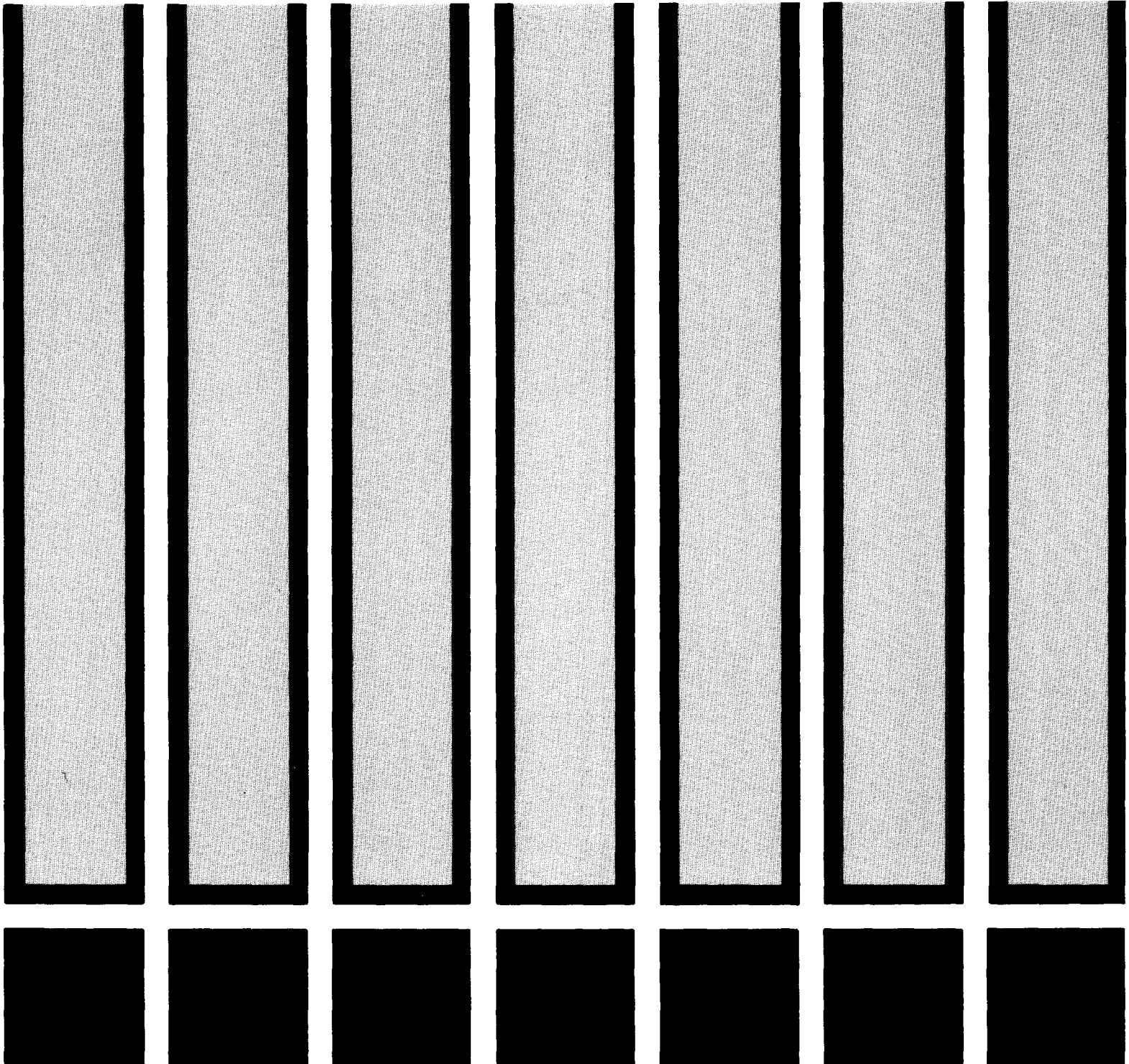


**criteria for a recommended standard
occupational exposure to**

NITRIC ACID



criteria for a recommended standard....

