

OCCUPATIONAL SAFETY AND HEALTH GUIDELINE FOR BROMINE PENTAFLUORIDE

INTRODUCTION

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 Recommendations may be superseded by new developments; readers are therefore advised to regard these recommendations as general guidelines and to determine periodically whether new information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

Bromine fluoride

• Identifiers

1. CAS No.: 7789-30-2
2. RTECS No.: EF9350000
3. DOT UN: 1745 44
4. DOT label: Oxidizer

• Appearance and odor

Bromine pentafluoride is a reactive, colorless or pale yellow, fuming liquid at temperatures below 40.3°C (104.5°F); it has a pungent odor and is not flammable. The odor threshold is unknown. At temperatures above 40.3°C (104.5°F), it is a colorless, pungent, and corrosive gas. It is shipped in compressed gas cylinders under its own vapor pressure.

CHEMICAL AND PHYSICAL PROPERTIES

• Physical data

1. Molecular weight: 174.92
2. Boiling point (760 mm Hg): 40.5°C (104.9°F)

3. Specific gravity (water = 1): 2.48 at 20°C (68°F)
4. Vapor density (air = 1 at boiling point of bromine pentafluoride): 6.05
5. Melting point: -60.5°C (-76.9°F)
6. Vapor pressure at 20°C (68°F): 328 mm Hg
7. Solubility: Reacts violently with water
8. Evaporation rate: Data not available

• Reactivity

1. Conditions contributing to instability: Bromine pentafluoride is stable under normal handling and storage procedures.

2. Incompatibilities: Bromine pentafluoride is a highly reactive compound; it reacts with every known element except the inert gases, nitrogen, and oxygen. Bromine pentafluoride is incompatible with acids, halogens, arsenic, selenium, alkaline halides, sulfur, iodine, glass, metallic halides, metal oxides, and metals (except copper, stainless steel, nickel, and Monel[®]). Fire or explosion may result from contact of bromine pentafluoride with combustibles or organic matter at room temperature, and contact of this substance with water produces an explosion.

3. Hazardous decomposition products: Toxic gases (such as hydrogen fluoride and hydrogen bromide) may be released in a fire involving bromine pentafluoride.

4. Special precautions: Even under mild reaction conditions, bromine pentafluoride attacks organic compounds vigorously, often causing an explosion.

• Flammability

The National Fire Protection Association has assigned a flammability rating of 0 (no fire hazard) to bromine pentafluoride.

1. Flash point: Not applicable
2. Autoignition temperature: Not applicable

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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

3. Flammable limits in air: Not applicable

4. Extinguishant: Avoid contact of this material with water. However, water may be used if large amounts of combustible material are involved in the fire and if firefighters can protect themselves by barriers or distance from the violent reaction of bromine pentafluoride and water. Fires involving bromine pentafluoride and small amounts of combustibles may be smothered using a carbon dioxide or dry chemical extinguishant.

Fires involving bromine pentafluoride 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 bromine pentafluoride 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 the containers. Stay away from the ends of containers. Runoff to sewers may create a fire or explosion hazard. 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 bromine pentafluoride. Chemical protective clothing that is specifically recommended for bromine pentafluoride may not provide thermal protection unless so stated by the clothing manufacturer. Firefighters' protective clothing may not provide protection against permeation by bromine pentafluoride.

EXPOSURE LIMITS

• OSHA PEL

The current Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for bromine pentafluoride is 0.1 ppm (0.7 mg/m³) as an 8-hr time-weighted average (TWA) [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 0.1 ppm (0.7 mg/m³) as an 8-hr TWA [NIOSH 1992].

• ACGIH TLV®

The American Conference of Governmental Industrial Hygienists (ACGIH) has assigned bromine pentafluoride a threshold limit value (TLV) of 0.1 ppm (0.7 mg/m³) as a

TWA for a normal 8-hr workday and a 40-hr workweek [ACGIH 1991b].

• Rationale for limits

The limits are based on the risk of irritation, corneal necrosis, and systemic effects associated with exposure to bromine pentafluoride.

HEALTH HAZARD INFORMATION

• Routes of exposure

Exposure to bromine pentafluoride can occur through inhalation, ingestion, and eye or skin contact.

• Summary of toxicology

1. *Effects on Animals:* Acute exposure to bromine pentafluoride is corrosive to the eyes, skin, mucous membranes, and upper respiratory tract, chronic exposure is toxic to the liver and kidneys. Experimental animals (species not identified) exposed to a 500-ppm concentration of bromine pentafluoride vapor immediately exhibited the following signs of acute distress: swollen eyelids, tearing, gasping, corneal cloudiness, and excessive salivation; reducing the concentration to 100 ppm produced these signs after an exposure of 3 min [ACGIH 1991a]. Exposure to 50 ppm caused death in these animals after 30 min [ACGIH 1991a]. At autopsy, animals chronically exposed to bromine pentafluoride at concentrations above 3 ppm showed toxic hepatitis and severe nephrosis, as well as severe respiratory involvement [ACGIH 1991a].

