

Occupational Health Guideline for Ammonia

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: NH_3
- Synonyms: Anhydrous ammonia
- Appearance and odor: Colorless gas with a penetrating, pungent, suffocating odor; it can be a liquid under pressure.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for ammonia is 50 parts of ammonia per million parts of air (ppm) averaged over an eight-hour work shift. This may also be expressed as 35 milligrams of ammonia per cubic meter of air (mg/m^3). NIOSH has recommended that the permissible exposure limit be changed to a ceiling of 50 ppm ammonia ($35 \text{ mg}/\text{m}^3$) averaged over a five-minute period. The NIOSH Criteria Document for Ammonia should be consulted for more detailed information.

HEALTH HAZARD INFORMATION

- Routes of exposure
Ammonia can affect the body if it is inhaled or if it comes in contact with the eyes or skin. It may also affect the body if it is swallowed.
- Effects of overexposure
1. Short-term Exposure: Ammonia is a severe irritant of the eyes, respiratory tract, and skin. It may cause burning and tearing of the eyes, runny nose, coughing, chest pain, cessation of respiration, and death. It may cause severe breathing difficulties which may be delayed in onset. Exposure of the eyes to high gas

concentrations may produce temporary blindness and severe eye damage. Exposure of the skin to high concentrations of the gas may cause burning and blistering of the skin. Contact with liquid ammonia may produce severe eye and skin burns. Contact of the eyes, nose, throat, and skin with solutions of ammonia may produce severe burns.

2. Long-term Exposure: Repeated exposure to ammonia gas may cause chronic irritation of the eyes and upper respiratory tract.

3. Reporting Signs and Symptoms: A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to ammonia.

- Recommended medical surveillance

The following medical procedures should be made available to each employee who is exposed to ammonia at potentially hazardous levels:

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Examination of the eyes and respiratory tract should be stressed. The skin should be examined for evidence of chronic disorders.

—14" x 17" chest roentgenogram: Ammonia causes human lung damage. Surveillance of the lungs is indicated.

—FVC and FEV (1 sec): Ammonia is a respiratory irritant. Persons with impaired pulmonary function may be at increased risk from exposure. Periodic surveillance is indicated.

2. Periodic Medical Examinations: The above medical examinations should be repeated on an annual basis, except that an x-ray is necessary only when indicated by the results of pulmonary function testing, or by signs and symptoms of respiratory disease.

- Summary of toxicology

Ammonia vapor is a severe irritant of the eyes, especially the cornea, the respiratory tract, and skin. Inhalation of concentrations of 2500 to 6500 ppm causes dyspnea,

These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

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bronchospasm, chest pain and pulmonary edema which may be fatal; production of pink frothy sputum often occurs. Consequences can include bronchitis or pneumonia; some residual reduction in pulmonary function has been reported. In a human experimental study which exposed 10 subjects to various vapor concentrations for 5 minutes, 134 ppm caused irritation of the eyes, nose, and throat in most subjects and 1 person complained of chest irritation; at 72 ppm, several reported the same symptoms; at 50 ppm, 2 reported nasal dryness and at 32 ppm only 1 reported nasal dryness. In a survey of 8 workers in a blueprint shop, ammonia concentrations of 4 to 29 ppm caused "barely noticeable" to "moderate" eye irritation; no respiratory irritation was reported. Tolerance to usually irritating concentrations of ammonia may be acquired by adaptation, a phenomenon frequently observed among workers who became inured to the effects of exposure; no data are available on concentrations that are irritating to workers who are regularly exposed to ammonia and who presumably have a higher irritation threshold. Liquid anhydrous ammonia in contact with the eyes may cause serious eye injury or blindness; on the skin it causes first- and second-degree burns which are often severe, and if extensive, may be fatal. Vapor concentrations of 10,000 ppm are mildly irritating to the moist skin, while 30,000 ppm or greater causes a stinging sensation and may produce skin burns and vesiculation. Increased cancer has been reported in workers exposed to high levels of ammonia and amines, although lack of details makes evaluation difficult.

