

QUALITY PERFORMS.



Bromine

Safety and Handling Guide

QUALITY WORKS.

LANXESS
Energizing Chemistry

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Emergency response

Telephone numbers for bromine

Country/ region	Emergency response provider and emergency number*
United States	CHEMTREC® +1-800-424-9300 or 1-703-527-3887
Europe	Carechem 24 +44 (0) 1235 239 670
China	Carechem 24 +86 10 5100 3039
India	Carechem 24 +91 1166 4114 05

* Refer to the Safety Data Sheet (SDS) for additional regional emergency response phone numbers.

Additional Information

Rocky Mountain Poison Control Center: +1-303-739-1153

The Rocky Mountain Poison and Drug Center Program, based in the United States, will provide medical advice to assist the global network of local care providers with the assessment and treatment of bromine related exposures.

INTRODUCTION

LANXESS: Innovative. Reliable. Sustainable.

For close to a century, we have helped our customers meet their needs with a broad portfolio of products and solutions. We are proud of our history and look forward to helping our customers meet future performance, safety, and compliance requirements. LANXESS is dedicated to providing products that are innovative, sustainable, and minimize the impact on our environment and human health without sacrificing performance or quality. We are committed to environmental, health, safety and security performance through the Responsible Care initiative with handling and stewardship being a critical component of that commitment. With significant and ongoing investment in increasing our bromine sources, our bromine ISO tank fleet, product stewardship, and maintenance capabilities, LANXESS is proud to be our customers' best partner for sustainable and secure global supply.

Bromine

Bromine is a member of the halogen group of elements and exists as a diatomic molecule. It is a heavy, reddish-brown liquid that gives off a red vapor at room temperature. It is the only non-metallic element that is liquid at room temperature.

Bromine serves as a starting material for a variety of products that are the building blocks for developing and engineering highly complex organic molecules that meet specific performance, environmental, and quality requirements. Bromine is utilized in many applications including flame retardants, agrochemicals, pharmaceuticals, fine chemicals, high performance rubber, polymers, biocides and energy, as well as in chemicals used by the oil and gas industries in completion fluids, and inorganic bromides for mercury control.

Bromine is extracted from reservoirs of naturally concentrated brine in deposits underground in Arkansas, United States, and in the surface waters of the Dead Sea in Israel. Natural bromide salts are also present in ocean water and other underground and surface waters brines.

LANXESS is among the world's largest producers and marketers of bromine and brominated specialty chemicals.



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RESPONSIBLE CARE

DOING THE RIGHT THING

Responsible Care is the chemical industry's health, safety, security, and environmental performance improvement initiative. As an obligation of membership, Responsible Care is the ethical framework around which American Chemistry Council member and partner companies, including LANXESS Corporation, operate. Responsible Care is our commitment to respond to public concerns about the safe management of chemicals and has become the single most important performance improvement initiative within the chemical industry.

Our industry creates products and services that make life better for people around the world – both today and tomorrow. The benefits of our industry are accompanied by enduring commitments to Responsible Care in the management of chemicals worldwide. We will make continuous progress toward the vision of no accidents, injuries, or harm to the environment and will publicly report our global health, safety and environmental performance. We will lead our companies in ethical ways that increasingly benefit society, the economy, and the environment while adhering to our Responsible Care Policy.



Our Responsible Care policy

LANXESS considers ensuring the safety and health of the public, our employees, contractors, and customers and the protection of the environment now and for future generations to be our core values. We are committed to meeting all applicable laws, regulations, permits, and internal standards throughout the world. Our goal is zero accidents and incidents, and zero harm to the environment. Continued performance improvement will be achieved with the involvement and commitment of our employees to:

- Conduct business ethically and in accordance with the Guiding Principles of Responsible Care and the concepts of Sustainable Development.
- Implement the LANXESS Management System, which integrates environmental, health, safety, and security considerations into daily business practices.
- Improve the safety of processes, reduce the quantity and/or hazard of wastes generated and through our commitment to pollution prevention – minimize or eliminate the release of contaminants into the environment.
- Ensure all products and intermediates are properly registered, comply with applicable regulatory requirements, and may be safely used for their intended purposes.
- Enhance the security of our employees and facilities, our information systems, and our raw materials and finished products throughout the value chain.
- Provide our employees and other stakeholders with appropriate information necessary for their understanding of the environmental, health, and safety aspects of our operations and products; our safety, health, and environmental performance; and the contribution our products make to the quality of life.

BROMINE

Bromine (Br₂) [7726-95-6] is the only nonmetallic element that is liquid at ordinary temperatures and pressures. It has a dark, amber-red color and an intensely irritating odor. The name is derived from the Greek (bromos), meaning “stench.” There are two stable isotopes, ⁷⁹Br, and ⁸¹Br, present in nearly equal proportions such that the atomic weight is 79.904. The atomic number is 35. Within rather wide limits the liquid and vapor are diatomic (Br₂).*

Bromine exposure, either by liquid contact or vapor inhalation, represents a hazard with the potential to cause serious injury. The liquid rapidly attacks skin and other tissues producing irritation, burns, and necrosis. Low concentrations of vapor are irritating to the eyes and the respiratory tract. Exposure to acutely dangerous concentrations may result in serious inflammation and edema, followed by pneumonia. Excessive exposure to low concentrations may result in inflammatory reactions in the eyes and respiratory passages. The maximum permissible exposure weighted over eight hours is 0.1 parts per million (ppm).



Bromine is an oxidizing agent. In the U.S., it is on the list of Extremely Hazardous Substances in section 302 of the Superfund Amendments and Reauthorization Act (SARA) Title III of 1986. Bromine is subject to the reporting requirements of Section 313 (40 CFR Part 372) of SARA Title III. The U.S. Environmental Protection Agency (US EPA) reportable quantity for a spill or release is 500 pounds.

The U.S. National Fire Protection Association (NFPA) rates bromine as follows:

- Health – 4
- Flammability – 0
- Reactivity – 0
- Oxidizer

The Hazardous Materials Identification System (HMIS) classification for bromine is as follows:

- Health – 4
- Flammability – 0
- Reactivity physical hazards – 3

Bromine’s UN number is 1744 and is classified as follows under Regulation(EC) No 1272/2008:

- Acute toxicity – category 1
- Skin corrosion – category 1A
- Acute aquatic toxicity – category 1

PHYSICAL PROPERTIES OF BROMINE (BR₂)

Atomic number	35
Molecular weight	159.808 [†]
Valences	-1,1,3,5,7 (Br ₂)
Boiling point	58.8°C (137.8°F) [†]
Compressibility, @ 20°C (77°F) from 0-10	MPa62.5 x 10 ⁻⁶ [†]
Pounds per gallon @ 25°C (77°F)	25.9
Specific gravity, 20°C/15°C (68°F / 59°F)	3.119 [†]
Dielectric constant, 10 freq., 25°C (77°F)	3.33 [†]
Explosive limits	Non-flammable; oxidizing properties, may ignite combustibles on contact
Flashpoint	None
Freezing point	-7.25°C (18.95°F) [†]
Hygroscopicity	Will absorb water from wet air
Specific gravity of vapor Relative to air	5.87 [†]
Heat of fusion, -7.25°C, J/g	66.11 [†]
Heat of vaporization 50°C, J/g	187 [†]
Refractive index, 20°C (68°F)	1.6083 [§]
Viscosity 20.5°C	0.9928cP [¶]

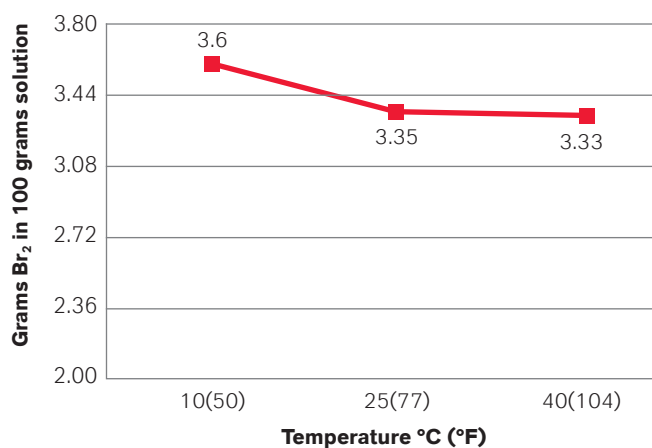
[†] Baruch Grinbaum and Mira Freiberg. "Bromine." Kirk-Othmer Encyclopedia of Chemical Technology (Wiley Online Library, 2011), 1–28.

[‡] Robert H. Perry, Chemical Engineers Handbook, 7th Ed., (McGraw Hill, 1997), 2-10.

[§] Robert H. Perry, Chemical Engineers Handbook, 5th Ed., (McGraw Hill, 1973).

