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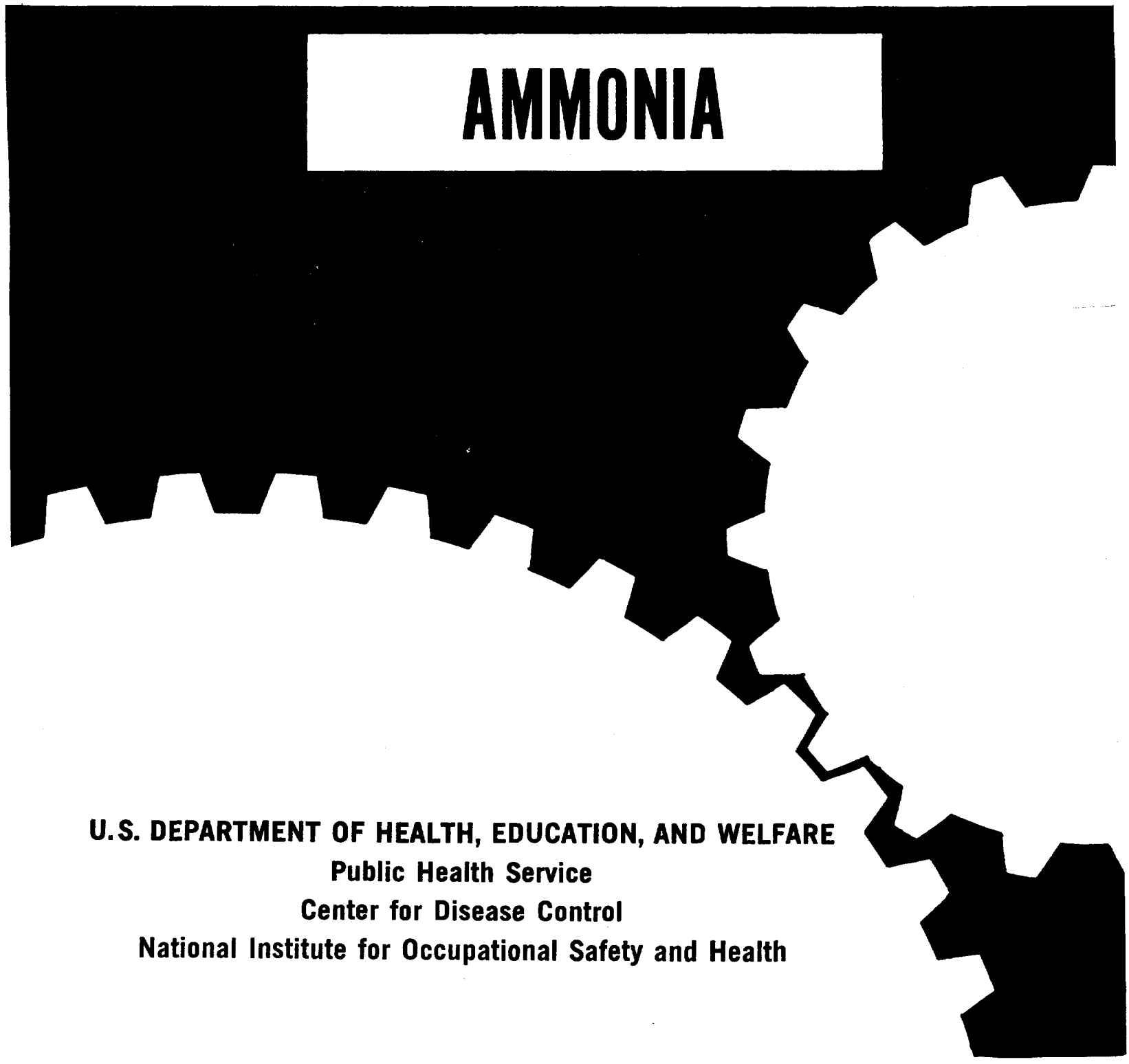
OCCUPATIONAL EXPOSURE TO AMMONIA