**OCCUPATIONAL EXPOSURE
TO
NITRIC ACID**



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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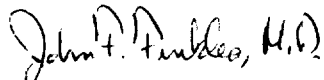
PREFACE

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. The National Institute for Occupational Safety and Health has projected a formal system of research, with priorities determined on the basis of specified indices, to provide relevant data from which valid criteria for effective standards can be derived. Recommended standards for occupational exposure, which are the result of this work, are based on the health effects of exposure. The Secretary of Labor will weigh these recommendations along with other considerations such as feasibility and means of implementation in developing regulatory standards.

It is intended to present successive reports as research and epidemiologic studies are completed and as sampling and analytical 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 nitric acid by members of my staff and the valuable constructive comments by the Review Consultants on Nitric Acid, ad hoc committees of the American Industrial Hygiene Association and the American Occupational Medical Association, by Robert B. O'Connor, M.D., NIOSH consultant in occupational medicine, and by Mary O. Amdur, Ph.D., NIOSH consultant in toxicology. The

NIOSH recommendations for standards are not necessarily a consensus of all the consultants and professional societies that reviewed this criteria document on nitric acid. 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 the recommended standard for nitric acid. Tabershaw-Cooper Associates, Inc. developed the basic information for consideration by NIOSH staff and consultants under contract No. HSM 99-73-26. B. Thomas Scheib served as criteria manager and Douglas L. Smith, Ph.D., had NIOSH program responsibility for development of the document.

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CRITERIA DOCUMENT: RECOMMENDATIONS FOR OCCUPATIONAL EXPOSURE
STANDARD FOR NITRIC ACID

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I. RECOMMENDATIONS FOR A NITRIC ACID STANDARD

The National Institute for Occupational Safety and Health (NIOSH) recommends that exposure to nitric acid in the workplace be controlled by compliance with the following sections. The standard is designed to protect the health and safety of workers for up to a 10-hour workday, 40-hour workweek over a working lifetime. Compliance with the standard should prevent adverse effects of occupational exposure to nitric acid. The standard is measurable by techniques that are valid, reproducible, and available. Sufficient technology exists to permit compliance with the recommended standard. The standard will be subject to review and revision as necessary.

"Nitric acid" is defined as the aqueous solutions of nitric acid and the vapor and mist thereof. "Occupational exposure to nitric acid" is defined as exposure to airborne concentrations of nitric acid equal to or exceeding one-half the recommended workroom environmental limit. Adherence only to sections 3, 4(a), 4(b), 4(c) (1) (C), 5, and 6 is required when workplace environmental concentrations of nitric acid are not greater than one-half of the recommended workplace environmental limit. It must be recognized that a potential exposure to oxides of nitrogen exists whenever airborne nitric acid is present in the workplace environment. Therefore, sampling for oxides of nitrogen, as specified in Criteria for a Recommended Standard....Occupational Exposure to Oxides of Nitrogen, must accompany measurements for airborne nitric acid.

Section 1 - Environmental (Workplace Air)

(a) Concentration

Occupational exposure to nitric acid shall be controlled so that no worker is exposed to a concentration of nitric acid vapor in excess of 2 ppm of air (5 mg/cu m air) determined as a time-weighted average (TWA) exposure for up to a 10-hour workday, 40-hour workweek.

(b) Sampling and Analysis

Procedures for sampling, calibration of equipment, and analysis 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

Medical surveillance shall be made available as specified below for all workers occupationally exposed to nitric acid.

(a) Preplacement and periodic medical examinations shall include:

- (1) Comprehensive or interim work and medical histories.
- (2) 14" x 17" posterior-anterior chest X-ray.
- (3) Pulmonary function tests including, as a minimum, a measurement of Forced Vital Capacity (FVC) and Forced Expiratory Volume in the first second (FEV 1).
- (4) Visual examination of the teeth for evidence of dental erosion.
- (5) A judgment of the worker's physical ability to use negative or positive pressure respirators as specified in 29 CFR 1910.134.

