OCCUPATIONAL SAFETY AND HEALTH GUIDELINE FOR BORON TRIFLUORIDE

INTRODUCTION

This guideline summarizes pertinent information about boron trifluoride for workers and employers as well as for physicians, industrial hygienists, and other occupational safety and health professionals who may need such information to conduct effective occupational safety and health programs. Recommendations may be superseded by new developments; readers are therefore advised to regard these recommendations as general guidelines and to determine periodically whether new information is available.

SUBSTANCE IDENTIFICATION

- **Formula**

BF_3

- **Synonyms**

Trifluoroboron, boron fluoride, trifluoroborane

- **Identifiers**

1. CAS No.: 7637-07-2
2. RTECS No.: ED2275000
3. DOT UN: 1008 15
4. DOT label: Nonflammable Gas and Poison

- **Appearance and odor**

Boron trifluoride is a nonflammable, colorless gas that fumes in moist air and has a pungent, irritating odor. The odor threshold is reported to range from 1 to 1.5 parts per million (ppm) parts of air.

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**

1. Molecular weight: 67.8
2. Boiling point (at 760 mm Hg): -100°C (-148°F)
3. Specific gravity (water = 1): 2.99 at 20°C (68°F)
4. Relative density (air = 1 at boiling point of boron trifluoride): 2.3
5. Melting point: -127.1°C (-196.8°F)
6. Vapor pressure at 20°C (68°F): Greater than 1 mm Hg
7. Solubility: Soluble in water and in most saturated and halogenated hydrocarbons and aromatic compounds; very soluble in concentrated acids and organic solvents
8. Evaporation rate: Not applicable

- **Reactivity**

1. Conditions contributing to instability: Boron trifluoride hydrolyzes in moist air to boric acid, hydrogen fluoride, and fluoboric acid. It also decomposes in hot water to form boric acid and fluoboric acid. This substance also decomposes when heated.
2. Incompatibilities: Fires and explosions may result from contact of boron trifluoride with alkali metals, alkaline earth metals (except magnesium), alkyl nitrate, or calcium oxide. Boron trifluoride incandesces when heated with alkali metals or alkaline earth metals (except magnesium).
3. Hazardous decomposition products: Toxic gases and vapors (such as fluorine and fluorine compounds) may be released when boron trifluoride is heated to decomposition.
4. Special precautions: Boron trifluoride corrodes most metals in the presence of moisture.

- **Flammability**

The National Fire Protection Association has not assigned a flammability rating to boron trifluoride; this substance is not flammable and will not support combustion.

1. Flash point: Not applicable
2. Autoignition temperature: Not applicable
3. Flammable limits in air: Not applicable
4. Extinguishant: Use an extinguishant that is suitable for the materials involved in the surrounding fire.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health
Division of Standards Development and Technology Transfer

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

Fires involving boron trifluoride should be fought upwind and from the maximum distance possible. Isolate the hazard area and deny access to unnecessary personnel. Emergency personnel should stay out of low areas and ventilate closed spaces before entering. Containers of boron trifluoride may explode in the heat of the fire and should be moved from the fire area if it is possible to do so safely. If this is not possible, cool containers from the sides with water until well after the fire is out. Do not get water inside containers. Stay away from the ends of containers. Personnel should withdraw immediately if they hear a rising sound from a venting safety device or if a container becomes discolored as a result of fire. Firefighters should wear a full set of protective clothing, including a self-contained breathing apparatus, when fighting fires involving boron trifluoride.

EXPOSURE LIMITS

• OSHA PEL

The Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for boron trifluoride is 1 ppm (3 mg/m^3) of air as a ceiling limit. A worker's exposure to boron trifluoride shall at no time exceed this ceiling limit [29 CFR 1910.1000, Table Z-1-A].

• NIOSH REL

The National Institute for Occupational Safety and Health (NIOSH) has established a recommended exposure limit (REL) of 1 ppm (3 mg/m^3) as a ceiling limit [NIOSH 1992].

• ACGIH TLV®

The American Conference of Governmental Industrial Hygienists (ACGIH) has assigned boron trifluoride a ceiling limit of 1 ppm (2.8 mg/m^3), which should not be exceeded during any part of the working day [ACGIH 1991b].

• Rationale for limits

The limits are based on the risk of severe pulmonary irritation associated with exposure to boron trifluoride.

HEALTH HAZARD INFORMATION

• Routes of exposure

Exposure to boron trifluoride can occur through inhalation and eye or skin contact.