[¶] Yaws, Carl L. (2012). Yaws' Critical Property Data for Chemical Engineers and Chemists. Knovel. <http://www.knovel.com>

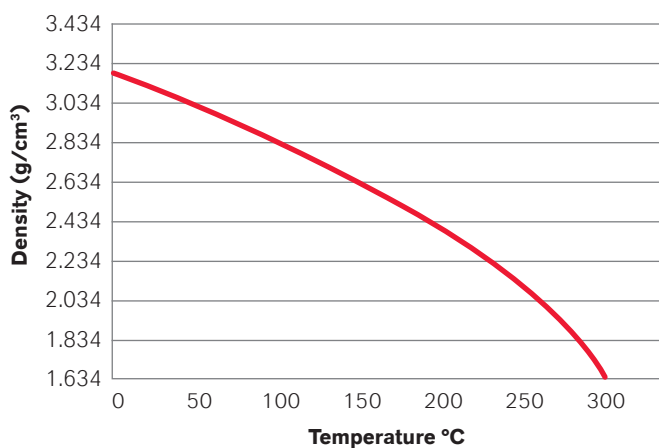
Aqueous solubility of bromine



Solubility, approximate, g/100 g solvent @ 25°C (77°F)

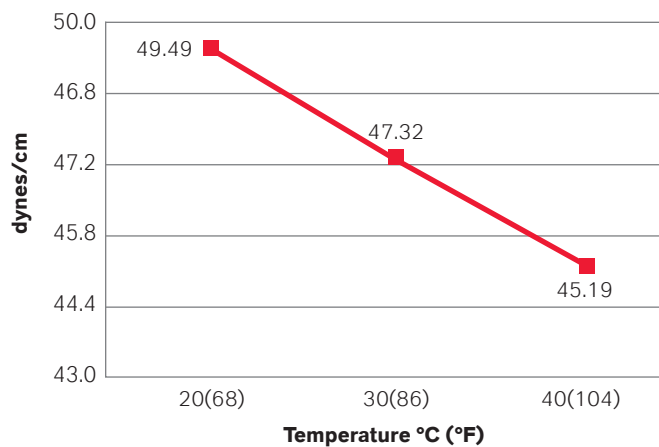
Carbon tetrachloride	Infinite
Chloroform	Infinite
Methylene chloride	Infinite
Carbon disulfide	Infinite
Alkyl bromides	Infinite
Ether	Infinite
Methanol	Infinite
Concentrated hydrochloric acid	Soluble
Aqueous metallic halides	Soluble
Aqueous solubility of bromine	
10°C (50°F)	3.60 [†]
25°C (77°F)	3.35 [†]
40°C (104°F)	3.33 [†]

Density of liquid bromine



Yaws, Carl L. (2012). Yaws' Critical Property Data for Chemical Engineers and Chemists. Knovel. <http://www.knovel.com>

Surface tension



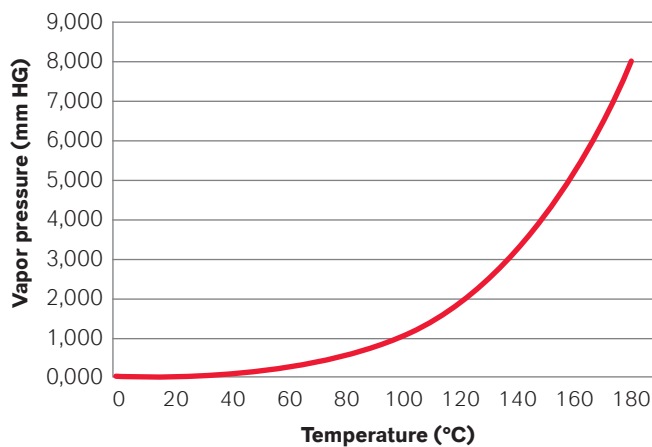
Robert R. Dreisbach, Physical Properties of Chemical Substances (The Dow Chemical Company, 1954).

Heat capacity, J/Mol

15K	7.217
30K	22.443
60K	36.33
240K	57.94
265.9K	61.64
265.9K (solid bromine)	77.735
288.15K (liquid bromine)	78.66
Electronegativity	3.0
Electron affinity kJ	330.5

Baruch Grinbaum and Mira Freiberg.
"Bromine." Kirk-Othmer Encyclopedia of Chemical Technology (Wiley Online Library, 2011), 1–28.

Vapor pressure of liquid bromine



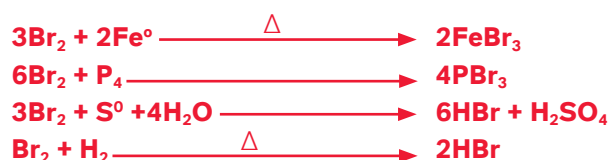
Yaws, Carl L. (2012). Yaws' Critical Property Data for Chemical Engineers and Chemists. Knovel. <http://www.knovel.com>

Chemical reactions

Bromine is a very reactive element characterized by a strong oxidizing capability. It forms a wide range of bromine-containing compounds on reaction with numerous inorganic and organic substrates. A limited, but typical, illustration of such reactions follows.

Inorganic bromine compounds

Bromine readily oxidizes metallic and nonmetallic elements as indicated by the following equations:



Reaction of bromine with water results in the formation of an aqueous solution of hydrobromic and hypobromous acids. The latter is relatively stable only in solution, decomposing under the influence of heat, light, or copper catalysis to produce hydrobromic acid and oxygen.



Reactions of bromine and ammonia occur readily, and depending upon conditions, produce nitrogen and hydrogen bromide, bromamines, or ammonium bromide. The ammonium bromide results in the reaction between hydrogen bromide and excess ammonia. In the vapor and liquid states, bromine and ammonia form ammonium bromide (NH_4Br) at normal temperature and atmospheric pressure.

With strong alkalis at low temperatures in aqueous solutions, bromine reacts to produce bromide and hypobromite salts.



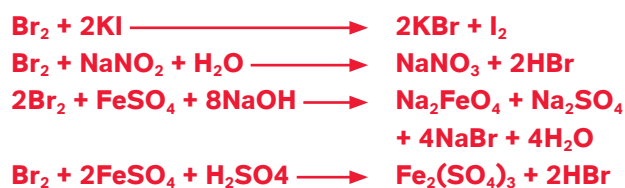
At elevated temperatures, the hypobromite undergoes an oxidation-reduction reaction to produce bromate and bromide salts.



The balanced summation of these two reaction equations yields:



Some typical oxidation-reduction reactions of bromine with inorganic compounds under alkaline or acidic conditions are illustrated in the following reactions:



Organic bromine compounds

The reactions of bromine with organic compounds may occur in a variety of ways. Typically, they involve:

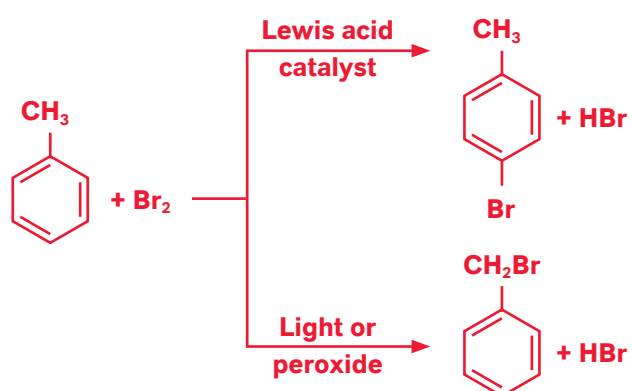
1. The addition of bromine to unsaturated hydrocarbons such as



2. The substitution of hydrogen on the organic substrate such as:



Reactions can be achieved under a variety of conditions, in liquid or vapor phase, and in the presence or absence of solvents or catalysts. Carbon tetrachloride, chloroform, and other halogenated solvents, acetic acid and other lower aliphatic acids, and hydrobromic acid are typically used as solvents. Lewis acid catalysts frequently are employed in the substitution bromination of aromatics and light or peroxide catalysts in the bromination of aliphatics. The choice of catalyst often dictates the course of a reaction.



Some organic bromine compounds are best prepared indirectly by the reaction of other functional groups with bromine derivatives. For example, alkyl bromides, such as methyl bromide, are best prepared by reaction of the corresponding alcohol with hydrogen bromide. Alkyl bromides can also be prepared by the reaction of HBr with olefins.



PROCEDURES FOR THE SAFE HANDLING OF BROMINE

Extreme care must be exercised in the storage, handling, shipping and use of bromine. Bromine vapors can irritate skin, eyes, and mucous membranes. Contact with liquid bromine can cause severe burns. The readily identifiable color and pungent odor gives immediate warning of bromine's presence.

At a concentration of only one part per million (ppm), bromine is easily detectable and even lesser amounts can cause eye irritation. The Occupational Safety & Health Administration (OSHA), U.S. Department of Labor, permissible exposure limit (PEL) for bromine is 0.1 ppm for 8 hours time weighted average.

Verify exposure limits in each region or country. Safety is the personal responsibility of everyone working with or around bromine. Supervisory personnel must know and enforce the recommended safe handling practices outlined in this guide. Every LANXESS employee and contract employee must pass safety training at the time of employment and must remain updated on safety procedures monthly. We recommend the same policy for our customers and anyone else using and handling bromine.