(b) Periodic examinations shall be at 1-year intervals or at some other frequency to be determined by the responsible physician.

(c) Proper medical management shall be provided for workers exposed to nitric acid.

(d) Initial annual examinations for presently employed workers shall be offered within six months of the promulgation of a standard incorporating these recommendations.

(e) The medical representatives of the Secretary of Health, Education, and Welfare, of the Secretary of Labor, and of the employer shall have access to all pertinent medical records. Physicians designated and authorized by any employee or former employee shall have access to that worker's medical records.

(f) Medical records shall be maintained for persons employed one or more years in work involving exposure to nitric acid. X-rays for the 5 years preceding termination of employment and all medical records with pertinent supporting documents shall be maintained at least 20 years after the individual's employment is terminated.

Section 3 - Labeling (Posting)

(a) Containers of nitric acid shall carry a label, and areas where exposure to nitric acid is likely to occur shall be posted with a sign, on which the following is stated:

NITRIC ACID
DANGER! CAUSES SEVERE BURNS
VAPOR EXTREMELY HAZARDOUS
SPILLAGE MAY CAUSE FIRE OR LIBERATE DANGEROUS GASES

Do not breathe vapor.

Do not get in eyes, on skin, on clothing.

In case of contact, immediately flush skin or eyes with plenty of water for at least 15 minutes. Get medical attention.

(b) The above label shall be in addition to, or in combination with, labels required by other statutes, regulations, or ordinances.

(c) The warning sign shall also be printed in the predominant language of non-English-speaking workers. All employees shall be trained and informed of the hazardous areas, with special instruction given to illiterate workers.

Section 4 - Personal Protective Equipment

Engineering controls shall be used to maintain nitric acid concentrations below the prescribed limit. Requirements for personal protective equipment shall be as approved under provisions of 29 CFR 1910 (Federal Register 37:22102, October 18, 1972, as amended).

(a) Skin Protection

(1) Skin contact with concentrated nitric acid will produce burns at the site of contact. Impervious protective clothing, such as rubber gloves, aprons, suits, and boots shall be provided by the employer and used by the employee when there is a likelihood of body contact with liquid acid.

(2) Nitric acid-wetted clothing shall be flooded with water and then removed promptly.

(3) All protective clothing and equipment shall be maintained in a clean, sanitary, and workable condition.

(b) Eye Protection

Eye protective equipment shall be provided by the employer and used by the employee where potential for eye contact with liquid nitric acid exists.

(1) Selection, use, and maintenance of eye protective equipment shall be in accordance with provisions of the American National Standard Institute Practice for Occupational and Educational Eye and Face Protection, ANSI Z87.1-1968.

(2) Chemical safety goggles -- Cup-type, cover-cup-type, or rubber-framed goggles, equipped with approved impact-resistant glass or plastic lenses, shall be worn whenever using or handling concentrated nitric acid.

(3) Face shields -- If there is danger of nitric acid striking the eyes or around the sides of the face, a full length, 8-inch minimum plastic shield with forehead protection shall be worn in addition to chemical safety goggles.

(c) Respiratory Protection (1) Engineering controls shall be used wherever feasible to maintain airborne nitric acid concentrations below the prescribed limit. Compliance with the permissible exposure limit may not be achieved by the use of respirators except:

(A) During the time period necessary to install or test the required engineering controls.

(B) For nonroutine operations such as a brief exposure to concentrations in excess of the permissible exposure limit as a result of maintenance or repair activities.

(C) During emergencies when air concentrations of nitric acid may exceed the permissible limit.

(2) When a respirator is permitted by paragraph (c) (1) of this Section, it shall be selected and used pursuant to the following requirements. For the purpose of determining the type of respirator to be used, the employer shall measure the atmospheric concentration of nitric acid in the workplace initially and thereafter whenever process, worksite, climate, or control changes occur which are likely to increase the airborne nitric acid concentrations; this requirement shall not apply when only atmosphere-supplying positive pressure respirators will be used. The employer shall ensure through proper respirator selection fit, use, and maintenance that no worker is being exposed to airborne nitric acid in excess of the standard.