2. *Effects on Humans:* Bromine pentafluoride is a severe pulmonary irritant and is also intensely corrosive to the skin, eyes, and mucous membranes of humans in either the liquid or vapor state [Genium 1986]. Exposure to high (not further specified) concentrations are usually fatal; death is caused by respiratory damage and pulmonary edema [Braker and Mossman 1980]. Exposure to a concentration of 5 to 10 ppm is irritating to the eyes, nose, and throat; based on effects seen in animals, chronic exposure may cause liver, kidney, and lung damage [Braker and Mossman 1980; Genium 1986].

• Signs and symptoms of exposure

1. *Acute exposure:* Acute exposure to bromine pentafluoride can cause redness and tearing of the eyes, coughing, breathing difficulty, and a burning sensation of the eyes, nose, and throat. Direct contact of this substance with the eyes or skin can cause severe thermal and chemical burns and tissue destruction.

2. *Chronic exposure:* On the basis of effects seen in animals, long-term exposure to low levels of this substance may cause pain in the abdomen; enlargement of the liver;

blood, pus, or protein in the urine; jaundice; and other signs of lung, liver, or kidney damage.

- **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 bromine pentafluoride! *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, skin corrosion, and absorption of toxic amounts 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 bromine pentafluoride are 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. *Ingestion exposure:* Take the following steps if bromine pentafluoride 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 may 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 uses of bromine pentafluoride may result in worker exposures to this substance:

- Use as an oxidizer in liquid rocket propellant combinations and in chemical synthesis

- Use as a fluorinating agent in isotope enrichment and in fuel-element reprocessing

The following methods are effective in controlling worker exposures to bromine pentafluoride, 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 bromine pentafluoride, 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 liver, kidneys, and lungs. 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 bromine pentafluoride 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 liver, kidney, or lung 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 bromine pentafluoride exposure. The interviews, examinations, and medical screening tests should focus on identifying the adverse effects of bromine pentafluoride on the liver, kidneys, and lungs. 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 bromine pentafluoride.

- **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 bromine pentafluoride may cause diseases with prolonged latent periods, the need for medical monitoring may extend well beyond the termination of employment.

WORKPLACE MONITORING AND MEASUREMENT

A worker's exposure to airborne bromine pentafluoride is determined by using a silica gel tube (Supelco ORBO 53 or equivalent). Samples are collected at a recommended flow rate of 0.2 liter/min until a recommended air volume of 48 liters is collected. Analysis is conducted by ion chromatography. This method is included in the *OSHA Chemical Information Manual* [OSHA 1987] and is based on OSHA Method ID-108.

PERSONAL HYGIENE

If bromine pentafluoride contacts the skin, workers should flush the affected areas immediately with plenty of water for 15 min and then wash with soap and water. Washing should be continued until the liquid is completely removed from the skin. The burned area should then be immersed in an ice bath, or a cold compress should be applied to the affected area.

Clothing and shoes contaminated with bromine pentafluoride 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 bromine pentafluoride, particularly its potential for being corrosive to the skin and eyes.

A worker who handles bromine pentafluoride 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 bromine pentafluoride is handled, processed, or stored.

STORAGE

Bromine pentafluoride should be isolated from other stored materials; it must be stored in a cool, dry, well-ventilated area in tightly sealed gas cylinders that are labeled in accordance with OSHA's hazard communication standard [29 CFR 1910.1200]. Extreme caution should be used when handling this material. Containers of bromine pentafluoride should be protected from physical damage and separated from combustible or organic materials, water, acids, halogens, arsenic, selenium, alkaline halides, sulfur, iodine, glass, metallic halides, metal oxides, metals (except for copper, stainless steel, nickel, and Monel), heat, sparks, and open flame. Bromine pentafluoride reacts with every known element except nitrogen, oxygen, and the inert gases. Because containers that formerly held bromine pentafluoride may still hold product residues, they should be handled appropriately.

SPILLS AND LEAKS

In the event of a spill or leak involving bromine pentafluoride, 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 potentially explosive atmospheres.
5. Remove leaking cylinder(s) to a safe place if feasible; attempt to stop the leak if it is possible to do so without risk.

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

Bromine pentafluoride 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 bromine pentafluoride; 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 bromine pentafluoride 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 bromine pentafluoride 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 limit. However, some situations may require the use of respirators to control exposure. Respirators must be worn if the ambient concentration of bromine pentafluoride 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 bromine pentafluoride. 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 bromine pentafluoride permeation; however, sources recommend the use of acid suits, aprons, boots, neoprene gloves, and other appropriate protective clothing when handling this substance. Since specific test data are not available for bromine pentafluoride, the information provided here should be considered as a guideline only. 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 bromine pentafluoride.

Safety glasses, goggles, or face shields should be worn during operations in which bromine pentafluoride might contact the eyes (e.g., through vapors or 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 bromine pentafluoride. Contact lenses should not be worn if the potential exists for bromine pentafluoride exposure.

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