U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Center for Disease Control
National Institute for Occupational Safety and Health

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OCCUPATIONAL EXPOSURE TO AMMONIA

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1974

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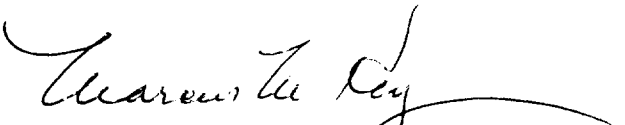
PREFACE

The Occupational Safety and Health Act of 1970 emphasizes the need for standards to protect the health and safety of workers exposed to an ever-increasing number of potential hazards at their workplace. To provide relevant data from which valid criteria and effective standards can be deduced, the National Institute for Occupational Safety and Health has projected a formal system of research, with priorities determined on the basis of specified indices.

It is intended to present successive reports as research and epidemiologic studies are completed and sampling and analytic methods are developed. Criteria and standards will be reviewed periodically to ensure continuing protection of the worker.

I am pleased to acknowledge the contributions to this report on ammonia by members of my staff, by the Review Consultants on Ammonia, by the ad hoc committee of the Industrial Medical Association, by Robert B. O'Connor, M.D., NIOSH consultant in occupational medicine, and by Edwin C. Hyatt, NIOSH consultant on respiratory protection. The NIOSH recommendations for standards are not necessarily a consensus of all the consultants and professional societies that reviewed this criteria document on ammonia. Lists of the NIOSH Review Committee members and of the Review Consultants appear on the following pages.



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The Office of Research and Standards Development, National Institute for Occupational Safety and Health, had primary responsibility for development of the criteria and recommended standard for ammonia. The University of Washington School of Public Health and Community Medicine developed the basic information for consideration by NIOSH staff and consultants under contract No HSM-99-73-36. Bryan D. Hardin had NIOSH program responsibility and served as criteria manager.

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CRITERIA DOCUMENT: RECOMMENDATIONS FOR AN OCCUPATIONAL EXPOSURE STANDARD FOR AMMONIA

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I. RECOMMENDATIONS FOR AN AMMONIA STANDARD

The National Institute for Occupational Safety and Health (NIOSH) recommends that worker exposure to ammonia be controlled by requiring compliance with the following sections. The standard is designed to protect the health and safety of workers for a 40-hour workweek over a working lifetime. Compliance with all sections of the standard should prevent adverse effects of exposure to ammonia in the workplace air. The standard is measurable by techniques that are valid, reproducible, and available to industry and government agencies. Sufficient technology exists to permit compliance with the recommended standard. The standard will be subject to review and revision as necessary.

"Ammonia" is defined as gaseous or liquified anhydrous ammonia and aqueous solutions thereof (aqua ammonia, ammonium hydroxide). "Strong aqua ammonia" is defined as aqueous solutions containing more than 10% ammonia. "Weak aqua ammonia" is defined as solutions of 10% or less.

Section 1 - Environmental (Workplace Air)

(a) Concentration

Occupational exposure shall be controlled so that no worker is exposed to ammonia at greater than a ceiling concentration of 50 ppm as determined by a 5-minute sampling period.

(b) Sampling and Analysis

Procedures for sampling, calibration of equipment, and analysis of ammonia samples shall be as provided in Appendices I and II, or by any method shown to be equivalent in precision, accuracy, and sensitivity to the methods specified.

Section 2 - Medical

(a) Preplacement medical examinations shall be made available for all workers whose employment may involve potential exposure to ammonia concentrations in excess of 50 ppm. The examination shall be directed toward, but not limited, to the eyes, skin, and upper respiratory system. Pulmonary function tests should be carried out at the time of the preplacement examination. An evaluation of the advisability of the worker's using negative or positive pressure respirators shall be made.

(b) Medical surveillance shall be made available for all workers in whose eyes liquid ammonia has been splashed, who have signs and symptoms of eye irritation after exposure to ammonia, who exhibit signs or symptoms of respiratory tract (throat, trachea, lungs) irritation caused by ammonia exposure, or who experience skin irritation as a result of ammonia exposure.