CHEMICAL AND PHYSICAL PROPERTIES

• Physical data

1. Molecular weight: 17
2. Boiling point (760 mm Hg): $-33.4\text{ C }(-28\text{ F})$
3. Specific gravity (water = 1): Liquid 0.67 at boiling point
4. Vapor density (air = 1 at boiling point of ammonia): 0.6
5. Melting point: $-77.7\text{ C }(-108\text{ F})$
6. Vapor pressure at 20 C (68 F): Greater than 1 atmosphere
7. Solubility in water, g/100 g water at 20 C (68 F): 51
8. Evaporation rate (butyl acetate = 1): Not applicable

• Reactivity

1. Conditions contributing to instability: Elevated temperatures may cause containers to explode.
2. Incompatibilities: Contact with strong oxidizers may cause fires and explosions. Contact with calcium, hypochlorite bleaches, gold, mercury, and silver may form highly explosive products. Contact with halogens may cause violent spattering.
3. Hazardous decomposition products: None.
4. Special precautions: Liquid ammonia will attack some forms of plastics, rubber, and coatings.

• Flammability

1. Flash point: Not applicable
2. Autoignition temperature: $651\text{ C } (1204\text{ F})$
3. Flammable limits in air, % by volume: Lower: 16; Upper: 25
4. Extinguishant: Stop flow of gas.

• Warning properties

1. Odor Threshold: The AIHA *Hygienic Guide* states that "ammonia is a colorless gas with a characteristic odor detectable at 1 to 5 ppm."
2. Eye Irritation Level: Grant states that "ammonia is slightly irritant to human eyes at a concentration of 140 ppm in air and immediately irritating at 700 ppm."
3. Other Information: The *Hygienic Guide* states that "irritation of the respiratory tract in workers inhaling 100 ppm has been found, but 55 ppm was unobjectionable."
4. Evaluation of Warning Properties: Because of its low thresholds of odor and irritation, ammonia is treated as a material with good warning properties.

MONITORING AND MEASUREMENT PROCEDURES

• Eight-Hour Exposure Evaluation

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

• Ceiling Evaluation

Measurements to determine employee ceiling exposure are best taken during periods of maximum expected airborne concentrations of ammonia. Each measurement should consist of a fifteen (15) minute sample or series of consecutive samples totalling fifteen (15) minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three (3) measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

• Method

Sampling and analyses may be performed by collection of vapors using an adsorption tube with a subsequent chemical analysis of the adsorption tube. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure ammonia may be used. An analytical method for ammonia is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 5, 1979, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00349-1).

RESPIRATORS

- Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.
- In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

- Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent any possibility of skin contact with liquid anhydrous ammonia or aqueous solutions of ammonia containing more than 10% by weight of ammonia and to prevent the skin from becoming frozen from contact with vessels containing liquid anhydrous ammonia.
- Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent repeated or prolonged skin contact with solutions containing 10% or less by weight of ammonia.
- Where there is any possibility of exposure of an employee's body to liquid anhydrous ammonia or aqueous solutions containing more than 10% ammonia by weight, facilities for quick drenching of the body should be provided within the immediate work area for emergency use.
- Non-impervious clothing which becomes contaminated with anhydrous ammonia or aqueous solutions containing more than 10% ammonia by weight should be removed immediately and not reworn until the ammonia is removed from the clothing.
- Non-impervious clothing which becomes wet with solutions containing 10% ammonia by weight or less should be removed promptly and not reworn until the ammonia is removed from the clothing.
- Clothing wet with liquid anhydrous ammonia or aqueous solutions of ammonia should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of ammonia

from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the ammonia, the person performing the operation should be informed of ammonia's hazardous properties.

- Employees should be provided with and required to use splash-proof safety goggles where there is any possibility of liquid anhydrous ammonia or aqueous solutions containing more than 10% ammonia by weight contacting the eyes.
- Employees should be provided with and required to use splash-proof safety goggles where solutions containing 10% ammonia by weight or less may contact the eyes.
- Where there is any possibility that employees' eyes may be exposed to liquid anhydrous ammonia or aqueous solutions containing more than 10% ammonia by weight, an eye-wash fountain should be provided within the immediate work area for emergency use.