PERSONAL SAFETY

PRECAUTION

1. Wear American National Standards Institute (ANSI) or equivalent approved chemical safety goggles at all times. When handling Bromine use an approved chemical resistant full-face shield over eyewear. Always carry a full-face respirator with you when handling Bromine in case of emergency. Fountains should be located in areas where bromine is handled, used, or stored. If bromine liquid or vapor contacts the eyes, irrigate immediately with large amounts of running water. Eye fountains are preferable for irrigation. If one is not available, a bubbler drinking fountain or a hose with a liberal, gentle flow may be utilized. The eyelids should be held apart during irrigation to ensure contact of water with all accessible tissues of the eyes and lids. Eyes should be washed continuously for a minimum of 15 minutes. After irrigation, the employee should seek medical attention immediately.
2. When in danger of contact with liquid bromine, wear an approved chemical resistant suit or smock that covers the whole body and has sealed cuffs at the hands and feet. In an enclosed area wear clean clothing, protective gloves, and eye and face protection. Never wear clothes that smell of bromine. Wash contaminated clothing and equipment before reuse.
3. Wear approved chemical Nitrile or Neoprene gloves. Discard gloves that have been in contact with liquid bromine.
4. Wear leather or other non-woven ANSI or equivalent approved steel-toed shoes. Protective chemical resistant rubber boots should be worn over shoes for extra protection. Discard shoes that have been in contact with liquid bromine.
5. For skin contact, the affected area should be flooded immediately with large amounts of water from a safety shower or other source of flowing water. All contaminated clothing, including shoes, should be removed as quickly as possible while the victim is under the shower. Washing should be continued for a minimum of 15 minutes. The victim should receive medical attention immediately.
6. To ensure adequate personal protection, protective clothing and equipment should be inspected before each use. Faulty protective clothing and equipment should not be repaired and discarded immediately.
7. To avoid bromine ingestion:
 - Always wash face, hands, and arms before eating.
 - Never place bromine contaminated articles in the mouth.
 - Don't siphon or blow out clogged lines or nozzles by mouth.
8. To avoid inhalation of bromine:
 - Stay upwind when loading, unloading, and transporting bromine.
 - Have the National Institution for Occupational Safety and Health (NIOSH) or equivalent approved respirators and self-contained breathing apparatus available.
 - When handling bromine in an enclosed area wear protective clothing and respiratory equipment.
 - Adhere to your plant regulations regarding respiratory equipment for bromine handling.
9. Bromine vapors are so irritating to the eyes, nose and throat that they provide ample warning of the presence of bromine in acutely hazardous concentrations. If over-exposure does occur, the exposed individual should be immediately removed from the contaminated area to fresh air. They should be placed in an upright position. They should avoid exertion. If vomiting occurs, turn the exposed individual on their side to avoid choking. Keep them warm. If they do not recover quickly or is coughing and showing signs of respiratory stress, properly trained personnel should administer oxygen. If respiration has ceased, artificial respiration should be administered. The exposed individual should receive medical attention immediately.

PERSONAL PROTECTIVE CLOTHING AND EQUIPMENT

Respiratory equipment

- **For escape only**, provide either a 5-minute air bottle with hood, a mouthpiece respirator with acid cartridge or a full-face respirator with chemical cartridges.
- **For work in an enclosed or a poorly ventilated area**, use a NIOSH or equivalent approved pressure demand self-contained breathing apparatus.
- **All respiratory equipment must be carefully maintained and stored in accordance with manufacturer's instructions.**



Clothing

The protective clothing listed below are examples of the recommended minimum protection that should be worn where bromine is handled. When making choices regarding personal protective equipment for bromine service, it is important that clothing is rated for bromine service to ensure it will provide an appropriate level of protection for the job.

Coveralls & jacket

Chemical resistant suit or smock with cuffed hands and feet

Face shield

Chemical resistant face shield

Goggles

ANSI, or equivalent, approved goggles

Boots

Chemical resistant rubber boots

Gloves

100% nitrile or neoprene gloves

SAFETY PRACTICES IN THE WORK AREA

General instructions

1. Read and follow all directions and warning labels carefully.
2. Inform all personnel of the potential hazards of contact with bromine and train them in appropriate first-aid procedures.
3. Store and handle bromine over drip pans drained by a sump that is vented to a scrubber system.
4. Bromine handling areas should be clearly marked and restricted to qualified and trained personnel only.
5. Maintain and clean uncontaminated equipment, floors, and work areas.
6. Immediately contain and clean up all bromine spills.
 - Wear approved respiratory equipment and protective clothing.
 - Carefully release anhydrous ammonia vapor to neutralize bromine vapors in the air. Be careful not to over apply anhydrous ammonia.
 - Pour soda ash solution or hypo solution* on the liquid bromine to neutralize.
 - Using cold water, wash neutralized bromine to a sump for disposal.
 - Open doors and windows to ventilate.
7. Avoid contact of bromine with strong reducing agents, strong alkalis, metals, wood, paper products, fabric, grease, and oil or other combustible materials.

Ventilation

1. Restrict bromine vapor concentration in the work area to less than 0.1 ppm with adequate exhaust hoods, ventilation systems, and scrubbers. Analyze the air for bromine concentrations to ensure proper control.
2. Transfer or repackage bromine only in a controlled, closed environment.
3. Positive exhaust ventilating systems must be used in enclosed areas where bromine is handled.

Containers and storage

1. Empty shipping containers completely.
2. Do not return used or recycled bromine or other bromine containing liquids to Chemtura Corporation in our containers as this could lead to catastrophic container failure.
3. Store bromine containers in dry, well-ventilated areas, protected from moisture and excessive heat or cold.
4. Store only in approved bromine containers. Never store in containers that resemble food or beverage packaging.
5. Check all equipment used for bromine handling or processing for deterioration, as well as leaky valves and couplings. Bromine handling equipment must be made of or lined with Kynar®, Halar®, Teflon®, Monel®, Pyrex® glass, nickel-lined steel, glass-lined steel or lead-lined steel. Proper maintenance requires periodic cleaning and drying with nitrogen.
6. Protect bromine-handling equipment from strong alkalis, reducing agents, other metals, wood, fabric, paper, grease, and oils.

* Halar® is a registered trademark of Solvay Solexis.

* Kynar® is a registered trademark of the Arkema inc.

* Teflon® is a registered trademark of the DuPont Company.

* Monel® is a registered trademark of Inco Corporation.

* Pyrex® is a registered trademark of Corning Incorporated.

Fire precautions

1. Always wear a self-contained breathing apparatus around bromine or bromine-containing compounds involved in a fire.
2. Bromine does not burn, but it is a strong oxidizer and will react violently with aluminum, titanium, mercury, sodium, and potassium.
3. Wood, paper products, fabric, petroleum products, plastics, and other organics may spontaneously combust in the presence of liquid bromine, which is a powerful oxidizer.
4. Dry bromates (products of sodium hydroxide neutralization of bromine) are powerful oxidants and are shock sensitive. They must be handled with extreme care.

* Hypo solution: dissolve 57 kgs of sodium thiosulfate and 1 kgs of soda ash in 709 liters of water.

HANDLING BROMINE IN THE LABORATORY

General instructions

All personnel using bromine in a laboratory should be properly trained regarding its characteristics, PPE and equipment requirements, and first aid procedures. Refer to the Safety Data Sheet for additional information.

Equipment

1. Air purifying cartridge respirator with proper acid gas or organic vapor/acid gas cartridge(s) (only to be used as an evacuation aid).
2. Operational safety shower and eyewash.
3. 10-25% aqueous NaOH or hypo solution* (see page 14 for formula) for spills.
4. Aqueous ammonium hydroxide for bromine vapor neutralization, placed in large surface area dishes to liberate NH₃ vapors (do not add directly to liquid bromine).
5. Safety glasses with side shields/chemical safety goggles.
6. Face shield.
7. Neoprene or nitrile gloves and apron, boots, and gauntlet sleeve protectors (chemical resistant suits are optional for maximum protection).

Storage and transport

1. Bromine should be stored in a properly operating fume hood or well-ventilated cabinet in glass bottles with Teflon[®]-lined caps. Store in a cool, dry place where freezing, heat and humidity, and moisture exposure possibilities are minimal.
2. Secondary containment pans with high sides or rubber bottle carriers should be used as a precautionary measure. Second skin plastic coated bottles are also recommended as a safeguard.
3. Bromine bottles should be transported in rubber bottle carriers or a closed container that is sufficiently padded to avoid bottle breakage.

Handling precautions

1. Bromine should be handled by trained individuals. Proper PPE should be worn at all times when handling bromine. Bromine transfer and handling should be done in a fume hood.
2. Proper fume hood operation should be checked prior to use. Sufficient bromine vapor scrubbing measures should be taken (i.e., caustic scrubber or other suitable material). Do not vent bromine vapors directly to the atmosphere.
3. Small quantities of bromine can be transferred by pouring, but larger volumes should be transferred using a laboratory scale pump of proper materials of construction.
4. Due to the dense nature of liquid bromine, lab glassware such as receivers (graduated cylinders or flasks) or addition funnels for reactors should be clamped and stabilized to avoid breakage and spills.