(c) Initial examinations for presently employed workers shall be made available within 6 months of the promulgation of a standard incorporating these recommendations.

(d) Records of preplacement medical examinations and of required medical surveillance shall be maintained for the period of employment. The medical representatives of the Secretary of Health, Education, and Welfare, of the Secretary of Labor, of the employer, and of the employee shall have access to all medical records.

Section 3 - Labeling (Posting)

(a) Containers of anhydrous ammonia shall be marked in accordance with 29 CFR 1910.111 as amended and shall bear the following label in

addition to or in combination with labels required by other statutes, regulations, or ordinances:

AMMONIA, ANHYDROUS

DANGER! HAZARDOUS LIQUID AND GAS

LIQUID CAUSES BURNS

GAS EXTREMELY IRRITATING

Do not breathe gas

Do not get in eyes, on skin, on clothing

In case of exposure, evacuate to fresh air

In case of contact, immediately flush skin or eyes with plenty of water for at least 15 minutes. Get medical attention at once in case of eye contact or burns to the nose or throat, or if the patient is unconscious.

CYLINDER HANDLING AND STORAGE

Keep away from heat

Never drop cylinders

Be sure connections are tight

Loosen closure carefully

Never refill cylinders. ICC Regulations prohibit refilling without permission of owner.

Have airline respirator or self-contained breathing apparatus available for emergency

(b) Containers of strong aqua ammonia (greater than 10%) shall bear the following label in addition to or in combination with labels required by other statutes, regulations, or ordinances:

AMMONIUM HYDROXIDE (STRONG AQUA AMMONIA)

WARNING! LIQUID CAUSES BURNS

GAS EXTREMELY IRRITATING

Avoid breathing gas

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

HANDLING AND STORAGE

Before moving containers, be sure closure is securely fastened

Avoid rough handling or dropping

Loosen closure carefully

Keep out of sun and away from heat

Completely drain container before returning to supplier

In case of spillage, flush with plenty of water

(c) Containers of weak aqua ammonia (10% or less) shall bear the following label in addition to or in combination with labels required by other statutes, regulations, or ordinances:

AMMONIUM HYDROXIDE (AQUA AMMONIA)

CAUTION! IRRITATING LIQUID AND GAS

Loosen closure carefully

Avoid breathing gas

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

In case of spillage, flush with plenty of water

(d) The following warning sign shall be affixed in a readily visible location at or near entrances to areas containing anhydrous or strong aqua ammonia and in which there is a reasonable potential for emergencies. This sign shall be printed both in English and in the predominant language of non-English-speaking workers, unless they are otherwise trained and informed of the hazardous areas. All illiterate workers shall receive such training.

WARNING!

AMMONIA HAZARD AREA

UNAUTHORIZED PERSONS KEEP OUT

In emergency, do not enter unless wearing respiratory, eye, and skin protection.

CAUSES BURNS--SEVERE EYE HAZARD

INHALATION OF HIGH CONCENTRATIONS MAY BE FATAL

GAS MASKS LOCATED AT (specific locations to be supplied by employer)

(e) All anhydrous ammonia systems, piping, and associated equipment shall comply with 29 CFR 1910.111, as amended. Shut-off valves of all ammonia systems shall be conspicuously labeled.

Section 4 - Personal Protective Equipment

(a) Protective Clothing

(1) Personnel handling anhydrous or strong aqua ammonia 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 afforded by a respirator hood or facepiece, chemical goggles and face shields shall be worn. Eye and face protective equipment and its use shall conform to 29 CFR 1910.133, as amended.

(2) In addition to the respiratory protection specified in Table I-1, 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 facepiece 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, stay time in the area shall be limited with due consideration to the heat stress factors involved.

(3) The employer shall supply and maintain all protective clothing in a clean, sanitary, and workable condition.