(3) A respiratory protective program meeting the general requirements outlined in Section 3.5 of American National Standard Institute Practices for Respiratory Protection Z88.2-1969 shall be established and enforced by the employer. In addition, Sections 3.6 (Program Administration), 3.7 (Medical Limitations), and 3.8 (Approval) shall be adopted and enforced.

(4) The employer shall provide respirators in accordance with Table I-1 and shall ensure that the employee uses the respirator provided.

(5) Respiratory protective devices described in Table I-1 shall be those approved under provisions of 30 CFR 11.

(6) Respirators specified for use in higher concentrations of nitric acid are permitted in atmospheres of lower concentrations.

(7) Employees shall be given instructions on the use of

respirators assigned to them, day-to-day maintenance and cleaning of the respirators, and how to test for leakage.

(8) Emergency and escape-type respirators shall be made immediately available at the work stations for each worker.

TABLE I-1
REQUIREMENTS FOR RESPIRATOR USAGE

Maximum Use Concentration (Multiples of Limit for Airborne Nitric Acid)	Respirator Type
Less than or equal to 125 mg/cu m	(1) A chemical cartridge respirator with a full facepiece and cartridge(s) providing protection against airborne nitric acid and oxides of nitrogen
	(2) A gas mask with a chin-style or front- or back-mounted canister providing protection against airborne nitric acid and oxides of nitrogen
	(3) Any supplied-air respirator with a full facepiece, helmet, or hood
	(4) Any self-contained breathing apparatus with a full facepiece
Less than or equal to 250 mg/cu m	(1) Type C supplied-air respirator operated in demand mode (negative pressure) with full facepiece
	(2) Self-contained breathing apparatus operated in demand mode (negative pressure) with full facepiece

TABLE I-1 (CONTINUED)

REQUIREMENTS FOR RESPIRATOR USAGE

Maximum Use Concentration (Multiples of Limit for Airborne Nitric Acid)	Respirator Type
Less than or equal to 500 mg/cu m	(1) Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure mode or with a full facepiece, hood, or helmet operated in continuous flow mode
Greater than 100 X or entry and escape from unknown concentrations	(1) Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode (2) 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
Firefighting	(1) Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode
Emergency, Escape	(1) Self-contained breathing apparatus operated in pressure-demand mode (positive pressure) with full facepiece

Section 5 - Informing Employees of Hazards from Nitric Acid

At the beginning of employment in a nitric acid area, employees exposed to nitric acid shall be informed of all hazards, relevant symptoms of overexposure, appropriate emergency procedures, and proper conditions and precautions for safe use or exposure. Instruction shall include, as a minimum, all information in Appendix III which is applicable to nitric acid. The information shall be posted in the work area and kept on file and readily accessible to the worker at all places of employment where nitric acid is used.

A continuing educational program shall be instituted to ensure that all workers have current knowledge of job hazards, proper maintenance procedures and cleanup methods, and correct use of respiratory protective equipment and protective clothing.

Information as specified in Appendix III 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

Protection against hazards from nitric acid requires the development and employment of sound work practices for use during routine operations as well as in emergencies. Procedures designed to prevent nitric acid contact with tissues must be used in the manufacturing, handling, transfer, and storage of the acid, in the cleaning, maintenance, and repair of tanks, other vessels, piping, and other appurtenances with which the acid may come in contact, as well as in the prevention, minimization, cleanup, and disposal of acid spills. Appropriate personal protective equipment must be

provided and used. There must also be equipment and procedures to ensure immediate flushing off of any acid coming in contact with the eyes or skin. In addition, suitable plans must be developed and personnel trained in the procedures to be followed in the event of major emergencies, such as large spills of nitric acid, massive release of airborne nitric acid or nitrogen oxides, fire, explosion, or other hazardous occurrences.