NEUTRALIZATION OF LABORATORY BROMINE WASTE STREAMS

Physical hazards/properties

Neutralization of bromine is extremely exothermic. It should be done slowly with sufficient external cooling capacities. Proper materials of construction of all equipment should be observed. Bromine is a strong oxidizer that reacts with some metals and is incompatible with many elastomers and plastics.

All considerations regarding the safety and handling of bromine should be observed when neutralizing bromine waste. Equipment guidelines and first aid procedures for the handling of bromine should be followed.

Apparatus

Assemble, in a fume hood, a 5 liter 3-neck round bottom flask supported at the base and the neck. Equip the flask with a sufficient cooling bath, mechanical stirrer, and a water-cooled or air-cooled condenser vented to a sodium hydroxide scrubber system. Neutralization of bromine waste on a scale larger than that described here is not recommended.

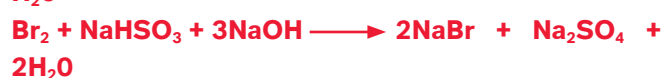
Stoichiometry

Neutralization with sodium bisulfite requires 3 moles of sodium hydroxide, 1 mole sodium bisulfite, and 1 mole bromine.

Neutralization with sodium sulfite requires 2 moles sodium hydroxide, 1 mole sodium sulfate, and 1 mole bromine.

The weights and volumes specified include a 10% excess of sodium hydroxide and sodium bisulfite or sodium sulfite. This excess should be observed.

Chemistry



This neutralization procedure is designed to assure that the final waste stream has been completely neutralized with respect to acidity and oxidation potential. It is also designed for safety and operational handling concerns in a laboratory setting.

Neutralization with bisulfite (based on 100 ml bromine)

1. Add 2500 ml of tap water to the flask.
2. Slowly add, with cooling and agitation, 345 ml of 50%

Neutralization with sulfite (based on 100 ml bromine)

sodium hydroxide (NaOH). Note: adjust water charge to achieve target concentration of 2.3 M NaOH if less concentrated sodium hydroxide solution is used.

3. Add 224g sodium bisulfite while stirring.
4. Continue stirring until most of the solids dissolve.

Procedure

1. Add 2500 ml of tap water to the flask.
2. Slowly add with cooling and agitation, 230 ml of 50% sodium hydroxide (NaOH). Note: adjust water charge to achieve target concentration of 1.6 M NaOH if less concentrated sodium hydroxide solution is used.
3. Add 271g sodium sulfite while stirring.
4. Continue stirring until most of the solids dissolve.

Be aware that organic or metal impurities may change normal characteristics of neutralization (i.e., color changes, foaming, etc.)

1. Slowly, with cooling, add 100 ml of bromine using a clamped addition funnel or pump and graduated cylinder. The addition rate should be slow enough to allow for color dissipation and temperature control below 50°C (122°F).
2. When addition is complete, allow the flask to cool to room temperature.
3. Check the contents with starch KI paper and pH paper to make sure no oxidizer is present and that pH is > 7. Solution should be colorless. If color persists, slowly add more sodium hydroxide/sodium bisulfite (sulfite) solution.
4. When neutralization is complete, filter off any insoluble material and separate any organic phases. Sodium bromide precipitate can be dissolved in water. The resulting solution should be 11 to 12% sodium bromide. This solution should be disposed of properly as a waste stream.

EMERGENCY PROCEDURES

Transportation emergencies

In emergency situations resulting from vehicle accidents:

1. Notify emergency authorities.
2. Dress in proper protective clothing and a NIOSH approved or equivalent self-contained breathing apparatus.
3. Isolate the area and remove any persons affected by the spill.
4. Administer immediate first aid and seek medical assistance for those injured.
5. Cautiously contain the bromine.
6. Call Chemtrec®, Carechem 24 (see page i) or one of the regional providers listed on your Safety Data Sheet for advice.
7. If the bromine discharge is contained within the transport vessel, with advice from LANXESS personnel, transfer the bromine into another container.
8. When bromine is escaping from the container, the leak must be stopped. Specialized training or advice may be required to stop leaks. Tightening loose fittings, plugging holes, or reorienting the container are all techniques used to stop or reduce leaks.
9. Use materials like clay, sand, or soil to confine bromine to the already contaminated area. Do not use spill pillows or other fibrous materials for containment as they may increase the potential for fire.
10. Gently cover any pooled bromine with a thin layer of water to minimize bromine vapor emission. While adding water, try not to agitate the bromine pool as this will cause excessive vapor. Placing a thick covering of hydrated limewater slurry over the bromine will slowly neutralize the bromine and stop vapor emissions.
11. If the soil has already absorbed the bromine, work lime deep into the ground with water. For large spills, earth-moving equipment may be required.

Leaking containers

1. When handling a leaking bottle, drum, or cylinder of bromine, personal protective clothing, goggles, and NIOSH or equivalent approved self-contained breathing equipment must be worn.
2. Clear contaminated area of non-essential personnel.
3. Maintain a slight ammonia atmosphere throughout the clean up. Carefully release anhydrous ammonia gas to neutralize bromine vapor, but do not over apply anhydrous ammonia. The ammonia gas will convert bromine to white ammonium bromide "smoke." Do not allow liquid bromine and liquid ammonia to combine; a violent reaction will occur. Ammonia (16 to 25% by volume) can form an explosive mixture with air.
4. Pour hypo solution* (see page 14 for formula), lime and water slurry, or soda ash solution over the spill. Hypobromine reactions produce hydrobromic acid. Dry sodium thiosulfate and liquid bromine produce a violent reaction; do not mix them.
5. Using cold water, wash neutralized bromine into a sump for transfer to an approved waste disposal facility where the waste can be processed.
6. Ventilate the area to remove the ammonium bromide and any bromine fumes. Clean the floors and equipment with soap and water.

Recovery and salvage

1. Remove undamaged containers and store for later inspection.
2. Under the advice and/or supervision of LANXESS or their partners, transfer the remaining bromine into other containers.

Cleaning up the contaminated area

1. Spread hypo solution* (see page 14 for formula), soda ash solution or lime slurry over the affected area.
2. Scrub the area well. Using cold water, wash the neutralizing solution to a sump for transfer to an approved waste facility for processing.
3. Use hot soapy wash water and large quantities of rinse water to clean equipment. Dispose of this waste in the same manner as described above.
4. Replace any porous materials, fabric, leather, wood, and paper products, which have been in contact with bromine.

Cleaning undamaged containers

1. If the container is tightly sealed and there appears to be no danger of contaminating the liquid inside, pour hypo solution* (see page 14 for formula) over the affected areas.
2. Wash with water and dry completely. Should markings and labels be illegible, remark and relabel. If needed, contact LANXESS for new labels.

Fire

1. In case of fire, notify the fire department and emergency responders immediately and evacuate the area.
2. Everyone should move a safe distance from the fire, upwind of the smoke.
3. Notify LANXESS at +1 870-862-5141.
4. Wearing self-contained breathing equipment, fire fighters should cool bromine containers with water, fog, or foam.
5. Any spilled bromine should be neutralized with hypo solution* (see page 14 for formula). Bromine is a powerful oxidizer; care should be taken to keep bromine away from other materials.



BROMINE

FIRST AID

Toxicology

Bromine is a very strong oxidant. It is extremely toxic and may prove fatal if inhaled or swallowed. Severe burns may result from skin contact and contact with the eyes may cause blindness. Bromine is extremely destructive to tissue of the mucous membranes and upper respiratory tract. Bromine exposure may result in spasm, inflammation and edema of the larynx and bronchi, chemical pneumonitis and pulmonary edema. Low concentrations of bromine vapor cause irritation, tearing, and inflammation of the eyes. At higher concentrations blepharospasm and photophobia develop and a splash in the eyes causes severe burns and/or blindness. Soft tissue burns may be deep and very slow to heal.

How to recognize bromine overexposure

Bromine is highly irritating to the eyes, nose, and mucous membrane. Because of these warning properties, overexposure is unlikely to occur. If overexposure does occur, symptoms can include excessive tearing, redness and irritation of the eyes, throat, and nose, and severe skin burns. Prolonged, unprotected exposure can result in respiratory damage and respiratory arrest.

