

OCCUPATIONAL SAFETY AND HEALTH GUIDELINE FOR BORON TRIBROMIDE

INTRODUCTION

This guideline summarizes pertinent information about boron tribromide 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 Recommendations may be superseded by new developments; readers are therefore advised to regard these recommendations as general guidelines and to determine periodically whether new information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



• Synonyms

Boron bromide; tribromoborane, trona

• Identifiers

1. CAS No.: 10294-33-4
2. RTECS No.: ED7400000
3. DOT UN: 2692 59
4. DOT label: Corrosive

• Appearance and odor

Boron tribromide is a colorless, fuming, nonflammable, volatile liquid with a sharp, irritating odor. No quantitative data are available on the odor threshold for boron tribromide.

CHEMICAL AND PHYSICAL PROPERTIES

• Physical data

1. Molecular weight: 250.6
2. Boiling point (760 mm Hg): 90°C (194°F)
3. Specific gravity (water = 1): 2.7 at 0°C (32°F)

4. Vapor density (air = 1 at boiling point of boron tribromide): 8.6

5. Melting point: -46°C (-51°F)

6. Vapor pressure at 33.5°C (92.3°F), 100 mm Hg; at 14°C (57.1°F), 40 mm Hg

7. Solubility: Decomposes in water or alcohol; soluble in carbon tetrachloride and sulfur dioxide

8. Evaporation rate: Data not available

• Reactivity

1. Conditions contributing to instability: Heat and moisture

2. Incompatibilities: Fire and explosions may result from contact of boron tribromide with water, steam, potassium, sodium, or alcohol.

3. Hazardous decomposition products: Toxic gases and particulates (such as hydrogen bromide, oxides of boron, and oxides of bromine) may be released in a fire involving boron tribromide.

4. Special precautions: Boron tribromide attacks metals, wood, rubber, and Bakelite[®] but does not attack Teflon[®] or stainless steel.

• Flammability

The National Fire Protection Association has not assigned a flammability rating to boron tribromide; this substance is not combustible.

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.

Fires involving boron tribromide should be fought upwind and from the maximum distance possible. Isolate the hazard

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area and deny access to unnecessary personnel. Emergency personnel should stay out of low areas and ventilate closed spaces before entering. Vapor explosion and poison hazards may occur indoors, outdoors, or in sewers. Containers of boron tribromide 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. 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. Dikes should be used to contain fire-control water for later disposal. If a tank car or truck is involved in a fire, personnel should isolate an area of a half mile in all directions. Firefighters should wear a full set of protective clothing (including a self-contained breathing apparatus) when fighting fires involving boron tribromide. Firefighters' protective clothing may not provide protection against permeation by boron tribromide.

EXPOSURE LIMITS

• OSHA PEL

The current Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for boron tribromide is 1 ppm (10 mg/m^3) as a ceiling limit. A worker's exposure to boron tribromide shall at no time exceed this 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 (10 mg/m^3) as a ceiling limit [NIOSH 1992].

• ACGIH TLV®

The American Conference of Governmental Industrial Hygienists (ACGIH) has assigned boron tribromide a threshold limit value (TLV) of 1 ppm (10 mg/m^3) as a ceiling limit that should not be exceeded during any part of the working exposure [ACGIH 1991b].

• Rationale for limits

The limits are based on the risk of irritation associated with exposure to boron tribromide.

HEALTH HAZARD INFORMATION

• Routes of exposure

Exposure to boron tribromide can occur through inhalation, ingestion, and eye or skin contact.

• Summary of toxicology

1. *Effects on Animals:* No acute toxicity data specific to boron tribromide is available. However, the toxicity and

action of boron tribromide is similar to that of boron trichloride, which causes marked swelling and burns in contact with the eyes, skin, or mucous membranes; hemorrhages of the lungs, kidneys, and intestines in some animals acutely exposed to lethal concentrations; and death in all mice and rats exposed to 20 ppm for 7 hr [Clayton and Clayton 1981]. The LC_{50} for a 1-hr exposure to hydrogen bromide, a hydrolysis product of boron tribromide, is 814 ppm in the mouse and 2,858 ppm in the rat [Sax and Lewis 1989].

2. *Effects on Humans:* Boron tribromide is an irritant that is strongly corrosive because of its rapid hydrolysis to boric acid and hydrogen bromide [ACGIH 1991a; Clayton and Clayton 1981]. Acute exposure to boron tribromide causes marked irritation of the eyes, nose, throat, and skin, and contact of the eyes or skin with boron tribromide leads to burns [NJDH 1985]. Pulmonary edema, which is potentially life threatening, may result from acute respiratory exposure to boron tribromide [NJDH 1985]. A chemist who splashed boron tribromide into his eyes experienced no pain at the time but subsequently developed permanent corneal injury, including corneal opacification, in the most severely exposed eye; the other eye gradually returned to normal [Grant 1986].

• Signs and symptoms of exposure

1. *Acute exposure:* Acute exposure to boron tribromide can cause redness, swelling, and tearing of the eyes; runny nose; coughing; and shortness of breath. Contact of this substance with the skin or eyes may lead to burns of the affected tissues.