The mechanics of handling, transfer, and storage of nitric acid will be related to the quantities involved, depending upon whether it is received in bottle, carboy, drum, tank truck, or tank car lots. The US Department of Transportation regulations governing the packaging and other requirements for shipment of nitric acid are found in 49 CFR 100-199 for highway and rail, in 14 CFR 103 for air, and in 46 CFR 146-149 for water.

(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 where large spills of nitric acid or massive release of nitrogen oxides may occur, shall be formulated in advance and employees shall be instructed in their implementation.

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

(2) All employees shall be evacuated from exposure areas during emergencies. Authorized personnel shall reenter only after donning proper eye, skin, and respiratory protection equipment and clothing.

(3) All injured personnel shall be removed upwind to a fresh air environment and a physician shall be called immediately. If the

injured person is not breathing, give artificial respiration. If breathing is difficult, give oxygen. Remove any contaminated clothing and shoes. In case of contact with material, immediately flush skin or eyes with running water (low pressure) for 15 minutes. Keep the patient warm and quiet.

(4) For the purpose of flushing any acid coming in contact with body tissues, safety showers and eyewash fountains shall be readily available in areas where nitric acid is being handled. The safety showers should have quick-acting valves and deluge-type heads. Eyewash fountains and safety showers should be inspected every 7 days. Also, each safety item shall have a tag to be dated and initialed at each inspection.

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

(b) Handling and Storage

(1) Carboys and drums of nitric acid shall be inspected, when received, for signs of leakage or damage. Any of the latter in damaged condition shall be set aside for special handling. Any tanks (rail, truck, etc) containing nitric acid shall be inspected for leaks before they are allowed to enter the plant. Necessary precautions shall be taken for prompt and safe unloading of leaking vehicles. The regulations of the US Department of Transportation (49 CFR, Chapters I and III) for the loading and unloading of tank cars, tank trucks, and portable tanks shall be adhered to.

(2) Only capable, trained employees shall be permitted to make connections from tank trucks or tank cars to receiving tanks. Moreover, the receiving tank must be properly vented. Wherever practicable, unloading should be done by pumping. If compressed air must be used, the pressure must never exceed the safe working pressure of the tank, and the

pressure must never exceed 30 pounds per square inch gauge (psi) under any circumstances.

(3) Storage shall be in noncorrosive containers fabricated of materials suitable for the concentration of the acid. Storage shall be out of the direct rays of the sun, preferably under cover. The storage area shall be isolated from materials such as turpentine, carbides, metallic powders, and combustible materials. Storage tanks shall not be used for purposes of bleaching the acid. Stored containers shall be inspected at least once a week for signs of leakage.

(4) Areas where nitric acid is stored, transferred, or used shall be posted with warning signs containing the same information specified in Section 3(a). Posted areas shall delineate locations where eating and food storage are prohibited.

(5) Carboys and drums of nitric acid shall be emptied by gravity or siphon, never by pressure. Faucets or siphons shall be made of material resistant to nitric acid, and siphons must not be started orally. Employees opening such containers shall wear goggles, face shields, and rubber gloves. Where the potential exists for exposure to either airborne nitric acid or oxides of nitrogen when opening drums or carboys, respiratory protective equipment shall be worn.

(6) Transfer of nitric acid from one container to another, or into any process, shall be performed in such a manner as to minimize the potential for leaks and spills. The safe practices described in Chemical Safety Data Sheet SD-5, "Properties and Essential Information for Safe Handling and Use of Nitric Acid," issued by the Manufacturing Chemists Association, are recommended.

(c) Spills, Leaks, and Waste Disposal

(1) In the event of spills or leaks of nitric acid, the contaminated area shall be immediately zoned off and flushed with copious amounts of water in order to dilute the acid as rapidly as possible. The water should be supplied through low pressure systems in order to avoid conveyance of the acid to uncontaminated areas. Water spray should also be used to absorb oxides of nitrogen. Contact with combustibles or organic materials such as sawdust, excelsior, wood scraps and shavings, paper, cotton waste, and burlap bags shall be prevented. Contact of nitric acid with such materials can result in spontaneous combustion. In the absence of water, clean sand or other noncombustible material may be employed to prevent the spread of the acid.