First aid for bromine exposure

1. Immediate medical assistance is required if bromine is swallowed, inhaled, or has contacted the eyes or skin.
2. If bromine has been ingested, do not give anything by mouth. Seek medical attention immediately. Do not induce vomiting.
3. If bromine has been inhaled, move the exposed person to a well-ventilated area. The exposed individual should be placed in an upright position. The exposed individual should avoid exertion. If vomiting occurs, turn the person on his or her side to avoid choking. Keep the individual warm. If the exposed individual does not recover quickly or is coughing and showing signs of respiratory distress, oxygen should be administered by properly trained personnel. If respiration has ceased artificial respiration should be administered using the proper barrier device. The exposed individual should receive medical attention as soon as possible.
4. For skin contact, the affected area must be flooded immediately with large amounts of water from a safety shower or other source of flowing water. All contaminated clothing, including shoes, should be removed as quickly possible while the exposed individual is under the shower (dispose of contaminated clothing). Washing should be continued for a minimum of 15 minutes. The exposed individual should receive medical attention as soon as possible.
5. If bromine liquid or vapor contacts the eyes, they must be irrigated immediately with large amounts of running water; eye wash fountains are preferable for irrigation. If one is not available, a bubbler drinking fountain or a hose with a liberal, gentle flow may be utilized. The eyelids must be held apart during irrigation to ensure contact of water with all accessible tissues of the eyes and lids. Eyes should be washed continuously for a minimum of 15 minutes. After irrigation, the exposed individual should be taken to a physician immediately.

In all cases of bromine injury, after initial first aid measures are completed, keep the person quiet, warm, and upright. Obtain immediate medical attention. Provide emergency personnel with information about all materials used by the person, appropriate information about bromine and first aid procedures.

ENGINEERING MATERIALS

LANXESS bromine is shipped with a very low water content (typically less than 30 ppm). However, bromine is hygroscopic and if improperly handled, water content can quickly increase to 300 ppm. As the water content increases so does the corrosive potential of bromine, making the storage of bromine under dry nitrogen or dry air necessary (dewpoint should be less than -40 °C/-40 °F). Bromine with water content of less than 30 ppm is non-corrosive to many non-ferrous metals including lead, nickel, tantalum, Hastelloy® B, and C, and Monel®. Bromine is extremely reactive with titanium and aluminum and contact with these metals must be avoided. Glass lined steel and ceramic materials (excluding carbon and graphite) are resistant to bromine. Do not use ordinary polymeric resins with bromine. However, fluoro-polymers such as Kynar®, Halar®, Kalrez®, are acceptable.

Lead

Lead and lead-lined steel are commonly used, versatile materials for in-process equipment and storage containers for dry bromine. A protective layer of lead bromide (which can be washed away by inorganic acids) forms on the interior of the vessel, making it suitable for use with bromine of up to 75 ppm water, at room temperature. If bromine contains less than 30 ppm water, it may be handled in lead equipment to 58.8°C (137.8°F). Lead-lined steel vessels used for bromine storage must be constructed and/or modified by certified personnel in accordance with ASTM standards. Solid Teflon® or Teflon®-envelope flange connection gaskets must be used.

Nickel and nickel alloys

Nickel, Monel®, Hastelloy® B, and Hastelloy® C containers are appropriate only for storage and handling of bromine with less than 30 ppm water at room temperature. Nickel may be used with dry (less than 30 ppm water) bromine up to 400°C (752°F).

Tantalum

Tantalum equipment can be used for wet or dry bromine, in temperatures of up to 149°C (300°F). However, in the presence of some organic materials, bromine will corrode tantalum.

Steel and stainless steel

Bromine and its vapors are severely corrosive to steel and stainless steel making them unacceptable for use in bromine process systems.

Glass and ceramics

Although inherently fragile, tempered glass, porcelain, fused silica, chemical stoneware and acid brick are acceptable materials for use with both wet and dry bromine at various temperatures.

Glass-lined steel

Due to its excellent chemical resistance and physical strength, glass-lined steel makes a versatile construction material for use with bromine. Glass-lined steel equipment must withstand a 20,000 volt spark test and can be used at temperatures up to 138°C (280°F).

Plastics

Fluorinated plastics such as Teflon®, Kalrez®, Halar®, Kynar® and Gylon® are resistant to bromine and are used in valves, piping, gaskets, and linings. Gaskets sheathed in Teflon® and steel or fibre-reinforced plastic lined with Kynar®, Halar®, Teflon® or Gylon® are acceptable for use in bromine distillation columns, other process equipment, and scrubbers. Plastics other than those mentioned here are not acceptable for use with bromine.

Lubricants

Avoid lubricants. Use non-lubricated valves lined or sleeved with Teflon®.

* Halar® is a registered trademarks of Solvay Solexis.

* Kynar® is a registered trademark of Arkema Inc.

* Kalrez® is a registered trademark of DuPont Company.

* Teflon® is a registered trademark of the DuPont Company

* Monel® is a registered trademark of the Inco Corporation.

* Hastelloy® is a registered trademark of Haynes International.

* Gylon® is a registered trademark of Garlock, Inc.

BROMINE STORAGE

In the laboratory

Bromine for laboratory or pilot plant use is usually purchased in glass bottles. Pour, siphon, or pump bromine into small glass, ceramic, or lead feed vessels with Teflon® stopcocks.

For use in bulk

Store drum, tank truck or ISO quantities of bromine in lead or lead-lined steel tanks, which feed to the process or reaction. For larger storage vessels where bottom outlets cannot be used, pump bromine out of the tank with nickel or plastic pumps. Contact your LANXESS representative for specific recommendations.

Protect storage tanks from moisture or humid air as bromine will absorb moisture from the air. When exposed to air having a normal summer dew point of 5-10°C (40–50°F), bromine will equilibrate at about 70–80 ppm water. Bromine this wet can cause severe corrosion of many metals. Keep a slight positive pressure (0.1 inch of H₂O) on the storage tanks by purging with dry (-40°C/ -40°F dew point) air or nitrogen into the tank.

For bulk storage

Store in either a glass-lined steel or lead-lined steel storage tank, properly designed for bromine's weight. Glass-lined steel tanks are not advised in active seismic areas. Stored bromine must be protected from temperatures below -7°C (20°F) to prevent freezing. Storage tanks should be located in concrete paved and diked areas so that any leak or spill can be contained.

SHIPPING CONTAINERS

ISO tank containers

LANXESS offers ISO tank containers in bromine service ranging in size from 14 to 23 tonnes to meet specific customer needs. The containers and frames are of steel construction. The tanks are lined with lead or nickel plating. They are fitted with either two or three valves. Frame sizes for ISO tank containers are the standard 8' X 8' X 20'. Platform and valve heights vary by ISO capacity and design style. Consult with your LANXESS representative if you have detailed information requests regarding platform and valve heights for containers you will receive.

Unloading ISO tank containers

ISO tank containers are fitted with two or three valves. The centered valve in either configuration is the discharge line. The remaining valves connect to the vapor space of the ISO container. In 3-valve configurations, one of the non-discharge valves can be utilized for venting and the other non-discharge valve can be used for pressurization of the container. Containers in non-US service are color coded yellow for discharge, red for venting and green for pressurization. In 2-valve configurations, the yellow valve is for discharge and the red valve is for container pressurization and venting.



Procedure for unloading bromine using 2 hose connections (recommended)

Any LANXESS bromine ISO container can be unloaded using the 2 hose connections procedure that follows (page 27).

There are 2 color-coded valves:

- Yellow for discharge
 - Red for venting and pressurizing the ISO container.
 - The green valve is not used in this procedure.
1. Ensure that the absorber/scrubbing unit is in good working order and is capable of handling the vented bromine fumes.
 2. Ensure that dry air or dry nitrogen (dew point \leq minus 40°C) is available. The system should be pressure controlled and excess-pressure-protected to less than 3 barg. The system must also be capable of handling bromine.
 3. Open the ISO container dome cover. Check that all valves are closed and the valve blanks are in place.
 4. Remove the blank flange from the red valve. Insert a new gasket to ensure a good connection, and connect the pressure release hose to the red valve.

Note: if the unloading facility has provision to apply dry air or nitrogen to the hoses, leak testing can be carried out before any valve on the ISO container has been opened. Cover the hose connection with soap solution and apply low pressure (1 barg should be sufficient) to the hose with the valves shut. Any leak will cause bubbles to form, and these leaks must be corrected before opening the ISO container valves.

A pressure-drop test is less effective and is not recommended for the identification of small leaks.

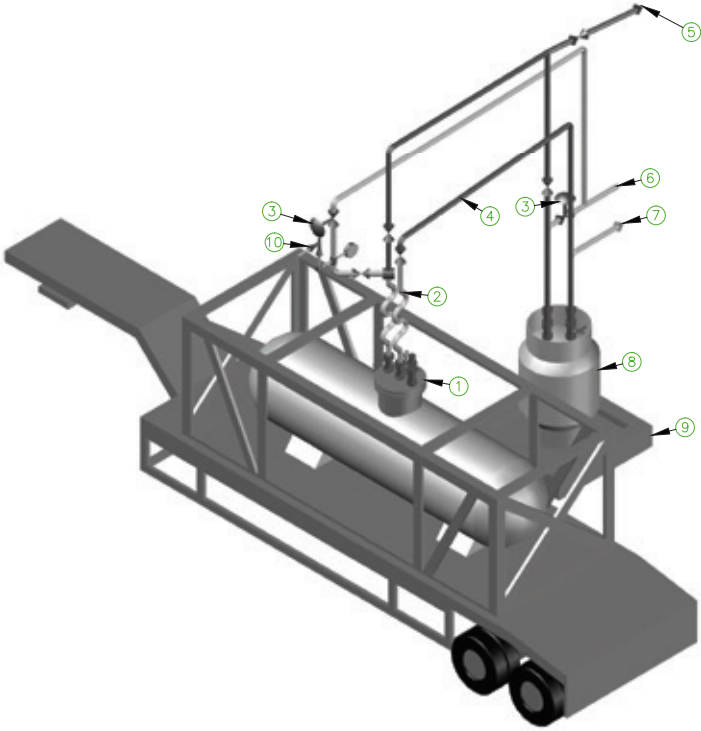
5. Slowly open the red vent valve and release any pressure that may have built up in the container, checking for leaks on the hose connection. An effective means of checking for leaks where bromine vapor may be present is to use ammonia vapor. Any minor, otherwise invisible leaks will react with the ammonia vapor and form white fumes of ammonium bromide. NEVER allow liquid ammonia to contact bromine as a violent reaction could occur. Leave the vent valve open.
6. **Caution:** Ensure that the ISO container is vented before proceeding, because any residual pressure in an ISO container could cause liquid bromine to flow through a valve leaking through.

