

# Occupational Health Guideline for Bromine

## 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: Br<sub>2</sub>
- Synonyms: None
- Appearance and odor: Heavy, red-brown, fuming liquid. The vapor has an irritating odor and causes choking and lacrimation.

## PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for bromine is 0.1 part of bromine per million parts of air (ppm) averaged over an eight-hour work shift. This may also be expressed as 0.7 milligram of bromine per cubic meter of air (mg/m<sup>3</sup>).

## HEALTH HAZARD INFORMATION

- Routes of exposure  
Bromine can affect the body if it is inhaled or if it comes in contact with the eyes or skin. It can also affect the body if it is swallowed.
- Effects of overexposure  
Bromine vapor is a severe irritant of the respiratory tract and eyes. Severe breathing difficulties may occur. These breathing difficulties may be delayed in onset. Pneumonia may be produced. Dizziness, headache, nose bleeds, and cough may occur, followed some hours later by abdominal pain, diarrhea, and sometimes a measles-like rash. The liquid or concentrated vapor in contact with the eyes will cause severe painful burns. If liquid bromine gets on the skin and is not removed immediately, severe burns may result, leading to the development of deep-seated ulcers which heal slowly.

- 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 bromine.

- Recommended medical surveillance

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

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

—14" x 17" chest roentgenogram: Bromine may cause human lung damage. Surveillance of the lungs 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

Bromine vapor is a severe respiratory and eye irritant, and the liquid causes skin burns. Exposure of three animal species to 180 ppm for 7 hours caused severe eye irritation with clouding of the cornea, severe irritation of the respiratory tract, dyspnea, and some fatalities. In humans, 10 ppm is intolerable, causing severe irritation of the upper respiratory tract; lacrimation occurs at levels below 1 ppm. Symptoms in humans also include dizziness, headache, epistaxis, and coughing, followed some hours later by abdominal pain, diarrhea, and sometimes by a measles-like eruption on the face, trunk,

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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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and extremities. Pulmonary edema and pneumonia may be a delayed complication of severe exposures. The liquid or concentrated vapor in contact with the eye will cause severe and painful burns. Liquid bromine spilled on the skin causes a mild cooling sensation on first contact followed by a burning sensation. If bromine is not removed from the skin immediately, deep surface burns result; brown discoloration appears, leading to the development of deep-seated ulcers which heal slowly.

## CHEMICAL AND PHYSICAL PROPERTIES

### • Physical data

1. Molecular weight: 159.8
2. Boiling point (760 mm Hg): 58.8 C (138 F)
3. Specific gravity (water = 1): 3.12
4. Vapor density (air = 1 at boiling point of bromine): 5.5
5. Melting point: -7.3 C (19 F)
6. Vapor pressure at 20 C (68 F): 175 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): 3.5
8. Evaporation rate (butyl acetate = 1): Data not available

### • Reactivity

1. Conditions contributing to instability: Heat may rupture containers.

2. Incompatibilities: Contact of bromine with combustible organic or other readily oxidizable materials may cause fires and explosions. Contact of bromine liquid with aqueous ammonia may cause violent reactions. Anhydrous bromine will react violently with aluminum, titanium, mercury, and potassium. Wet bromine also reacts with other metals.

3. Hazardous decomposition products: None

4. Special precautions: Bromine will attack some forms of plastics, rubber, and coatings.

### • Flammability

1. Not combustible by itself, but it is a strong oxidizing material reactive with many substances.

### • Warning properties

1. Odor Threshold: Both Patty and the Pennsylvania Department of Environmental Resources, Occupational Health Division, report that odor threshold is 3.5 ppm; May reports an odor threshold of 1 ppm; Thienes and Haley report 0.05 ppm. The 0.05 ppm was confirmed by Leohardos and Kendall in the *Journal of the Air Pollution Control Association*, Vol. 19, 1969. For the purposes of this guideline, bromine is treated as a substance with adequate warning properties.

