

# Occupational Health Guideline for Boron 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:  $\text{BF}_3$
- Synonyms: None
- Appearance and odor: Colorless gas which fumes in moist air and has a pungent, irritating odor.

## PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for boron trifluoride is a ceiling level of 1 part of boron trifluoride per million parts of air (ppm). This may also be expressed as 3 milligrams of boron trifluoride per cubic meter of air ( $\text{mg}/\text{m}^3$ ). NIOSH has completed a criteria document for boron trifluoride but, due to the unavailability of a reliable measurement method, an environmental limit has not been recommended. For more detailed information, consult the NIOSH Criteria Document for Boron Trifluoride.

## HEALTH HAZARD INFORMATION

- Routes of exposure  
Boron trifluoride can affect the body if it is inhaled or if it comes in contact with the eyes or skin.
- Effects of overexposure
  1. *Short-term Exposure:* Boron trifluoride may cause nasal irritation and severe irritation of the eyes and skin. Animals exposed to elevated levels of boron trifluoride have developed pneumonia and kidney damage.
  2. *Long-term Exposure:* Repeated or prolonged exposure to boron trifluoride may cause nasal dryness and nose bleeding.

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 boron trifluoride.

- Recommended medical surveillance

The following medical procedures should be made available to each employee who is exposed to boron 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 respiratory system and kidneys should be stressed. The skin and eyes should be examined for evidence of chronic disorders.

—14" x 17" chest roentgenogram: Boron trifluoride causes lung damage in animals. Surveillance of the lungs is indicated.

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

2. *Periodic Medical Examination:* The aforementioned 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 when signs and symptoms of respiratory disease occur.

- Summary of toxicology

Boron trifluoride gas is a severe irritant of the lungs, eyes, and skin. Exposure of six animal species to 100 ppm, 4 to 7 hours/day, 5 days/week in a 30-day experiment killed all animals, most within the test period. Guinea pigs were the most susceptible, with 40 dead in two days. Dogs were the least susceptible, all dying after the test period. The primary site of damage was the lung, with severe irritation leading to death by pneumonia. Kidney damage, leading to nephritis, also occurs. Morbidity and mortality at lower levels of

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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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exposure were proportionate to the concentration time. Bronchitis, kidney damage, retarded growth, and fibrosis of teeth and bones occur in surviving animals. Exposure of 6 animal species to 100 ppm for 30 days resulted in a high mortality rate. Exposure of animals to a concentration of 42 mg/m<sup>3</sup> (approximately 15 ppm) for an unspecified time period was fatal in some cases; autopsy findings were pneumonitis and degenerative changes in the renal tubules. Repeated exposure of mice to 15 ppm for 30 days resulted in mortality of 19% due to pulmonary irritation; rats similarly exposed for 2 weeks developed hypoplasia of the teeth and deposition of fluoride up to 25 times normal levels, both in the incisors and in femoral epiphyses. Three species of animals repeatedly exposed to levels of 12.8, 7.7, or 3 ppm for periods up to 6 months developed pneumonitis and evidence of dental fluorosis; high concentrations caused deaths in guinea pigs. In humans, the gas in high concentration produces burns of the eyes and skin similar to those caused by hydrogen fluoride, but less severe. Workers exposed to concentrations of up to 90 mg/m<sup>3</sup> (approximately 32 ppm) for 10 to 15 years developed dryness of the nasal mucous membranes and epistaxis (nosebleed).

## CHEMICAL AND PHYSICAL PROPERTIES

### • Physical data

1. Molecular weight: 67.8
2. Boiling point (760 mm Hg): -100.4 C (-149 F)
3. Specific gravity (water = 1): 1.6 (liquid)
4. Vapor density (air = 1 at boiling point of boron trifluoride): 2.3
5. Melting point: -127 C (-197 F)
6. Vapor pressure at 20 C (68 F): Greater than 1 atm.
7. Solubility in water, g/100 g water at 20 C (68 F): Dissolves with evolution of heat (369 g/100 g water at 6 C (42.8 F))
8. Evaporation rate (butyl acetate = 1): Not applicable

### • Reactivity

1. Conditions contributing to instability: None
2. Incompatibilities: Boron trifluoride reacts with alkalis. It fumes strongly in moist air forming particulates which may reduce visibility.
3. Hazardous decomposition products: Toxic gases and vapors (such as boric acid and fluoroboric acid) may be released when boron trifluoride decomposes.
4. Special precautions: Boron trifluoride will attack some forms of plastics, rubber, and coatings. See 29 CFR 1910.101 for specific regulations on storage of compressed gas cylinders.

### • Flammability

1. Not combustible

### • Warning properties

1. Odor Threshold: Stauden states that "boron trifluoride, BF<sub>3</sub>, is a colorless gas in a dry atmosphere, but it fumes in the presence of moisture, producing a dense white smoke. Upon hydrolysis, it generates an acidic,

pungent odor that is irritating but not appreciably toxic." No quantitative information is available concerning the odor threshold of boron trifluoride.

2. Eye Irritation Level: The ILO states that "the principal feature in the acute action of this substance is the irritation of the mucous membranes of the respiratory tract and eyes." No quantitative information is available concerning the levels which produce eye irritation.

3. Evaluation of Warning Properties: Since no quantitative information is available relating warning properties to air concentrations of boron trifluoride, this gas is treated as a material with poor warning properties.

## MONITORING AND MEASUREMENT PROCEDURES

### • Ceiling Evaluation

Measurements to determine employee ceiling exposure are best taken during periods of maximum expected airborne concentrations of boron trifluoride. 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

At the time of publication of this guideline, no measurement method for boron 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 boron trifluoride may occur and control methods which may be effective in each case:

Operation	Controls
Use as a Lewis acid catalyst for alkylation of aromatic compounds; use in polymer technology in manufacture of phenolic and epoxy resins	Process enclosure; local exhaust ventilation; general dilution ventilation; personal protection equipment
Use in synthesis of other boron-containing organic and inorganic compounds; use in purification of hydrocarbons to remove unsaturates and sulfur-, nitrogen-, and oxygen-containing compounds	Process enclosure; local exhaust ventilation; general dilution ventilation; personal protection equipment
Use in nuclear technology for separation of boron isotopes; as a filling gas for neutron counters	Process enclosure; local exhaust ventilation; general dilution ventilation; personal protection equipment
Use in metallurgy as flux and antioxidant; use as flame-coloring agent for liquefied petroleum gas	Process enclosure; local exhaust ventilation; general dilution ventilation; personal protection equipment

## 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 strong concentrations of boron trifluoride 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 strong concentrations of boron trifluoride gas contact the skin, immediately flush the contaminated skin with water. If strong concentrations of boron trifluoride gas penetrate through the clothing, remove the clothing immediately and flush the skin with water. If irritation persists after washing, get medical attention.

### • Breathing

If a person breathes in large amounts of boron 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 boron trifluoride is leaked, the following steps should be taken:

1. Ventilate area of leak to disperse the 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.

## REFERENCES

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## RESPIRATORY PROTECTION FOR BORON TRIFLUORIDE

Condition	Minimum Respiratory Protection* Required Above 1 ppm
Gas Concentration	
10 ppm or less**	Any supplied-air respirator. Any self-contained breathing apparatus.
50 ppm or less	Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
100 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 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 providing protection against boron trifluoride. Any escape self-contained breathing apparatus.

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

\*\*If eye irritation occurs, full-facepiece respiratory protective equipment should be used.

\*\*\*Use of supplied-air suits may be necessary to prevent skin contact while providing respiratory protection from airborne concentrations of boron trifluoride; 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.