(b) Respiratory Protection

The employer shall provide appropriate respirators and ensure proper use when a variance has been granted under the provisions of the Occupa-

tional 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, eg, for nonroutine operations, for occasional brief concentrations above the ceiling, cr 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 I-1 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 concentration 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 of 29 CFR 1910.134 as amended shall be established and enforced by the employer.

(3) The employer shall provide respirators in accordance with Table I-1 and shall ensure that when required by circumstances the employee uses the respirator provided.

(4) Each area required to be posted in accordance with Section 3(d) shall have emergency respiratory protection readily available

TABLE I-1
RESPIRATOR SELECTION GUIDE FOR PROTECTION AGAINST AMMONIA

Multiples of Ceiling	Respirator Type
Less than or equal to 2X	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.
Less than or equal to 20X	Fullface gas mask, chin type, with ammonia canister.*
Less than or equal to 50X	1) Fullface gas mask, chest or back mounted type, with industrial size ammonia canister;** or 2) Type C supplied air respirator, demand or pressure demand type (negative or positive pressure), with full facepiece, hood, or helmet with shroud.
Greater than 50X	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.
Emergency (no concentration limit)	1) Self-contained breathing apparatus with positive pressure in full facepiece; 2) Combination supplied air respirator, pressure demand type, with auxiliary self-contained air supply; or 3) Fullface gas mask, back or front mounted type, with industrial size ammonia canister. Not for use in limited egress emergencies.
Evacuation or Escape (no concentration limit)	1) Self-contained breathing apparatus in demand or pressure demand mode (negative or positive pressure); 2) Fullface gas mask, front or back mounted type, with industrial size ammonia canister; or 3) Mouthpiece respirator with escape type ammonia canister (escape type gas mask).

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

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 fullface 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 fullface 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 (positive pressure). In addition, see Work Practices requirements in Section 6(f)(2).

(5) Respiratory protective devices described in Table I-1 shall be those approved under the provisions of 30 CFR 11, published in the Federal Register, March 25, 1972, as amended.

(6) Respirators specified for use in higher concentrations of ammonia may be used in atmospheres of lower concentrations.

(7) The employer shall ensure that respirators are adequately cleaned, maintained, and stored when not in use, and that employees are instructed on the use of respirators assigned to them and on testing for leakage.

(8) Canisters shall be discarded and replaced with fresh canisters after use. Unused canisters shall be discarded and replaced when the seal is broken, after 3 years if seals are unbroken, or on the manufacturer's recommendation, whichever is first.

Section 5 - Informing Employees of Hazards from Ammonia

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. 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, byproduct, 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:

Evacuation procedures

Handling of spills and leaks, including decontamination

Location and use of emergency firefighting equipment

First aid and rescue procedures

Use of protective clothing and location, use, and care of respiratory protective equipment

Location and use of shut-off valves

Location, purpose, and use of safety showers, eye wash fountains, and other sources of water for emergency use

Operating procedures

Entry procedures for confined spaces

Prearranged procedures for obtaining emergency medical care.

Deficiences noted during the 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.

Section 6 - Work Practices

(a) Emergency Procedures

For all work areas in which there is a 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.

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

(2) Approved eye, skin, and respiratory protection as specified in Section 4 shall be used by personnel essential to emergency operations.

(3) Nonessential employees shall be evacuated from exposure areas during emergencies. Perimeters of areas of hazardous exposures shall be delineated, posted, and secured.

(4) Personnel shall keep upwind of spills or leaks if possible. Personnel properly trained in the procedures and adequately protected against the attendant hazards shall shut off sources of ammonia, clean up spills, and immediately repair leaks.

(5) Water sprays to absorb ammonia gas or to dilute aqua ammonia shall be used as needed. Water used to absorb ammonia shall not be discharged to municipal or confined sewers unless adequately diluted or otherwise treated to meet applicable local, state, or federal discharge and water pollution regulations. Water should not be used on large spills of liquid anhydrous ammonia because heat generated may increase volatilization of the ammonia with consequent increase of exposure.

(6) In case of fire, ammonia sources shall be shut off or removed. Containers shall be cooled with water spray. Chemical foam or dry chemicals shall be used for fighting anhydrous ammonia fires, and proper respiratory protection and protective clothing shall be worn.