2. Irritation Levels: According to the *Hygienic Guide* of the Pennsylvania Department of Environmental Resources, bromine "is a primary irritant of the mucous membranes, and irritation to the eyes and upper and lower respiratory tracts is generally produced." Both the Manufacturing Chemists Association and the AIHA *Hygienic Guide* note that exposure to a concentration below 1 ppm bromine causes lacrimation. The AIHA

*Hygienic Guide* points out that "undisturbed work is possible when the concentration is 0.15 to 0.3 ppm and impossible at 0.6 ppm."

3. Evaluation of Warning Properties: Based upon the information given above, it appears that bromine can be detected below the threshold limit value. Therefore, for the purposes of this guideline, bromine is treated as a substance with adequate 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 bromine 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.

## PERSONAL PROTECTIVE EQUIPMENT

• Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent any possibility of skin contact with liquid bromine.

• Where there is any possibility of exposure of an employee's body to liquid bromine, facilities for quick drenching of the body should be provided within the immediate work area for emergency use.

- Non-impervious clothing which becomes contaminated with bromine should be removed immediately and not reworn until the bromine is removed from the clothing.

- Employees should be provided with and required to use splash-proof safety goggles where there is any possibility of liquid bromine contacting the eyes.

- Where there is any possibility that employees' eyes may be exposed to liquid bromine, an eye-wash fountain should be provided within the immediate work area for emergency use.

## SANITATION

- Skin that becomes contaminated with bromine should be immediately washed or showered with soap or mild detergent and water to remove any bromine.

## COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to bromine may occur and control methods which may be effective in each case:

Operation	Controls
Use during synthesis of ethylene dibromide; use in manufacture of pesticides	Process enclosure; local exhaust ventilation
Use as a laboratory reagent; use as a sanitizing, disinfecting, and bleaching agent	Local exhaust ventilation; personal protective equipment
Use in preparation of flame retardants in plastics and fiber industry; use in manufacture of organic and inorganic compounds for use in photography, pharmaceuticals, fungicides, intermediates, dyes and dyestuffs, war gas, and bleaching agents	Process enclosure; local exhaust ventilation

## 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 liquid bromine or strong concentrations of bromine vapor 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 liquid bromine gets on the skin, immediately wash the contaminated skin using soap or mild detergent and water. If liquid bromine soaks through the clothing, remove the clothing immediately and flush the skin using soap or mild detergent and water. If irritation or burns are present after washing, get medical attention.

### • Breathing

If a person breathes in large amounts of bromine, 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.

### • Swallowing

When liquid bromine has been swallowed and the person is conscious, give the person large quantities of water immediately to dilute the bromine. Do not attempt to make the person vomit. Get medical attention immediately. (If milk is immediately available, give the person milk instead of water).

### • 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.

## SPILL, LEAK, AND DISPOSAL PROCEDURES

- Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

- If bromine is spilled or leaked, the following steps should be taken:

1. Ventilate area of spill or leak.
2. Collect for reclamation or absorb in vermiculite, dry sand, earth, or a similar material or pour sodium thiosulfate or lime water over small spills.

- Waste disposal method:

Bromine may be disposed of by absorbing it in vermiculite, dry sand, earth or a similar material and disposing in sealed containers in a secured sanitary landfill.

## ADDITIONAL INFORMATION

To find additional information on bromine, look up bromine in the following documents:

- Medical Surveillance for Chemical Hazards
- Respiratory Protection for Chemical Hazards
- Personal Protection and Sanitation for Chemical Hazards

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 BROMINE

Condition	Minimum Respiratory Protection* Required Above 0.1 ppm
Vapor Concentration	
5 ppm or less	<p>A chemical cartridge respirator with a full facepiece and cartridge(s) containing non-combustible sorbents and providing protection against bromine.</p> <p>A gas mask with a chin-style or a front- or back-mounted canister containing non-combustible sorbents and providing protection against bromine.</p> <p>Any supplied-air respirator with a full facepiece, helmet, or hood.</p> <p>Any self-contained breathing apparatus with a full facepiece.</p>
10 ppm or less	<p>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.</p>
Greater than 10 ppm or entry and escape from unknown concentrations	<p>Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.</p> <p>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.</p>
Fire Fighting	<p>Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.</p>
Escape	<p>Any gas mask containing non-combustible sorbents and providing protection against bromine.</p> <p>Any escape self-contained breathing apparatus.</p>

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