(2) Waste (including tank washings) or spilled nitric acid shall be diluted or neutralized before disposal. Soda ash, lime, slaked lime, or other alkali or alkaline earth metal carbonates and bicarbonates may be used for neutralization.

(3) All local, state, and federal regulations concerning waste disposal to streams, waste treatment plants, or impounding basins shall be followed.

(4) All employees handling nitric acid, or who might be involved in cleanup operations in the event of a leak or spill, shall be instructed in the safe practices involved in such work, including not only the prevention of skin contact with the acid, but also the prevention of inhalation of either the acid vapor or the oxides of nitrogen. Instruction shall be given before the employee commences such work. A continuing educational program on these instructions (or improvised ones) should be instituted to ensure responsible and efficient handling of emergency situations.

(d) Cleaning and Repair

(1) Cleaning, inspecting, and repairing tanks which contain or have contained nitric acid shall be under the direction of thoroughly trained personnel who are aware of the potential health, safety, fire, and explosion hazards. Tanks and equipment, pumps, lines, and valves should be drained and thoroughly flushed with water before being repaired. Personal contact with liquid from such equipment should be avoided. Pipe lines leading from tanks shall be sealed with blanks during maintenance of pumps, lines, valves, or ancillary equipment. After tanks to be entered have been flushed, soda ash, lime, or slaked lime shall be used to neutralize any residual acid. The tank shall then be purged with air and tested for oxides of nitrogen before personnel are permitted to enter. Testing shall be done by using nitrogen dioxide detector tubes certified by the National Institute for Occupational Safety and Health or portable, direct reading nitrogen dioxide meters of at least equivalent sensitivity and reliability. The tank atmosphere shall not be considered safe for use without respiratory protection until no discoloration is observed in the detector tube.

(2) No one shall enter a tank or confined space until a work permit has been signed by an authorized employer representative certifying that the area has been tested and found safe, or that preparation of the confined space, precautionary measures, including personal protective equipment, and procedures to be followed are all adequate.

(3) Personnel entering confined spaces shall be furnished with appropriate personal protective equipment and protected by a lifeline

tended outside the space by another worker who shall also be equipped for entry with approved respiratory, eye and skin protection, and a lifeline, and who shall have contact with a third party.

(4) Mechanical ventilation of the tank is required where the levels of airborne nitric acid, oxides of nitrogen, and oxygen are unknown.

(e) Ventilation

(1) Where operations or processes result in the evolution of nitric acid vapor or mist, or oxides of nitrogen, ventilation shall be provided which will protect employees from airborne concentrations in excess of the standard specified in Criteria for a Recommended Standard....Occupational Exposure to Oxides of Nitrogen. Ventilation systems shall be designed to prevent the accumulation or recirculation of nitric acid vapor or the oxides of nitrogen in the workroom and to effectively remove such vapors and gases from the breathing zones of workers.

(2) Ventilation systems shall be inspected quarterly and shall be subject to regular preventive maintenance and cleaning. Ventilation efficiency shall be assessed at the time of inspection by air-flow measurements in accordance with procedures recommended by the American Conference of Governmental Industrial Hygienists. [1]

(3) Exhaust ventilation systems discharging to outside air must conform with applicable local, state, and federal air pollution regulations.

Section 7 - Monitoring and Recordkeeping

(a) Workers are considered "occupationally exposed" to nitric acid if environmental levels, as determined on the basis of an industrial

hygiene survey conducted within 6 months of the promulgation of this standard, equal or exceed one-half of the TWA limit. Records of these surveys, including the basis for concluding that airborne levels are below the level defining "occupational exposure," shall be maintained. Surveys shall be repeated within 30 days of installing new equipment or processes, process modifications, or worksite changes which are likely to result in an increase of airborne nitric acid. If it has been decided that nitric acid levels equal or exceed the level defining "occupational exposure," then the following requirements apply.

