Occupational Health Guideline for Nitric Oxide

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: NO
- Synonyms: Nitrogen monoxide
- Appearance and odor: Colorless gas with a sharp, sweet odor. In high concentrations, nitric oxide turns brown rapidly in air.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for nitric oxide is 25 parts of nitric oxide per million parts of air (ppm) averaged over an eight-hour work shift. This may also be expressed as 30 milligrams of nitric oxide per cubic meter of air (mg/m³). NIOSH has recommended a permissible exposure limit of 25 ppm (30 mg/m³) averaged over a work shift of up to 10 hours per day, 40 hours per week. The NIOSH Criteria Document for Oxides of Nitrogen should be consulted for more detailed information.

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Nitric oxide can affect the body if it is inhaled or if it comes in contact with the eyes or skin.

- **Effects of overexposure**

Nitric oxide changes into nitrogen dioxide in air. Nitrogen dioxide is more toxic than nitric oxide and may cause severe breathing difficulties which may be delayed in onset. Nitrogen dioxide may also cause irritation of the eyes, nose, throat, and wet skin. Exposure of animals to nitric oxide has caused drowsiness, unconsciousness, and death.

- **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 nitric oxide.

- **Recommended medical surveillance**

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

1. Initial Medical Examination:

—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 central nervous system, respiratory tract, and cardiovascular system should be stressed.

—14" x 17" chest roentgenogram: Exposure to nitric oxide involves simultaneous exposure to nitrogen dioxide which causes human lung damage. Surveillance of the lungs is indicated.

—FVC and FEV (1 sec): Exposure to nitric oxide involves simultaneous exposure to nitrogen dioxide which is a respiratory irritant. Persons with impaired pulmonary function may be at increased risk from exposure. Periodic surveillance is indicated.

—Cardiovascular disease: Persons with cardiac disease may be at increased risk. An electrocardiogram should be performed on workers over 40 years of age and where indicated.

2. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis or as otherwise indicated by the responsible physician.

- **Summary of toxicology**

Nitric oxide (NO) causes narcosis in animals. Exposure of mice to 2500 ppm for 6 or 7 minutes caused narcosis, and death occurred within 12 minutes. Some early reports attributed the toxicity of nitric oxide to the formation of methemoglobin; however, more recent studies indicate that nitric oxide reacts in vitro with normal (ferrous) hemoglobin but in exposed animals this interaction does not occur and no methemoglobin is

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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formed. Nitric oxide is converted spontaneously in air to nitrogen dioxide; hence, some of the latter gas is invariably present whenever nitric oxide is found in the air. At concentrations below 50 ppm, however, this reaction is slow, and frequently substantial concentrations of nitric oxide may occur with negligible quantities of nitrogen dioxide. Nitrogen dioxide may cause delayed pulmonary edema and irritation of the eyes, nose, throat, and wet skin.

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**
  1. Molecular weight: 30
  2. Boiling point (760 mm Hg): −152 C (-241 F)
  3. Specific gravity (water = 1): 1.27 (at boiling point)
  4. Vapor density (air = 1 at boiling point of nitric oxide): 1.0
  5. Melting point: −164 C (−263 F)
  6. Vapor pressure at 20 C (68 F): 26,000 mm Hg (500 psig, cylinder pressure)
  7. Solubility in water, g/100 g water at 20 C (68 F): Reacts
  8. Evaporation rate (butyl acetate = 1): Not applicable
- **Reactivity**
  1. Conditions contributing to instability: Elevated temperatures may cause cylinders to burst.
  2. Incompatibilities: Contact with all combustible materials, chlorinated hydrocarbons, ammonia, carbon disulfide, many metals, fluorine, and ozone may cause fires and explosions.
  3. Hazardous decomposition products: Toxic gases and vapors (such as oxides of nitrogen) may be released when nitric oxide decomposes.
  4. Special precautions: Nitric oxide will attack some forms of plastics, rubber, and coatings.
- **Flammability**
  1. Not combustible, but strong oxidizing agent.
- **Warning properties**
  1. Odor Threshold: May gives odor thresholds for nitric oxide of 0.3 ppm and 1 ppm.
  2. Eye Irritation Level: According to Patty, nitric oxide is not an irritant. It is oxidized in air to NO_2, however, and NO_2 is known to produce eye irritation.
  3. Evaluation of Warning Properties: Since the odor threshold of nitric oxide is well below the permissible exposure limit, nitric oxide is treated as a material with good warning properties.

MONITORING AND MEASUREMENT PROCEDURES

- **General**

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).

- **Method**

Nitric oxide may be measured by the collection of nitric oxide on a solid sorbent, followed by extraction with triethanolamine and subsequent spectrophotometric analysis. Detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure nitric oxide may be used. An analytical method for nitric oxide is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 4, 1978, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00317-3).

• 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.

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.

COMMON OPERATIONS AND CONTROLS

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

Operation	Controls
Liberation of fumes caused by direct combination of nitrogen and oxygen at elevated temperatures; action of dilute nitric acid on some metals; oxidation of nitrogenous materials	Local exhaust ventilation; general dilution ventilation; personal protective equipment

Use as an intermediate in synthesis of nitric acid, acrylonitrile, hydroxylamine, nitrosyl halides, nitrosyl hydrogen sulfate, nitrogen dioxide	Process enclosure; local exhaust ventilation; general dilution ventilation; personal protective equipment
Use as decomposition agent in certain gaseous products; additive to rocket propellants; bleaching of rayon; laboratory research	Local exhaust ventilation; general dilution ventilation; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

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

• **Breathing**

If a person breathes in large amounts of nitric oxide, 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.

• **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.

LEAK PROCEDURES

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

• If nitric oxide is leaked or released in hazardous concentrations, the following steps should be taken:

1. Ventilate area of leak or release to disperse the gas.
2. Stop flow of gas. If source of leak is a cylinder and the leak cannot be stopped inplace, remove the leaking cylinder to a safe place in the open air, and repair the leak or allow the cylinder to empty.

REFERENCES

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RESPIRATORY PROTECTION FOR NITRIC OXIDE

Condition	Minimum Respiratory Protection* Required Above 25 ppm
Gas Concentration	
100 ppm or less	Any chemical cartridge respirator with a full facepiece and cartridge(s) containing non-oxizidable sorbents and providing protection against nitric oxide.**
	A gas mask with a chin-style or a front- or back-mounted canister containing non-oxidizable sorbents and providing protection against nitric oxide.
	Any supplied-air respirator with a full facepiece, helmet, or hood.
	Any self-contained breathing apparatus with a full facepiece.
Greater than 100 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 containing non-oxidizable sorbents and providing protection against nitric oxide.
	Any escape self-contained breathing apparatus.

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

**Nitric oxide is an oxidizer and should not come in contact with oxidizable materials. Some cartridges and canisters may contain oxidizable materials, such as activated charcoal, and therefore and should not be used to provide protection against nitric oxide. Only non-oxidizable sorbents are allowed.

***Use of supplied-air suits may be necessary to prevent skin contact while providing respiratory protection from airborne concentrations of nitric oxide; 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 100 ppm, an auxiliary self-contained breathing apparatus operated in positive pressure mode should also be worn.