequate protective equipment in case it becomes necessary for him to enter the contaminated area.

8.3.4 EYE, SKIN AND MUCOUS MEMBRANE PROTECTION

The following protective equipment should be used as required for protection of the eyes, skin and mucous membranes:

- (a) Cotton shirt, trousers, and underwear (cotton resists alkalis better than does wool).
- (b) Rubber boots, gloves, apron and coat (rubber is more resistant to ammonia than is leather).
- (c) Rubber hat or felt hat with broad brim.
- (d) Safety goggles of an approved type.

For optimum protection the collar should be kept buttoned, glove gauntlets should be tucked inside of sleeves, and trouser legs should be left outside of boots.

In areas of high ammonia concentration, ammonia may condense on any body area subject to perspiration even though appropriate protective clothing is worn. The severe discomfort caused by such condensation may be minimized or prevented by the application of protective oil to such body areas in addition to the wearing of protective clothing.

CAUTION: Protective creams alone do not afford adequate protection.

8.4 First Aid and Medical Treatment

8.4.1 GENERAL PRINCIPLES. Speed in removing ammonia from contact with the patient and in moving the patient to an uncontaminated atmosphere is of primary importance. In all cases of severe injury call a physician at once giving him a complete, accurate account of the accident. Until the physician arrives, and after having accomplished as thor-

ough removal of the ammonia as possible, keep the patient comfortably warm and quiet. Take such specific actions as may be indicated (see 8.4.2).

8.4.2 SPECIFIC ACTIONS

8.4.2.1 Inhalation

A worker who has been overcome by gaseous ammonia must be carried at once into an uncontaminated atmosphere and effective artificial respiration initiated immediately if breathing has ceased. A physician should be called at once.

In order to prevent the development of severe lung congestion (pulmonary edema), 100 per cent oxygen should be administered as soon as possible after a severe exposure. Oxygen administration is most effective if expiration is made against a positive pressure of 6 cm (about 2 1/8 inches) of water. This may be accomplished readily by use of a rubber tube connected to the outlet valve of a snugly fitting face mask and inserted to a depth of not more than 6 cm below the surface of water in a suitable container. The pressure resisting exhalation should be adjusted to the patient's tolerance by varying the depth of the end of the tube below the water's surface. Oxygen inhalation must be continued as long as necessary to maintain the normal color of the skin and mucous membranes. In cases of severe exposure, the patient should breathe 100 per cent oxygen under positive exhalation pressure for one-half hour periods every hour for at least three hours. If there are no signs of lung congestion at the end of this period, breathing is easy, and the color is good, oxygen inhalation may be discontinued. Throughout this time the patient should be kept comfortably warm but not hot.

Stimulants will rarely be necessary where adequate oxygenation is maintained. Any such drugs or shock treatment should be given only by the attending physician. Never attempt to give anything by mouth to an unconscious patient.

8.4.2.2 Contact with Skin and Mucous Membranes

All contaminated clothing should be removed at once. The affected areas should be washed thoroughly with large quantities of cool water, followed, if available, with lemon juice, vinegar, or a 2 per cent solution of acetic acid, and finally, once again with large quantities of water.

Under no condition should salves or ointments be applied to skin or mucous mem-

brane burns during the twenty-four hour period following the injury. During this time the burns should be covered with dressings kept wet continuously with a mild oxidizing-reducing solution, such as a saturated solution of sodium thiosulfate. The patient should be kept comfortably warm. For persistent cases of skin irritation or for serious burns of the skin or mucous membranes, a physician should be consulted immediately.

8.4.2.3 Contact with Eyes

If even minute quantities of aqua ammonia enter the eyes, they should be irrigated immediately and copiously with water for a minimum of 15 minutes. The eye lids should be held apart during the irrigation to insure contact of water with all the tissues of the surface of the eye and lids. A physician should be called in attendance at the first possible moment, preferably an eye specialist. If a physician is not immediately available, the eye irrigation should be continued for a second period of 15 minutes. After the first 15 minute period of irrigation is completed, it is permissible, as a first aid measure, to instill two or three drops of an 0.5 per cent pontocaine solution or an equally effective aqueous topical anesthetic. No oils or oily ointments should be instilled unless ordered by the physician.

Ophthalmologists may be interested in a method of treatment for chemical burns of the eye described by Ralph S. McLaughlin, "Chemical Burns of the Human Cornea", American Journal of Ophthalmology, 29:1355, 1946.

8.4.2.4 Taken Internally

Call a physician immediately, telling him the nature of the accident. If patient is conscious, encourage the drinking of large quantities of water followed, if available, by dilute vinegar, lemon juice, cider or other weak acid juices, such as orange or lime. Administer a demulcent such as raw egg, milk or cream, barley water or olive oil. If the patient does not vomit spontaneously, stimulate vomiting by having him tickle the back of the throat. Keep the patient warm and quiet until the physician arrives. Administer oxygen or artificial respiration if necessary.

WARNING: Signs and symptoms of shock, such as pallor; coldness of the extremities; weak, rapid, or irregular pulse; or stupor, as well as changes in the rate and depth of respiration, should be reported immediately to the attending physician, and treated only as directed by him.

Never attempt to give anything by mouth to an unconscious patient!

The medical information in this publication has been supplied by the Medical Advisory Committee of the Manufacturing Chemists' Association

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