(1) A program of personal monitoring shall be instituted to identify and measure or permit calculation of the exposure of all employees occupationally exposed to nitric acid.

(2) Routine monitoring of employee exposure shall be conducted at least semiannually.

(3) If an employee monitoring program measurement reveals that an employee is exposed in excess of the recommended limit as prescribed in Section 1(a), the exposure of that employee shall be monitored at 15-day intervals. Measures designed to control employee exposure to nitric acid shall be implemented, and the employee shall be notified of his or her exposure as well as the control measures being implemented. Monitoring shall continue until 2 consecutive determinations indicate that employee exposure no longer exceeds the recommended environmental limit. Semiannual monitoring may then be resumed.

(4) In all personal monitoring, samples representative of the exposure in the breathing zone of the employee shall be collected. Procedures for sampling, calibration of equipment, and analysis of airborne

nitric acid samples shall be as provided in Section 1(b).

(5) For each TWA determination, a sufficient number of samples shall be taken to characterize the employee's exposure during each workshift. The accuracy of the sampling and analytical methods as well as the variation of employee exposure shall be considered in determining whether full-period consecutive sampling, partial-period consecutive sampling, or partial-period nonconsecutive sampling is used. A determination of compliance with the recommended environmental limit shall be made based upon the accuracy of the sampling and analytic methods, the frequency and type of sampling, and the recommended environmental limit as prescribed in Appendix I.

(6) The number of representative TWA determinations for an operation or process shall be based upon the mobility of the workers and the variation in work procedures in that operation or process.

(b) The employer shall keep records on all industrial hygiene surveys and all breathing zone TWA determinations. Records of the latter shall include the determined concentration of exposure and a description of the monitoring, sampling, and analytic methods. In addition, records shall be maintained on the types of respirators and personal protective equipment, if any, worn by employees. The monitoring records shall identify the employees for whom breathing zone air samples were collected, and the employer shall make such records available to representatives of the Secretary of Health, Education, and Welfare, of the Secretary of Labor, and to the employee or former employee.

(c) The employer shall keep the records of all environmental monitoring on the levels of airborne nitric acid for each employee for whom breathing zone air samples were collected for at least 20 years after the employee's employment is terminated.

II. INTRODUCTION

This report presents the criteria and the recommended standards based thereon which were prepared to meet the need for preventing occupational diseases resulting from exposure to nitric acid. 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. It should be pointed out that any criteria and recommended standard should enable management and labor to develop better engineering controls resulting in more healthful work practices and should not be used as a final goal.

These criteria for a standard for nitric acid are in a continuing series of criteria developed by NIOSH. The proposed standard applies to the processing, manufacture, and use of nitric acid as applicable under the Occupational Safety and Health Act of 1970.

One of the more important chemicals in use in American industry, nitric acid presents a dual problem of skin and eye contact hazard from the liquid acid as well as one from inhalation of the acid vapor or mist.

Since the vapor, if present in the work environment, usually occurs in varying mixtures with oxides of nitrogen, reference is frequently made to the provisions and information contained in Criteria for a Recommended Standard....Occupational Exposure to Oxides of Nitrogen.

The development of the recommended standard for occupational exposure to nitric acid has revealed deficiencies or limitations in the available data in the following areas:

(1) epidemiologic data which focus on changes in the pulmonary system or the incidence of chronic obstructive pulmonary diseases in workers exposed to nitric acid vapor and mist in the occupational environment;

(2) acute changes in pulmonary function in both humans and experimental animals exposed to low concentrations of airborne nitric acid;

(3) chronic effects of long-term low-level exposure in experimental animals exposed 8-10 hours/day for 12-18 months;

(4) mutagenic, carcinogenic, or teratogenic effects of exposure to nitric acid; and

(5) additive, synergistic, or inhibitory effects of nitric acid in combination with hydrocarbons, fibrous dusts, and other pulmonary irritants on neoplastic dose-response relationships.