7. Remove the valve blank from the yellow valve. Insert a new gasket to ensure a good connection and connect the unloading line to the yellow discharge valve.
8. Slowly open the yellow discharge valve, then all the valves in the unloading line, checking for leakage.
9. Close the vent valve from the ISO container to the scrubber.
10. Slowly open the pressurizing valve to the ISO container. Check all joints for leakage, and then continue to open the pressurizing valve fully to allow the bromine discharge to start. Use only sufficient pressure to lift the bromine to the highest point of the system. (Note: 1 barg pressure will lift bromine about 3.2 meters) Do not leave ISO unattended while discharging.

Do not exceed 3 barg pressure

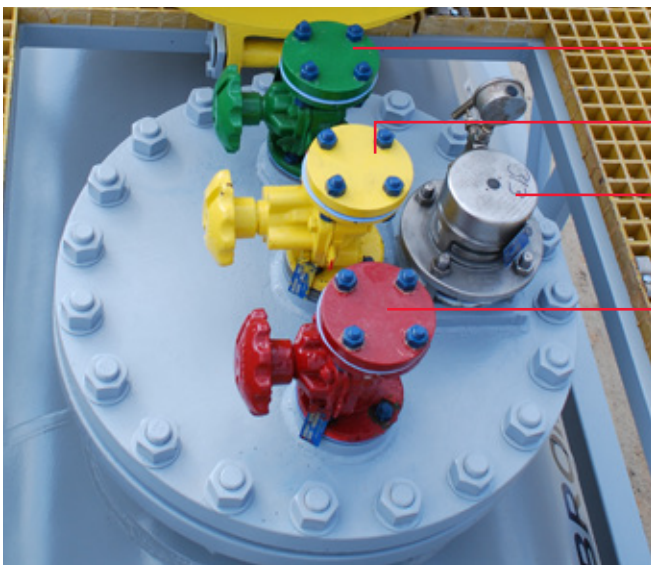
11. When air or nitrogen blows through into the storage tank, the ISO container is empty. The unloading hose will shake slightly as the last of the bromine leaves the container.
12. Purge the hose, until all bromine vapor has been removed.
13. Close the air/nitrogen.
14. Open the system vent to the scrubber.
15. Close the yellow discharge valve, followed by the other valves in the unloading line.
16. Slowly open the red vent valve to the scrubber to release any residual pressure in the ISO container. Wait 5 minutes to ensure that the ISO container has completely vented by de-pressurization. Returning ISO containers should have zero pressure for transportation.
17. Close the red pressurizing/vent valve on the ISO container.
18. Close all valves in the vent and air/nitrogen lines on the system.
19. Remove both hoses from the ISO container, and blank off the hoses to prevent moisture getting into them.
Caution: Be extremely careful disconnecting the liquid as there may be some bromine left in the hose.
20. Replace all valve blanks on the correct color-coded valves using the original gaskets. Ensure all bolts are tight. Refer to manufacturer's advice on reuse of the gasket used for the transfer.
21. If any bromine has spilled on the tank or valves during unloading, neutralize with hypo solution* (see page 14 for formula) and wash with water.
22. Close the valve dome and replace the locking pin .

ISO trailer unloading



1. 2 Teflon®/Kynar® lined diaphragm valves in dome: vapor – red; liquid – yellow; relief valve
2. Teflon® lined flexible hose
3. Pressure reducer valve
4. Kynar®, Teflon®, or appropriate line pipe
5. Vent to scrubber
6. Dry purge air (-40 °C/-40 °F or nitrogen)
7. Bromine to process
8. Lead or glass-lined steel storage vessel
9. Concrete safety sump
10. Pressure relief valve for nitrogen or dry air system

Typical ISO valve arrangement



1. Pressurizing valve (green)
2. Discharge valve (yellow)
3. Bursting disc and pressure relief assembly
4. Vent valve (red)

TANK TRUCKS

In North America, LANXESS supplies bulk bromine in lead-lined double barrel tank trailers with a length of about 32 feet and clearance not to exceed 10' 10". Each tank has a capacity of about 600 gallons, giving the trailer an approximate total net weight of 30,000 pounds. Bromine is also available in North America in nickel-lined 1,800-gallon (44,000 to 45,000 pound net weight) tank trailers with lengths of 33' 3" to 40' 7" and clearances not to exceed 9' 2". These trailers are designated as MC310, MC312, and MC412 as detailed in DOT requirements 49CFR.

Adequate storage facilities are necessary for prompt return of these special trucks. For those designing new or revising existing bromine handling and storage facilities, LANXESS can provide design assistance and guidance.

Unloading for tank trucks

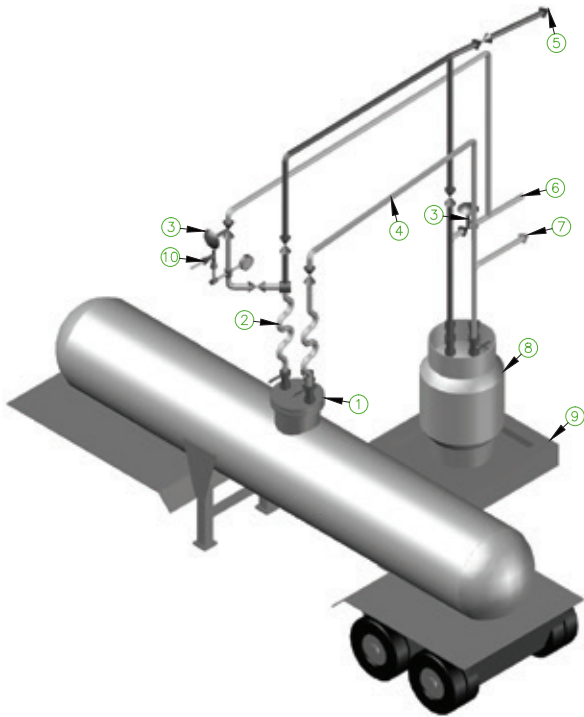
The schematic on page 29 shows a typical tank truck's unloading set-up.

■ Red for discharge

■ Green for venting and pressurizing the tank truck

1. Wear personal protective equipment at all times while unloading a tank truck.
2. Position trailer under unloading racks so no undue stress is placed upon unloading hoses.
3. Remove the blank flange from the vent valve (green) and connect the 3504 Gylon® gasketed vapor line. Tighten flange securely. Slowly release any pressure into the scrubber system by slowly opening the green vent valve checking the connection for leaks. If leaks are detected, close the vent valve. Check the gasket alignment and tighten all the flange bolts. Repeat leakage check.
4. Make sure the dip-pipe liquid valve is closed.
5. Remove the blank flange from the red liquid valve and attach the liquid unloading line using Teflon® gaskets and four bolts.
6. Open the red liquid valve slowly, checking the connection for leaks. If leaks are detected, close the red discharge valve. Check the gasket alignment and tighten all the flange bolts. Repeat leakage check.
7. Pressurize the trailer with dry air (-40°C/40°F dew point) or nitrogen through the green vent valve with the minimum necessary to remove the bromine. Pressure should not exceed 30 psig.
8. After approximately an hour of unloading, the discharge hose will begin to surge indicating the trailer is nearly empty. Close the trailer's green vent valve and allow the discharge line to surge for five to seven minutes to empty the line and vent to the scrubber system and cut off the nitrogen/air supply.
9. Close the red liquid valve and disconnect the vapor line, then disconnect the liquid line. Caution: Be extremely careful disconnecting the discharge line as there may be some bromine left in the hose.
10. Replace the gaskets and blind flanges on both tank valves' unloading hoses. Replace all bolts and fasten securely.
11. If any bromine has spilled on the tank or valves during the operation, neutralize with hypo solution* (see page 14 for formula) and wash thoroughly with water.