• Summary of toxicology

1. *Effects on Animals*: Boron trifluoride is potentially a corrosive poisonous gas that can cause burns to the nasal and respiratory passages, eyes, and skin. It can also be dermally absorbed. Acute exposure of guinea pigs to 100 ppm resulted in the death of all animals. The 1-hr and 4-hr LC_{50}s for rats are 387 (320-467) and 393 ppm, respectively. Before the deaths of these animals, they exhibited respiratory irritation, pneumonia, kidney damage, retarded growth, and severe progressive dental fluorosis [NLM 1991]. In six studies, subchronic exposure of multiple species spanned 0.67 to 100 ppm for 0.5 to 6 months [NLM 1991]. Irritation was noted at all reported levels. Serum chemistry changes (dysproteinemia, decreased globulinemia and cholinesterase), nervous lability, decreased body weight, and pneumonitis occurred at 1 to 4 ppm over a 3 to 6 month exposure period. Rales, renal tubular necrosis, and death occurred at 6 ppm following 3 to 6 months of exposure. Progressive pulmonary involvement (difficult breathing, pneumonitis, emphysema, and alveolar collapse) and death from respiratory failure were noted during months 3 to 6 at 12.8 ppm. Increased lung and liver weights were noted in animals exposed to 22 or 60 ppm for 2 weeks. A 1-month exposure of six species to 100 ppm caused lung and kidney damage and the death of all animals [NLM 1991].

2. *Effects on Humans*: Boron trifluoride is a severe irritant of the nasal passages, lungs, skin, and eyes in humans, producing burns similar to those caused by hydrofluoric acid. Because this substance forms acids when it comes into contact with moisture, the eyes and skin can be severely burned if exposed to boron trifluoride. Exposure at 50 ppm for 30 to 60 min is believed to be lethal to humans [Braker and Mossman 1980]. Eight of 13 workers exposed for 1 to 27 years to boron trifluoride concentrations ranging from an estimated 0.1 to 1.8 ppm showed decreased pulmonary function (forced ventilatory capacity and expiratory volume) on clinical examination, although their chest X-rays were normal [Clayton and Clayton 1981]. A group of 78 workers exposed for 10 to 15 years to boron trifluoride at unspecified concentrations (estimated occasionally to be as high as 32 ppm) developed nosebleeds and dryness of the nasal mucosa, bleeding gums, dry and scaly skin, and joint pain. Concurrent exposures to ethylene and isobutylene were also reported [Parmeggiani 1983; Proctor et al. 1988].

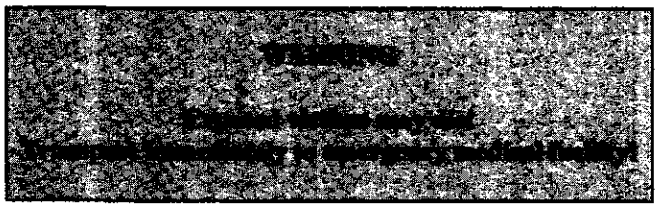
• Signs and symptoms of exposure

1. *Acute exposure*: Severe ambient exposure to boron trifloride can cause severe irritation or burns of the eyes, eyelids, and skin, inflammation and congestion of the lungs, cardiovascular collapse, respiratory failure, and death. Direct tissue contact with the gas can cause frostbite. Inhalation can induce severe salivation, nausea, gastritis, gastroenteritis, abdominal pain, retching, and prolonged vomiting with hematemesis, watery or tarry diarrhea, dehydration, shock, palor, cyanosis, coldness, rapid weak

pulse, rapid shallow breathing, drowsiness, hyporeflexia or convulsions, dilated pupils, coma, and death. Survivors may develop pyloric stenosis, hepatic cirrhosis, and renal damage.

2. *Chronic exposure*: Chronic exposure to boron trifluoride can cause nosebleeds and dryness of the nasal mucosa, bleeding gums, dry and scaly skin, joint pain, osteosclerosis, increased bone density and brittleness, mottled tooth enamel, weight loss, anemia, weakness, and decreased pulmonary function.

- **Emergency procedures**



Keep unconscious victims warm and on their sides to avoid choking if vomiting occurs. ***Immediately*** initiate the following emergency procedures, continuing them as appropriate en route to the emergency medical facility:

1. *Eye exposure*: If tissue is frozen, seek medical attention ***immediately***. In addition, tissue destruction and blindness may result! ***Immediately but gently*** flush the eyes with large amounts of water for at least 15 min, occasionally lifting the upper and lower eyelids.