(b) Control of Airborne Ammonia

(1) Engineering controls such as process enclosure or local exhaust ventilation shall be used to maintain ammonia concentrations within the limits of the recommended standard. Ventilation systems shall be designed to prevent the accumulation or recirculation of ammonia in the

workroom and to effectively remove ammonia from the breathing zones of workmen. Exhaust ventilation systems discharging to outside air must conform with applicable local, state, and federal air pollution regulations. Ventilation systems shall be subject to regular preventive maintenance and cleaning to ensure maximum effectiveness, which shall be verified by periodic airflow measurements.

(2) General ventilation may be used to reduce room concentrations of ammonia if worker exposure is not increased thereby.

(c) Storage

(1) Anhydrous ammonia shall be stored in accordance with the provisions of 29 CFR 1910.111, as amended.

(2) Strong aqua ammonia shall be stored in:

(A) Cool, dry, well ventilated areas located outside buildings or in sections especially provided for ammonia.

(B) Areas free from oxidizers and sources of ignition. Due consideration shall be given to health and fire hazards, population density, and proximity of water supplies when locating ammonia storage areas.

(C) Containers which are protected from heat, corrosion, and mechanical damage.

(D) Closed containers which are provided with safety relief valves as necessary.

(d) Waste Disposal

(1) Disposal of waste ammonia shall conform to all applicable local, state, and federal regulations. Rapid neutralization of large amounts of ammonia, or addition of water to liquid anhydrous ammonia is not

desirable because the heat generated may increase exposure of personnel. If regulations permit, spills shall be diluted with water, carefully neutralized, and discharged to the sewer with a large excess of water.

(2) Any discharges of ammonia to the atmosphere shall be controlled to prevent injury.

(e) General Work Practices

(1) Written operating instructions and emergency medical procedures shall be formulated and posted where ammonia is handled or used.

(2) Contact lenses should not be worn when working with ammonia.

(3) Ammonia should never be mixed with chlorine bleach. To do so releases the hazardous gas chloramine.

(4) Metals other than iron or steel should not be used in contact with ammonia.

(5) Containers and systems shall be handled and opened with care to avoid sudden release of pressure. Approved eye and respiratory protection shall be worn while opening, connecting, or disconnecting ammonia containers and systems. When opening containers and systems, adequate ventilation shall be available to remove inadvertent discharges of ammonia.

(6) Containers and systems shall be frequently inspected for leaks. All ammonia equipment including hose fittings and connections shall be inspected frequently for tightness and good working order. Needed repairs and adjustments shall be promptly made.

(7) Workers should stand upwind when transferring ammonia and in a position from which the operation can be controlled. Workers

should not stand in direct line of any valve or fitting opening, particularly the openings of safety relief valves, in order to avoid being sprayed with ammonia.

(8) Inadvertent entry of ammonia into disconnected containers and systems while work is in progress shall be prevented by blanking off ammonia supply lines.

(9) Work areas where ammonia is handled or used shall be equipped with sources of water. Permanent installations shall have eye wash fountains and safety showers. Hoses shall be available for washing down spills and decontaminating surfaces where applicable.

(10) Mobile operations involving handling of anhydrous or strong aqua ammonia shall have at least 5 gallons of clean, fresh water available in a readily accessible container. If necessary, these containers shall be protected from freezing by insulation or by an external source of heat. More than 5 gallons may be needed based on the number of workers or their dispersion. A means of utilizing this water for flushing eyes and skin, such as a dipper or squeeze bottle, shall be available.

(11) Unauthorized personnel shall not be permitted to enter areas required to be posted in accordance with Section 3(d).

(12) Work areas shall be kept clean and orderly. Accesses to ammonia shut-off valves shall be kept unobstructed. Shut-off valves shall be conspicuously marked.

(f) Work Practices for Specific Operations or Areas

The following is not intended to be a comprehensive or complete listing. It is presented to emphasize and clarify the requirements, in

addition to those listed under General Work Practices, for the following operations or areas.