Tank truck unloading



1. Two Teflon®/Kynar® lined plug valves in dome (vapor/green and liquid/red) plus relief valve
2. Teflon® lined flexible hose
3. Pressure reducer valve
4. Kynar®, Teflon®, or appropriate line pipe
5. Vent to scrubber
6. Dry purge air (-40 °C/-40 °F or nitrogen)
7. Bromine to process
8. Lead or glass-lined steel storage vessel
9. Concrete safety dump
10. Pressure relief valve for nitrogen or dry air system



RETURNABLE CYLINDERS

For European customers wanting smaller containers, LANXESS offers 125 liter (330 kgs bromine net weight) lead-lined returnable cylinders (“pots”). These containers have the same valve arrangement as ISO containers, but use DN25 PVDF lined, ANSI125 valves. The valves are protected during transport by a hinged valve protection dome. The containers can be lifted for transport using forklift or stacker trucks. These containers are discharged using a maximum allowable working pressure of 2.5 barg. The yellow valve is the discharge valve, the red valve is the vent, and the green valve is the pressurizing valve.

In North America, LANXESS offers bromine in returnable 115 gallon and 40 gallon lead lined steel cylinders. An empty 115 gallon cylinder weighs approximately 2050 lbs and will hold 2800 lbs of bromine. This 115 gallon cylinder has a 3-valve configuration different from European containers. The red valve is the discharge valve, the yellow valve is the vent valve, and the green valve is the pressurizing valve.

The 40 gallon cylinder has a tare weight of about 2100 lbs and a payload of about 1000 lbs. The 40 gallon cylinder features a 2-valve configuration and a relief device. For this cylinder, the red valve is the discharge valve and the green valve is for venting and pressurizing. The containers are fitted with lifting lugs on either side of the tank and are made for use in an upright position. A fork truck or other lifting systems rated for weights of 5100 lb or greater is required for handling the 115 gallon container.

LANXESS can assist with the design of cylinder delivery systems that meet the needs of individual customer plant locations. Contact your LANXESS sales representative with inquiries.

Storage

Store either full or empty bromine cylinders upright, indoors in a cool dry location. Keep the containers out of direct sunlight to avoid overheating, which may cause internal pressure to build. Protect cylinders from humidity and other forms of moisture. Never store where temperature falls below -7 °C (20 °F), bromine’s freezing point.



Unloading for 3-valve cylinders

Cylinders are fitted with two or three valves. The centered valve in either configuration is the discharge line. The remaining valves connect to the vapor space of the cylinder. In 3-valve configurations one of the non-discharge valves can be utilized for venting and the other non-discharge valve can be used for pressurization of the cylinder.

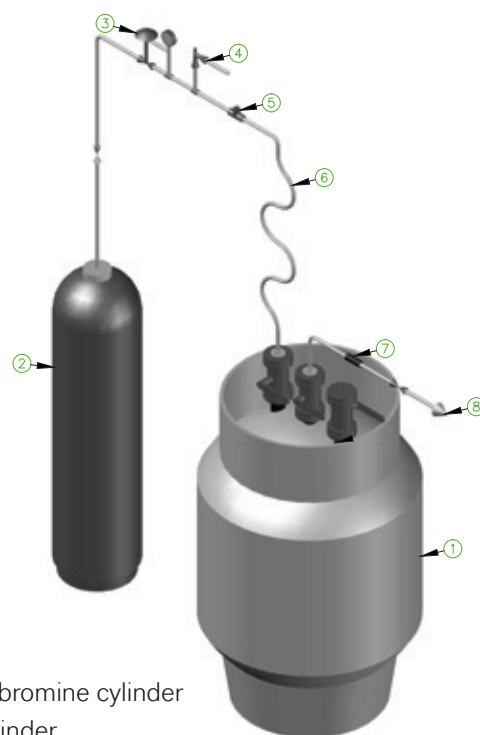
An example of an offload procedure using a North American 3-valve cylinder provided below:

1. Ensure that the absorber/scrubbing unit is operational and capable of handling the vented bromine fumes.
2. Ensure that dry air or dry nitrogen (dew point < -40 °C) is available. This system should also be pressure controlled and excess pressure protected to less than 30 psig. It must also be capable of handling bromine.
3. Open the cylinder valve protection dome. Be sure all valves are closed and valve blanks are in place.
4. Remove the valve blank flange from the vent valve and connect the pressure release hose to the vent valve using a new gasket to ensure a good connection.
5. **NOTE:** If the unloading facility has provision to apply dry air/nitrogen to the hoses, leak testing can be carried out before any valve on the cylinder has been opened. By applying low pressure to the connected hoses with the valves shut, the hose connection can be leak tested using a soap solution. Any leak will cause soap bubbles to form, which must be corrected before opening the cylinder valves. A pressure drop test is less effective and not recommended to identify small leaks.

6. Slowly open the vent valve and release any pressure that may have built up in the cylinder, checking for leaks on the hose connection. An effective means of checking for leaks where bromine vapor may be present is by using ammonia vapor, but never liquid ammonia. Any minor non-visible leaks will react with the ammonia and form white fumes of ammonium bromide. Leave the vent valve open.
7. **Caution:** Any residual pressure in an cylinder could cause liquid bromine to flow through a leaking valve. Ensure that the cylinder is vented before proceeding.
8. Remove the valve blank from the discharge valve and connect the unloading line to the discharge valve using a new gasket to ensure a good connection.
9. Slowly open the discharge valve and all the valves in the unloading line, checking for leakage.
10. Close the vent valve.
11. Remove the valve blank from the pressurizing valve and connect the pressurizing hose to the valve using a new gasket to ensure a good connection.
12. Slowly open the pressurizing valve. Check all joints for leakage. Continue to open the valve fully to allow the bromine discharge to start. Use only sufficient pressure to lift the bromine to the highest point of the system. do not exceed 30 psig
13. When air/nitrogen blows through into the storage tank, the cylinder is empty. The unloading hose will shake slightly as the last bromine leaves the container.
14. Close all valves in the vent and air/nitrogen lines.
15. Close the pressurizing valve after the hose has been purged sufficiently.
16. Close the discharge valve followed by others valves in the unloading line.
17. Slowly open the vent valve to release any residual pressure remaining in the cylinder. Wait 5 minutes then close the red vent valve. The cylinder should have zero pressure for transportation and return.
18. Remove all hoses from the cylinder and blank off the hose to prevent moisture ingress.

19. Replace all valve blanks on the correct color coded valves using the original gaskets. Ensure all bolts are tight.
20. If there has been any bromine leakage/spillage, neutralize with hypo solution* (see page 14 for formula) and wash the cylinder with water to prevent corrosion.
21. Close the valve dome and replace the locking pin.

Tank truck unloading



1. 115 gallon bromine cylinder
2. Nitrogen cylinder
3. Pressure regulator
4. Relief valve
5. Teflon check valve
6. Flex hose
7. Kynar® union
8. Bromine to storage or use

DRUMS

The 14 gauge Monel® drum used to supply customers in North America has a ten-gallon capacity and holds 225 pounds of liquid bromine. The two bung openings in the drum are 2 inches and ¾ inches with a continuous thread and Teflon® gaskets. The larger opening has 2-inch NPS 8 TPI threads. The smaller opening has ¾-inch NPS 14 TPI threads. The foot rings on these drums have drain holes but it is important that they be protected from moisture. The 2-inch plug is tightened to 60 ft pounds of torque and the ¾-inch plug is tightened to 20 ft pounds of torque when shipped.

Storage

Store drums (empty or full) upright indoors in a cool (above -7°C/20°F), dry location. Exposing drums to heat will cause dangerous pressure to develop. Severe corrosion occurs if the drums are exposed to moisture. Do not expose to rough handling. Never return bromine to these drums due to the potential of contamination and corrosion. When stored over extended periods, periodically inspect drums, bungs, and gaskets.



Caution: Never return used bromine or other liquids back to the drum. This can lead to serious corrosion of the drum and eventual failure.

Unloading – pump method recommendations

1. Personal protective equipment is required.
2. Before handling, check for damage or leakage. Set aside any damaged drums for special handling.
3. Tighten any loose plugs.
4. Use a hand-truck or chain fall to carefully move unopened drums.
5. If drums are warm to the touch, do not open. Allow them to cool to ambient temperature.
6. Use the pump method unloading system schematic on page 37 as a guide.
7. Use a pipe or plug wrench with a long handle to remove the drum plug. Have a scrubber system with adequate suction available to contain escaping vapors. Carefully turn the 2-inch plug no more than one full turn, allowing any internal pressure to equilibrate with atmospheric pressure. Then loosen the plug completely.
8. Install a dip-pipe assembly in the drum and connect it to a bromine-resistant positive displacement pump.
9. To inhibit corrosion, pad the drum with dry (-40°C/-40°F dew point) air or nitrogen to a pressure of 4 psig through the ¾-inch opening.
10. Start the pump to draw bromine from the drum, through the dip tube and pump, and into the desired process.
11. When the bromine drum is empty or product removal is completed, disconnect the dip pipe assembly from the pump and remove it from the drum. **Caution:** Be extremely careful removing the dip pipe as there may be some bromine left in the pipe.
12. To reseal the drum, make sure all gaskets are in place and tighten plugs to secure.
13. If the drum is empty, label the drum “Empty” and contact LANXESS Customer Service for return.