2. *Skin exposure*: If frostbite occurs, seek medical attention ***immediately***. In addition, severe burns, skin corrosion, and absorption of toxic amounts may result! ***Immediately and gently*** wash skin for at least 15 min. Use soap and water if skin is intact; use only water if skin is not intact.

3. *Inhalation exposure*: If boron trifluoride is inhaled, move the victim to fresh air ***immediately***.

If the victim is not breathing, clean any chemical contamination from the victim's lips and perform cardiopulmonary resuscitation (CPR); if breathing is difficult, give oxygen.

4. *Rescue*: Remove an incapacitated worker from further exposure and implement appropriate emergency procedures (e.g., those listed on the material safety data sheet required by OSHA's hazard communication standard [29 CFR 1910.1200]). All workers should be familiar with emergency procedures and the location and proper use of emergency equipment.

EXPOSURE SOURCES AND CONTROL METHODS

The following uses of boron trifluoride may result in worker exposures to this substance:

—Use as a Lewis acid catalyst for alkylation of aromatic compounds and in the polymerization of phenolic and epoxy resins

—Use in nuclear technology for separation of boron isotopes, as a filling gas for neutron counters, in the production of neutron-absorbing salts for molten-salt breeder reactors, and in ionization chambers to detect weak neutrons

—Use as a fumigant

—Use in gas brazing and in the production of diborane and other boron-containing compounds

—Use in the electronics industry to treat separators for high-temperature cells, to prepare high-breakdown voltage varistors, and to enhance the surface conductivity of perylene

—Use in the magnesium industry during casting and heat-treating operations as a fire retardant and antioxidant

The following methods are effective in controlling worker exposures to boron trifluoride, depending on the feasibility of implementation:

—Process enclosure

—Local exhaust ventilation

—General dilution ventilation

—Personal protective equipment

Good sources of information about control methods are as follows:

1. ACGIH [1992]. Industrial ventilation—a manual of recommended practice. 21st ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

2. Burton DJ [1986]. Industrial ventilation—a self study companion. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

3. Alden JL, Kane JM [1982]. Design of industrial ventilation systems. New York, NY: Industrial Press, Inc.

4. Wadden RA, Scheff PA [1987]. Engineering design for control of workplace hazards. New York, NY: McGraw-Hill.

5. Plog BA [1988]. Fundamentals of industrial hygiene. Chicago, IL: National Safety Council.

MEDICAL MONITORING

Workers who may be exposed to chemical hazards should be monitored in a systematic program of medical surveillance that is intended to prevent occupational injury and disease. The program should include education of employers and workers about work-related hazards, placement of workers in jobs that do not jeopardize their safety or health, early detection of adverse health effects, and referral of workers for diagnosis and treatment. The occurrence of disease or other work-related adverse health effects should prompt immediate evaluation of primary preventive measures (e.g., industrial hygiene monitoring, engineering controls, and personal protective equipment). A medical monitoring program is intended to supplement, not replace, such measures. To place workers effectively and to detect and control work-related health effects, medical evaluations should be performed (1) before job placement, (2) periodically during the term of employment, and (3) at the time of job transfer or termination.

- **Preplacement medical evaluation**

Before a worker is placed in a job with a potential for exposure to boron trifluoride, a licensed health care professional should evaluate and document the worker's baseline health status with thorough medical, environmental, and occupational histories, a physical examination, and physiologic and laboratory tests appropriate for the anticipated occupational risks. These should concentrate on the function and integrity of the respiratory system, kidneys, and skin. Medical monitoring for respiratory disease should be conducted using the principles and methods recommended by the American Thoracic Society [ATS 1987].

A preplacement medical evaluation is recommended to assess an individual's suitability for employment at a specific job and to detect and assess medical conditions that may be aggravated or may result in increased risk when a worker is exposed to boron trifluoride at or below the prescribed exposure limit. The licensed health care professional should consider the probable frequency, intensity, and duration of exposure as well as the nature and degree of any applicable medical condition. Such conditions (which should not be regarded as absolute contraindications to job placement) include a history and other findings consistent with respiratory system, kidney, or skin diseases.