SANITATION

- Skin that becomes contaminated with liquid anhydrous ammonia or solutions containing more than 10% ammonia by weight should be immediately washed or showered to remove any ammonia.
- Skin that becomes wet with solutions containing 10% ammonia by weight or less should be promptly washed or showered to remove any ammonia.
- Employees who handle liquid anhydrous ammonia or aqueous solutions of ammonia should wash their hands thoroughly before eating, smoking, or using toilet facilities.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to ammonia may occur and control methods which may be effective in each case:

Operation	Controls
Use as a chemical in manufacture of fertilizers, as solvent in manufacture of textiles, leather, and pulp and paper processing; as a stabilizer in rubber manufacture	Process enclosure; local exhaust ventilation; general dilution ventilation; personal protective equipment

Operation

Use in organic and inorganic synthesis of nitric acid, urea, plastics, fibers, synthetic resins, pharmaceuticals, pesticides, explosives, rocket fuels, cyanides, amides, dyestuffs, amines, flame retardants, and household cleaners

Use in mining/metallurgy ore extraction and purification, treatment of scrap metal, annealing, atomic hydrogen welding, electronics, nitriding steel

Use in petroleum refining as a neutralizing agent; manufacture and recovery of cracking catalysts; and in dewaxing of lubrication oils

Use as a refrigerant in food installations, production of ice, cold-storage, food lockers, deicing

Use during blueprinting and photography, electroplating, and as a laboratory reagent

Controls

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containing ammonia, or high concentrations of ammonia gas penetrate through the clothing, remove the clothing immediately and flush the skin with water. If irritation or burns are present after washing, get medical attention.

• Breathing

If a person breathes in large amounts of ammonia, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• Swallowing

When ammonia has been swallowed and the person is conscious, give the person large quantities of water immediately to dilute the ammonia. Do not attempt to make the exposed person vomit. Get medical attention immediately.

• Rescue

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL AND LEAK PROCEDURES

• Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

• If ammonia is spilled or leaked, the following steps should be taken:

1. Ventilate area of spill or leak to disperse gas.
2. If in gaseous form, stop flow of gas. If source of leak is a cylinder and the leak cannot be stopped in place, remove the leaking cylinder to a safe place in the open air, and repair the leak or allow the cylinder to empty.
3. If in liquid form, allow to vaporize.

REFERENCES

- American Conference of Governmental Industrial Hygienists: "Ammonia," *Documentation of the Threshold Limit Values for Substances in Workroom Air* (3rd ed., 2nd printing), Cincinnati, 1974.
- American Industrial Hygiene Association: "Ammonia," *Hygienic Guide Series*, Detroit, Michigan, 1971.
- Deichmann, W. B., and Gerarde, H. W.: *Toxicology of Drugs and Chemicals*, Academic Press, New York, 1969.
- Gleason, M. N., Gosselin, R. E., Hodge, H. C., and Smith, R. P.: *Clinical Toxicology of Commercial Products* (3rd ed.), Williams and Wilkins, Baltimore, 1969.
- Grant, W. M.: *Toxicology of the Eye* (2nd ed.), C. C. Thomas, Springfield, Illinois, 1974.
- "Exposure to Ammonia, Proposed Standards," *Federal Register*, 40:54684-54693, November 25, 1975.

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• Eye Exposure

If liquid anhydrous ammonia, solutions containing ammonia, or high concentrations of ammonia gas get into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.

• Skin Exposure

If liquid anhydrous ammonia, strong solutions of ammonia, or high concentrations of ammonia gas get on the skin, immediately flush the contaminated skin with water. If liquid anhydrous ammonia, strong solutions

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RESPIRATORY PROTECTION FOR AMMONIA

Condition	Minimum Respiratory Protection* Required Above 50 ppm
Gas Concentration	
100 ppm or less	Any chemical cartridge respirator with an ammonia cartridge(s). Any supplied-air respirator. Any self-contained breathing apparatus.
300 ppm or less	A chemical cartridge respirator with a full facepiece and an ammonia cartridge(s).
500 ppm or less	A gas mask with a chin-style or a front- or back-mounted ammonia canister. Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
Greater than 500 ppm** or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	Any gas mask providing protection against ammonia. Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.

**Use of supplied-air suits may be necessary to prevent skin contact while providing respiratory protection from airborne concentrations of ammonia; however, this equipment should be selected, used, and maintained under the immediate supervision of trained personnel. Where supplied-air suits are used above a concentration of 500 ppm, an auxiliary self-contained breathing apparatus operated in positive pressure mode should also be worn.