2. *Chronic exposure:* No signs or symptoms of chronic exposure to boron tribromide have been reported.

• 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:* Tissue destruction and blindness may result from exposure to concentrated solutions, vapors, mists, or aerosols of boron tribromide! *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:* Severe burns and skin corrosion may result! *Immediately* remove all contaminated clothing! *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 vapors, mists, or aerosols of boron tribromide are inhaled, move the victim to fresh air *immediately*.

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

4. *Ingestion exposure:* Take the following steps if boron tribromide or a solution containing it is ingested:

—Do *not* induce vomiting.

—Have the victim rinse the contaminated mouth cavity several times with a fluid such as water. Immediately after rinsing, have the victim drink one cup (8 oz) of fluid and *no more*.

—Do *not* permit the victim to drink milk or carbonated beverages!

—Do *not* permit the victim to drink any fluid if more than 60 min have passed since initial ingestion.

NOTE: These instructions must be followed exactly. Drinking a carbonated beverage or more than one cup of fluid could create enough pressure to perforate already damaged stomach tissue. The tissue-coating action of milk can sometimes impede medical assessment of tissue damage. Ingestion of any fluid more than 60 min after initial exposure could further weaken damaged tissue and result in perforation.

5. *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 operations may involve boron tribromide and may result in worker exposures to this substance:

- Use of boron tribromide as a catalyst in organic synthesis
- Production of diborane and ultra-high-purity boron
- Manufacture of semiconductors

The following methods are effective in controlling worker exposures to boron tribromide, 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 tribromide, 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. 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 tribromide 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 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 tribromide exposure. The interviews, examinations, and medical screening tests should focus on identifying the adverse effects of boron tribromide on the respiratory system. 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. No biological monitoring test acceptable for routine use has yet been developed for boron tribromide.

- **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.

WORKPLACE MONITORING AND MEASUREMENT

A worker's exposure to airborne boron tribromide is determined by using a midjet fritted-glass bubbler containing 10 ml of 0.003M NaHCO_3 /0.0024 M Na_2CO_3 . Samples are collected at a recommended flow rate of 1.0 liter/min until a recommended air volume of 5 liters is collected. Analysis is conducted by ion chromatography. The limit of detection for this procedure is 0.01 mg/m³. This method is included in the OSHA Laboratory In-House Methods File [OSHA 1991].

PERSONAL HYGIENE

If boron tribromide contacts the skin, workers should immediately flood the affected areas with water and then wash with soap and water.

Clothing and shoes contaminated with boron tribromide should be removed immediately, and provisions should be made for safely removing this chemical from these articles. Persons laundering contaminated clothing should be informed of the hazardous properties of boron tribromide, particularly its potential to cause skin burns.

A worker who handles boron tribromide 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 tribromide or a solution containing boron tribromide is handled, processed, or stored.

STORAGE

Boron tribromide 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]. Containers of boron tribromide should be protected from physical damage and should be stored away from water, steam, potassium, sodium, alcohol, heat, sparks, and open flame. Because containers that formerly contained boron tribromide may still hold product residues, they should be handled appropriately.

SPILLS AND LEAKS

In the event of a spill or leak involving boron tribromide, 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 spill or leak:

1. Do not touch the spilled material; stop the leak if it is possible to do so without risk.
2. Notify safety personnel.
3. Remove all sources of heat and ignition.
4. Ventilate the area of the spill or leak.
5. Use water spray to reduce vapors; do not put water directly on the leak or spill area.
6. Absorb small liquid spills with sand or other noncombustible absorbent material and place the material in a covered container for later disposal.
7. For large liquid spills, build dikes far ahead of the spill to contain the boron tribromide for later reclamation or disposal.

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

Boron tribromide is not subject to EPA emergency planning requirements under the Superfund Amendments and Reauthorization Act (SARA) [42 USC 11022].

• Reportable quantity requirements for hazardous releases

Employers are not required by the emergency release notification provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) [40 CFR 355.40] to notify the National Response Center of an accidental release of boron tribromide; there is no reportable quantity for this substance.

• Community right-to-know requirements

Employers are not required by Section 313 of SARA to submit a Toxic Chemical Release Inventory Form (Form R) to EPA reporting the amount of boron tribromide 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 tribromide 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 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 limits. However, some situations may require the use of respirators to control exposure. Respirators must be worn if the ambient concentration of boron tribromide 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* [NIOSH 1987b] and the *NIOSH Guide to Industrial Respiratory Protection* [NIOSH 1987a].

PERSONAL PROTECTIVE EQUIPMENT

Protective clothing should be worn to prevent any possibility of skin contact with boron tribromide. Full-body protection and gloves are recommended to prevent skin contact with this substance. 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. Chlorinated polyethylene has demonstrated fair to good protection against permeation by boron tribromide.

If boron tribromide is dissolved in 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 tribromide might contact the eyes (e.g., through splashes of solution). Eyewash

fountains and emergency showers should be available within the immediate work area whenever the potential exists for eye or skin contact with boron tribromide. Contact lenses should not be worn if the potential exists for boron tribromide exposure.

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