- **Periodic medical examinations and biological monitoring**

Occupational health interviews and physical examinations should be performed at regular intervals during the employment period, as mandated by any applicable Federal, State, or local standard. Where no standard exists and the hazard is minimal, evaluations should be conducted every 3 to 5 years or as frequently as recommended by an experienced occupational health physician. Additional examinations may be necessary if a worker develops symptoms attributable to boron trifluoride exposure. The interviews, examinations, and medical screening tests should focus on identifying the adverse effects of boron trifluoride on the respiratory system, kidneys, and skin. Current health status should be compared with the baseline health status of the individual worker or with expected values for a suitable reference population.

Biological monitoring involves sampling and analyzing body tissues or fluids to provide an index of exposure to a toxic substance or metabolite. Urinary fluoride is a nonspecific indicator of exposure to a fluoride compound. Maintaining preshift and postshift urinary fluoride concentrations below 4 and 7 mg/g creatinine, respectively, appears to protect against the development of bony fluorosis.

- **Medical examinations recommended at the time of job transfer or termination**

The medical, environmental, and occupational history interviews, the physical examination, and selected physiologic or laboratory tests that were conducted at the time of job placement should be repeated at the time of job transfer or termination. Any changes in the worker's health status should be compared with those expected for a suitable reference population. Because occupational exposure to boron trifluoride may cause diseases with prolonged latent periods, the need for medical monitoring may extend well beyond the termination of employment.

WORKPLACE MONITORING AND MEASUREMENT

Neither NIOSH nor OSHA has a recommended method for sampling boron trifluoride in the workplace. However, the following secondary analytical method, which has not been validated, is available. A worker's exposure to airborne boron trifluoride is determined by using a midget fritted-glass bubbler containing 10 ml of 0.1M ammonium fluoride. Samples are collected at a maximum flow rate of 1 liter/min until a maximum air volume of 480 liters is collected. A stock standard is made by dissolving 0.125 g of potassium tetrafluoroborate in 100 ml of 0.1M ammonium fluoride. Working standards are then made by making serial dilutions of the stock standard in 0.1M ammonium fluoride to the appropriate ranges. Analysis is done using the fluoborate specific-ion electrode and a double junction reference electrode. This method is described in the OSHA Laboratory In-House Methods File [OSHA 1989].

PERSONAL HYGIENE

If boron trifluoride contacts the skin, the victim should immediately and thoroughly wash the affected areas with soap and water. Medical attention should be obtained immediately.

Clothing contaminated with boron trifluoride should be removed immediately. In case of massive exposure, the contaminated clothing should be removed under a drenching safety shower and medical attention should be obtained immediately.

A worker who is exposed to boron trifluoride should thoroughly wash hands, forearms, and face with soap and water before eating, using tobacco products, or using toilet facilities.

Workers should not eat, drink, or use tobacco products in areas where boron trifluoride is present.

STORAGE

Boron trifluoride should be stored in a cool, dry, well-ventilated area in tightly sealed containers that are labeled in accordance with OSHA's hazard communication standard [29 CFR 1910.1200]. Outside or detached storage in a noncombustible structure is preferred. Cylinders should be stored and handled in accordance with OSHA's compressed gases standard [29 CFR 1910.101]. Containers of boron trifluoride should be protected from physical damage and should be stored separately from alkali metals, alkaline earth metals (except magnesium), alkyl nitrates, calcium oxide, heat, sparks, and open flame. Because containers that formerly contained boron trifluoride may still hold product residues, they should be handled appropriately.

LEAKS

Before boron trifluoride is used in the workplace, emergency procedures should be established and made known to all affected personnel. In the event of a leak involving boron trifluoride, persons not wearing protective equipment and clothing should be restricted from contaminated areas until cleanup is complete. The following steps should be undertaken following a leak:

1. Evacuate the leak area for at least 50 ft in all directions.
2. Notify safety personnel.
3. Stop the leak or remove the leaking cylinder if this can be done safely.
4. Do not get water inside cylinders containing boron trifluoride.
5. Flush the leak area with enough water to flood it.

SPECIAL REQUIREMENTS

U.S. Environmental Protection Agency (EPA) requirements for emergency planning, reportable quantities of hazardous releases, community right-to-know, and hazardous waste management may change over time. Users are therefore advised to determine periodically whether new information is available.

- **Emergency planning requirements**

Employers owning or operating a facility with 500 lb or more of boron trifluoride onsite must comply with EPA's emergency planning requirements [40 CFR 355.30].

- **Reportable quantity requirements for hazardous releases**

A hazardous substance release is defined by EPA as any spilling, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing of hazardous substances into the environment (including the abandonment or discarding of contaminated containers). In the event of a release that is above the reportable quantity for that chemical, employers are required by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) [40 CFR 355.40] to notify the proper Federal, State, and local authorities.