(1) Ammonia Hazard Areas

Exits from areas required to be posted in accordance with Section 3(d) shall be plainly marked. Emergency exit doors shall be conveniently located and shall open into areas which will remain free of contamination in an emergency.

(2) Confined Spaces

(A) Tanks, pits, tank cars, process vessels, tunnels, sewers, etc, which have contained ammonia shall be thoroughly ventilated, tested for ammonia, and inspected prior to entry.

(B) Inadvertent entry of ammonia into the confined space while work is in progress inside shall be prevented by disconnecting and blanking off ammonia supply lines.

(C) Confined spaces shall be ventilated to keep any ammonia concentration below the standard and to prevent oxygen deficiency.

(D) Personnel entering confined spaces shall be equipped with a lifeline tended by another worker outside the space. The worker on the outside shall be equipped with approved respiratory, eye, and skin protection.

(E) Entry into confined spaces shall be controlled by a permit system. Permits shall be signed by an authorized employer representative certifying that preparation of the confined space, precautionary measures, personal protective equipment, and procedures to be used are all adequate.

(3) Enclosed Spaces

Enclosed spaces (rooms, buildings, etc) which ordinarily are safe to enter but which, due to the failure of a system inside, could contain hazardous concentrations of ammonia should have a continuous automatic monitor set to sound an alarm outside the enclosed space if ammonia concentrations exceed the recommended standard. If such areas are not monitored in this way, the enclosed space shall be entered only if the worker is under observation by a co-worker or if the worker has in his possession a respirator suitable for escape.

(4) Diazo-type Reproducing Operations

(A) Diazo-type reproducing equipment shall have mechanical local exhaust ventilation to control ammonia escaping from the machine, from the paper discharged from the machine, and during refilling of reservoirs with ammonia.

(B) Anhydrous or aqua ammonia containers should be stored outdoors or in ventilated rooms separate from the reproducing machine room.

(C) Approved protective clothing, eye and respiratory protection shall be used when handling ammonia, or connecting or disconnecting ammonia containers.

(5) Laboratories

Work with ammonia in laboratories shall take place in properly designed and functioning laboratory hoods. Approved eye and skin protection should be worn while handling ammonia.

(6) Nitriding Furnaces

Exhaust ventilation shall be installed over the vent.

(7) Agricultural Operations

(A) Farm vehicles for transporting ammonia shall conform to the provisions of 29 CFR 1910.111, as amended.

(B) When manipulating or adjusting ammonia dispensing equipment or when working in close proximity to it (for example, see (E) and (G), below), agricultural workers shall use approved chemical goggles or face shields, and gloves impervious to ammonia.

(C) Individual plastic squeeze bottles holding at least 8 ounces of water shall be carried by each worker for flushing ammonia from eyes without delay.

(D) For washing ammonia from eyes and skin, at least 5 gallons of clean, potable water shall be carried with all fertilizer nurse and applicator tanks. The container shall be checked daily and be protected as necessary from freezing by insulation or by an external source of heat. A dipper or other means of utilizing the water shall be carried.

(E) All ammonia equipment including hose fittings and connections shall be checked frequently for tightness and good working order.

(F) Farm workers shall be thoroughly indoctrinated in correct operating procedures before using ammonia equipment.

(G) Workers should stand upwind when transferring ammonia and in a position where the operation can be controlled. Workers should not stand in direct line of any valve or fitting opening, particularly the openings of safety relief valves, in order to avoid being sprayed with ammonia.

(H) Farm workers shall be alerted to the possible buildup of hazardous concentrations of ammonia gas in enclosed spaces from the biological decay of organic material such as manure. Barns, chicken houses, and similar buildings should be well ventilated.

Section 7 - Sanitation Practices

(a) It is most important that adequate supplies of clean water be available in areas where ammonia is handled or used. Speed is imperative in the removal of ammonia in contact with the eyes or skin by flushing with copious quantities of water.