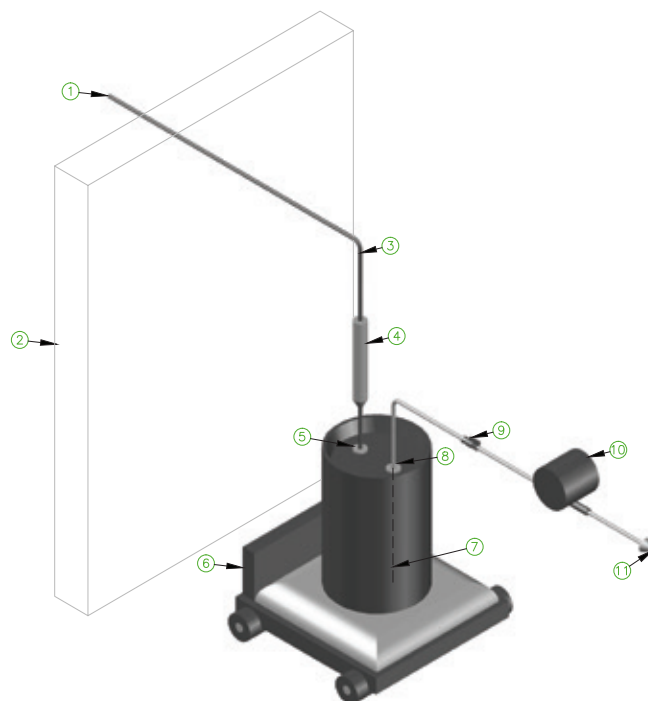
Unloading – pump method recommendations

1. Personal protective equipment is required.
2. Before handling, check for damage or leakage. Set aside any damaged drums for special handling.
3. Tighten any loose plugs.
4. Use a hand-truck or chain fall to carefully move unopened drums.
5. If drums are warm to the touch, do not open. Allow them to cool to ambient temperature.
6. Use the pump method unloading system schematic on page 37 as a guide.
7. Use a pipe or plug wrench with a long handle to remove the drum plug. Have a scrubber system with adequate suction available to contain escaping vapors. Carefully turn the 2-inch plug no more than one full turn, allowing any internal pressure to equilibrate with atmospheric pressure. Then loosen the plug completely.
8. Install a dip-pipe assembly in the drum and connect it to a bromine-resistant positive displacement pump.
9. To inhibit corrosion, pad the drum with dry (-40°C/-40°F dew point) air or nitrogen to a pressure of 4 psig through the 3/4-inch opening.
10. Start the pump to draw bromine from the drum, through the dip tube and pump, and into the desired process.
11. When the bromine drum is empty or product removal is completed, disconnect the dip pipe assembly from the pump and remove it from the drum.

Caution: Be extremely careful removing the dip pipe as there may be some bromine left in the pipe.
12. To reseal the drum, make sure all gaskets are in place and tighten plugs to secure.
13. If the drum is empty, label the drum “Empty” and contact LANXESS Customer Service for return.

Caution: Never return used bromine or other liquids back to the drum. This can lead to serious corrosion of the drum and eventual failure.

Bromine drum unloading pump method



- | | |
|---------------------------------------------------------------|----------------------------------------------------------------------------------------------|
| 1. 1/2" Kynar® vent outside | 7. Dip Tube-1/2" Kynar® or Monel®
Pipe-hold approximately
1/4" off bottom. (Bevel end) |
| 2. Building wall | 8. 2" x 1/2" Monel® bushing |
| 3. 1/2" Kynar® or Monel® Line | 9. 1/2" Kynar® ball valve |
| 4. Dryer-2" x 12" Pyrex® with Drierite® or Silica-gel packing | 10. Positive displacement pump |
| 5. 3/4" Monel® bushing | 11. 1/2" Kynar® or Monel® piping to
bromine process |
| 6. Scale | |

Pyrex® is a registered trademark of Corning, Inc.

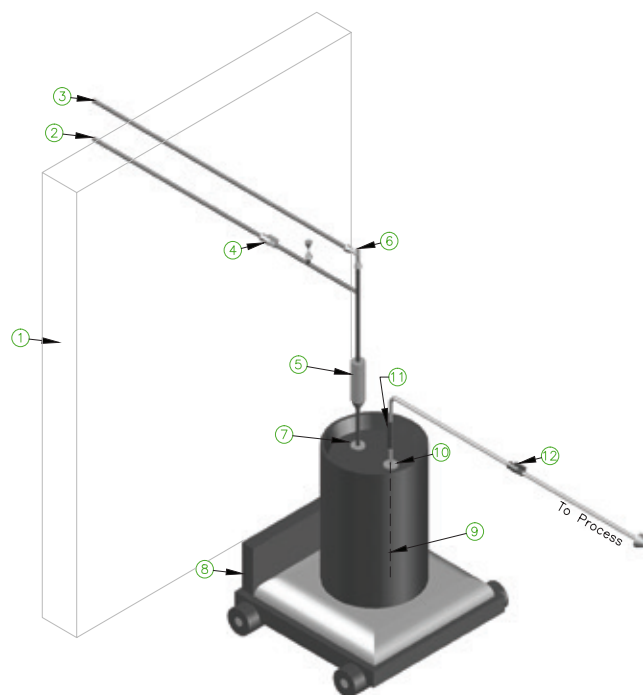
Drierite® is a registered trademark of W.A. Hammond Drierite Co.

Unloading – pressure method recommendations

1. Personal protective equipment is required.
2. Before handling, check for damage or leakage. Set aside any damaged drums for special handling.
3. Tighten any loose plugs.
4. Use a hand-truck or chain fall to carefully move unopened drums.
5. If drums are warm to the touch, do not open. Allow them to cool to ambient temperature.
6. Use the pressure method unloading system schematic as a guide.
7. Use a pipe or plug wrench with a long handle to remove the two-inch drum plug. Use an adequate scrubber system to contain the escaping vapors. Carefully turn the plug no more than one full turn, allowing any internal pressure to reach ambient pressure. Then loosen the plug completely.
8. Install a dip tube assembly in the drum and connect it to the pipe feeding the process.
9. Pad the drum with dry (-40 °C/-40 °F dew point) air or nitrogen to a pressure no greater than 4 psig through the 3/4-inch opening. Bromine will be pushed through the dip tube into the desired process.
10. When the bromine drum is empty or product removal is completed, disconnect the dip pipe assembly from the process feed pipe and remove it from the drum. Caution: Be extremely careful removing the dip pipe as there may be some bromine left in the pipe.
11. To reseal the drum, make sure all gaskets are in place and tighten plugs to secure.
12. If drum is empty, label the drum "Empty" and contact LANXESS Customer Service for return.

Caution: Never return used bromine or other liquids back to the drum. This can lead to serious corrosion of the drum and eventual failure.

Bromine drum unloading pressure method



- | | |
|----------------------------------------------------------------------|-----------------------------------------------------------------------------------------|
| 1. Building wall | 7. 3/4" Monel® bushing |
| 2. Dry Air (-40 °C/-40 F dew point) or nitrogen not to exceed 4 PSIG | 8. Scale |
| 3. 1/2" Kynar® pipe vent to atmosphere | 9. Dip tube 1/2" Kynar® or Monel® pipe (hold approximately 1/4" off bottom – bevel end) |
| 4. 1/2" Ball valve | 10. 2" x 1/2" Monel® bushing |
| 5. Dryer 2" x 6" Pyrex® with Drierite® or silica-gel packing | 11. 1/2" Union
1/2" Ball Valve |
| 6. Pressure relief valve | |

Pyrex® is a registered trademark of Corning, Inc.

Drierite® is a registered trademark of W.A. Hammond Drierite Co.

GLASS BOTTLES

LANXESS supplies bromine in a 13 pound (net weight) glass bottles that are packaged 4 to a case. These glass bottles are ideal for laboratory or other small scale uses. The bottles are sealed with a Teflon[®] faced screw cap. Bromine can be discharged from the bottle through pouring, siphoning, or with the use of pumps.



Storage

Store bottles in their case in a cool dry location away from direct sunlight and protected from the weather. Storage temperatures must not fall below -7 °C (20 °F), the freezing point of bromine.

ADDITIONAL RESOURCES

LANXESS has many years of experience in the safe production, handling, transport, storage and use of bromine. We are committed to sharing our expertise with our customers to enhance their capabilities to handle bromine safely. If you have technical or safety related questions regarding bromine handling in your facility, we encourage you to contact your LANXESS sales representative for assistance.

Assistance can include:

- Visit to your storage and handling facilities
- Training of personnel
- Review of your operating and maintenance procedures
- Site visit safety review

Please contact your LANXESS representative to discuss how we can assist you in the safe handling of bromine.



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Unless specified to the contrary, the values given have been established on standardized test specimens. The figures should be regarded as guide values only and not as binding minimum values. Kindly note that the results refer exclusively to the specimens tested. Under certain conditions, the test results established can be affected to a considerable extent by the processing conditions and manufacturing process.

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