The reportable quantity for boron trifluoride is 1 lb. If an amount equal to or greater than this quantity is released within a 24-hr period in a manner that will expose persons outside the facility, employers are required to do the following:

—Notify the National Response Center ***immediately*** at (800) 424-8802 or at (202) 426-2675 in Washington, D.C. [40 CFR 302.6].

—Notify the emergency response commission of the State likely to be affected by the release [40 CFR 355.40].

—Notify the community emergency coordinator of the local emergency planning committee (or relevant local emergency response personnel) of any area likely to be affected by the release [40 CFR 355.40].

- **Community right-to-know requirements**

Employers are not required by Section 313 of the Superfund Amendments and Reauthorization Act (SARA) [42 USC 11022] to submit a Toxic Chemical Release Inventory Form (Form R) to EPA reporting the amount of boron trifluoride emitted or released from their facility annually.

- **Hazardous waste management requirements**

EPA considers a waste to be hazardous if it exhibits any of the following characteristics: ignitability, corrosivity, reactivity, or toxicity as defined in 40 CFR 261.21-261.24. Although boron trifluoride is not specifically listed as a hazardous waste under the Resource Conservation and Recovery Act (RCRA) [40 USC 6901 et seq.], EPA requires employers to treat any waste as hazardous if it exhibits any of the characteristics discussed above.

Providing detailed information about the removal and disposal of specific chemicals is beyond the scope of this guideline. The U.S. Department of Transportation, EPA, and State and local regulations should be followed to ensure that removal, transport, and disposal of this substance are conducted in accordance with existing regulations. To be certain that chemical waste disposal meets EPA regulatory requirements, employers should address any questions to the RCRA hotline at (800) 424-9346 or at (202) 382-3000 in Washington, D.C. In addition, relevant State and local authorities should be contacted for information about their requirements for waste removal and disposal.

RESPIRATORY PROTECTION

- **Conditions for respirator use**

Good industrial hygiene practice requires that engineering controls be used where feasible to reduce workplace concentrations of hazardous materials to the prescribed exposure limit. However, some situations may require the use of respirators to control exposure. Respirators must be worn if the ambient concentration of boron trifluoride exceeds prescribed exposure limits. Respirators may be used (1) before engineering controls have been installed, (2) during work operations such as maintenance or repair activities that involve unknown exposures, (3) during operations that require entry into tanks or closed vessels, and (4) during emergencies. Workers should use only respirators that have been approved by NIOSH and the Mine Safety and Health Administration (MSHA).

- **Respiratory protection program**

Employers should institute a complete respiratory protection program that, at a minimum, complies with the requirements of OSHA's respiratory protection standard [29 CFR 1910.134]. Such a program must include respirator selection, an evaluation of the worker's ability to perform the work while wearing a respirator, the regular training of personnel, fit testing, periodic workplace monitoring, and regular respirator maintenance, inspection, and cleaning. The implementation of an adequate respiratory protection program (including selection of the correct respirator) requires that a knowledgeable person be in charge of the program and that the program be evaluated regularly. For additional information on the selection and use of respirators and on the medical screening of respirator users, consult the *NIOSH Respirator Decision Logic* [1987b] and the *NIOSH Guide to Industrial Respiratory Protection* [1987a].

PERSONAL PROTECTIVE EQUIPMENT

Protective clothing should be worn to prevent any possibility of skin contact with boron trifluoride. Gloves, aprons, coveralls, long sleeves, and other protective equipment are recommended as necessary for workers exposed to boron trifluoride. Chemical protective clothing should be selected on the basis of available performance data, manufacturers' recommendations, and evaluation of the clothing under actual conditions of use. No reports have been published on the resistance of various protective clothing materials to boron trifluoride permeation. If permeability data are not readily available, protective clothing manufacturers should be requested to provide information on the best chemical protective clothing for workers to wear when they are exposed to boron trifluoride.

If boron trifluoride is dissolved in water or an organic solvent, the permeation properties of both the solvent and the mixture must be considered when selecting personal protective equipment and clothing.

Safety glasses, goggles, or face shields should be worn during operations in which boron trifluoride gas might contact the eyes. Eyewash fountains and emergency showers should be available within the immediate work area whenever the potential exists for eye or skin contact with boron trifluoride. Contact lenses should not be worn if the potential exists for boron trifluoride exposure.

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