(b) General plant housekeeping should be of a high order, assuring that escape routes and ammonia control equipment are kept clear. Plant sanitation shall meet the requirements of 29 CFR 1910.141, as amended.

Section 8 - Monitoring and Recordkeeping Requirements

Workroom areas shall be monitored for ammonia exposure if environmental levels, as determined on the basis of an industrial hygiene survey or by the judgment of a compliance officer, exceed half of the 5-minute ceiling of 50 ppm. Records of these surveys, including the basis for concluding that air levels are below 25 ppm, shall be maintained until a new survey is conducted. Surveys shall be repeated when any process change indicates a need for reevaluation or at the discretion of the compliance officer.

Requirements set forth below apply to areas in which there is exposure to 25 ppm or more. Employers shall maintain records of environmental

exposures to ammonia based upon the following sampling and recording schedules:

(a) In all monitoring, samples representative of the exposure in the breathing zone of at least 25% of the employees in each operation or process shall be collected. Each worker shall be included in the sampling at least every 2 years.

(b) The first environmental sampling shall be completed within 6 months of the promulgation of a standard incorporating these recommendations.

(c) Environmental samples shall be taken as soon as possible, but no later than 30 days after first operation of a new process or process changes.

(d) Samples shall be collected at least semiannually in accordance with Appendix I for the evaluation of the work environment with respect to the recommended standard.

(e) Environmental monitoring of an operation or process shall be repeated at least weekly when the ammonia concentration has been found to exceed the recommended environmental standard. In such cases, suitable controls shall be initiated and monitoring shall continue at weekly intervals until 3 consecutive surveys indicate the adequacy of these controls. Monitoring need not be repeated at weekly intervals if the excessive exposure was the result of an unusual but readily identified and corrected cause such as a minor accidental spill. However, in such cases immediate action shall be taken to reduce exposure and to prevent a recurrence.

(f) Records of environmental measurements shall be maintained so that exposure information is available for individual employees and shall be maintained for the duration of that worker's employment. Records shall indicate the type of personal protective devices, if any, in use at the time of sampling. Each employee shall be able to obtain information on his own environmental exposure.

II. INTRODUCTION

This report presents the criteria and the recommended standard based thereon which were prepared to meet the need for preventing occupational diseases arising from exposure to ammonia. The criteria document fulfills the responsibility of the Secretary of Health, Education, and Welfare, under Section 20(a)(3) of the Occupational Safety and Health Act of 1970 to "...develop criteria dealing with toxic materials and harmful physical agents and substances which will describe...exposure levels at which no employee will suffer impaired health or functional capacities or diminished life expectancy as a result of his work experience."

The National Institute for Occupational Safety and Health (NIOSH), after a review of data and consultation with others, formalized a system for the development of criteria upon which standards can be established to protect the health of workers from exposure to hazardous chemical and physical agents.

Ammonia is a chemically simple compound with diverse properties that make it a widely used substance. It is a readily assimilated form of reduced nitrogen, so it is widely used as a fertilizer in the form of anhydrous or aqua ammonia or as the source of nitrogen for dry fertilizers; it has a boiling point of -33 C (-27 F) and is easily liquified, so it is useful in refrigeration systems; and it is a volatile alkali, thus useful for cleaning. Its alkaline properties make it a skin and eye irritant, but it is especially dangerous to the eyes because of its initially silent but subsequently blinding action. It is an annoying gas whose offensiveness can be readily confused with toxic effects. This offensiveness provides

excellent warning properties, but perhaps has helped obscure proper attention to possible long-term toxic properties.

These criteria for a standard for ammonia are part of a continuing series of criteria developed by NIOSH. The proposed standard applies to the processing, manufacture, use of, or other occupational exposure to ammonia as applicable under the Occupational Safety and Health Act of 1970. The standard was not designed for the population-at-large, and any extrapolation beyond occupational exposures is not warranted. It is intended to (1) protect against injury from ammonia, (2) be measurable by techniques that are valid, reproducible, and available to industry and official agencies, and (3) be attainable with existing technology.