Occupational Health Guideline for Nitrogen Trifluoride

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: NF_3
- Synonyms: None
- Appearance and odor: Colorless gas with a moldy odor.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for nitrogen trifluoride is 10 parts of nitrogen trifluoride per million parts of air (ppm) averaged over an eight-hour work shift. This may also be expressed as 29 milligrams of nitrogen trifluoride per cubic meter of air (mg/m^3).

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Nitrogen trifluoride can affect the body if it is inhaled.

- **Effects of overexposure**

There are no reports of human intoxication from nitrogen trifluoride. In animals, nitrogen trifluoride can affect the ability of the blood to carry oxygen by forming methemoglobin. In man, methemoglobin formation may cause a bluish discoloration of the skin, drowsiness, dizziness, nausea, rapid heart beat, headache, shortness of breath, and unconsciousness.

- **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 nitrogen trifluoride.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to nitrogen trifluoride 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 blood, cardiovascular system, nervous system, liver, and kidneys should be stressed.

—A complete blood count: Nitrogen trifluoride has been shown to cause methemoglobinemia in animals. Persons with blood disorders may be at increased risk from exposure. A complete blood count should be performed including a red cell count, a white cell count, a differential count of a stained smear, as well as hemoglobin and hematocrit.

2. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis. Methemoglobin determinations should be performed if overexposure is suspected or signs and symptoms of toxicity occur.

- **Summary of toxicology**

Nitrogen trifluoride gas causes anoxia due to the formation of methemoglobin in animals. Rats died from exposure to 10,000 ppm for 60 to 70 minutes; the methemoglobin concentrations at the time of death were equivalent to 60 to 70% of available hemoglobin. Animals exposed to nearly lethal concentrations suffered severe respiratory distress and cyanosis due to methemoglobinemia; severely affected animals showed incoordination, collapse and convulsions. Rats repeatedly exposed to 100 ppm for 4-½ months appeared normal, but autopsy findings indicated injury to the liver and kidneys. There are no reports of human intoxication from nitrogen trifluoride; however, the expected effects of methemoglobinemia in humans would result from anoxia and include cyanosis, evident

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especially in the lips, nose, and ear lobes; other effects are weakness, dizziness, and severe headache.

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**
  1. Molecular weight: 71
  2. Boiling point (760 mm Hg): −129 C (−200 F)
  3. Specific gravity (water = 1): 1.54 (liquid)
  4. Vapor density (air = 1 at boiling point of nitrogen trifluoride): 2.5
  5. Melting point: −206.8 C (−340 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): Insoluble
  8. Evaporation rate (butyl acetate = 1): Not applicable
- **Reactivity**
  1. Conditions contributing to instability: Particularly hazardous under pressure; can react spontaneously due to shock or heat.
  2. Incompatibilities: Contact of nitrogen trifluoride with oxidizable materials (such as ammonia, carbon monoxide, methane, hydrogen, and hydrogen sulfide), chemically active metals, and oxides (such as silica (sand)) may cause fires and explosions. Mixtures of nitrogen trifluoride and water vapor may explode when ignited by high energy sources. It can react violently with grease or oil.
  3. Hazardous decomposition products: None
  4. Special precautions: None
- **Flammability**
  1. Not combustible by itself, but can react explosively with reducing materials.
  2. See 29 CFR 1910.101 for specific regulations on storage of compressed gas cylinders.
- **Warning properties**
  1. Odor Threshold: According to the *Documentation of TLV's*, "NF_3 provides no odor-warning properties at potentially dangerous levels."
  2. Eye Irritation Level: The ILO states that "nitrogen trifluoride is strikingly less irritating than elemental fluorine, chlorine trifluoride, and oxygen difluoride." Information is not available concerning the threshold of eye irritation.
  3. Evaluation of Warning Properties: Since no quantitative information is available relating warning properties to air concentrations of nitrogen trifluoride, and since the *Documentation of TLV's* states that "NF_3 provides no odor-warning properties at potentially dangerous levels," this substance is treated as a material with poor 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**

At the time of publication of this guideline, no measurement method for nitrogen trifluoride had been published by NIOSH.

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 nitrogen trifluoride may occur and control methods which may be effective in each case:

Operation	Controls
Use in the manufacture of flash cubes; use in welding, brazing, and cutting of metals using hydrogen-nitrogen trifluoride torch	Process enclosure; local exhaust ventilation; personal protective equipment
Use in research as an oxidizer for rocket and other high-energy fuels	Process enclosure; local exhaust ventilation; personal protective equipment
Use in manufacture of tetrafluorohydrazine	Process enclosure; local exhaust 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 nitrogen trifluoride, 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 nitrogen trifluoride is leaked, the following steps should be taken:

1. Ventilate area of leak to disperse gas.
2. 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.

These documents are available through the NIOSH Division of Technical Services, 4676 Columbia Parkway, Cincinnati, Ohio 45226.

REFERENCES

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RESPIRATORY PROTECTION FOR NITROGEN TRIFLUORIDE

Condition	Minimum Respiratory Protection* Required Above 10 ppm
Gas Concentration	
100 ppm or less	Any supplied-air respirator. Any self-contained breathing apparatus.
500 ppm or less	Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
2000 ppm or less	A Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure mode or with a full facepiece, helmet, or hood operated in continuous-flow mode.
Greater than 2000 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 nitrogen trifluoride. Any escape self-contained breathing apparatus.

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