Public Health England

Protecting and improving the nation's health

Bromine

Incident Management

Key Points

Fire

- strong oxidant
- reacts violently with combustible and reducing materials
- when heated will emit highly toxic fumes and will react with water or steam to produce toxic and corrosive fumes
- in the event of a fire involving bromine, use fine water spray and liquid tight fire kit with breathing apparatus

Health

- irritation of eyes and nose with sore throat, cough, chest tightness and wheeze follows inhalation exposure; headache, fever, tachycardia and confusion may also develop
- Ingestion causes pain in mouth, throat and abdomen, vomiting, haematemesis and dyspnoea
- skin contact with can cause burns which take a long time to heal and can become deeply ulcerated if left untreated; burns may initially cause no pain or visible effects and may develop 1 to 5 days after exposure
- lower concentrations cause inflammation of the eyelids, lacrimation, conjunctivitis and irritation while high concentrations can cause blepharospasm, palpebral oedema and photophobia

Environment

- hazardous to the environment; inform the Environment Agency of substantial incidents

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Hazard Identification

Standard (UK) dangerous goods emergency action codes

Bromine or Bromine solution

UN		1744	Bromine or bromine solution	
EAC		●2XE	Use alcohol-resistant foam but, if not available, fine water spray can be used. Wear chemical protective clothing with liquid-tight connections for whole body in combination with breathing apparatus*. Danger that the substance can be violently or explosively reactive. Spillages and decontamination run-off should be prevented from entering drains and watercourses. There may be a public safety hazard outside the immediate area of the incident†	
APP		A(!)	Gas-tight chemical protective suit in combination with breathing apparatus‡ The substance may have a particularly deleterious effect on chemical protective clothing	
Hazards	**Class**	8	Corrosive substances	
	Sub-risks	6.1	Toxic substances	
HIN		886	Highly corrosive substance, toxic	

UN – United Nations number, EAC – emergency action code, APP – additional personal protection, HIN – hazard identification number

* Chemical protective clothing with liquid-tight connections for whole body (type 3) conforming to the relevant standards such as BS 8428 or EN 14605, in combination with breathing apparatus BS EN 137

† People should stay indoors with windows and doors closed, ignition sources should be eliminated and ventilation stopped. Non-essential personnel should move at least 250 m away from the incident

‡ Normal fire kit in combination with gas-tight chemical protective clothing conforming to BS EN 943 part 2; thermal-resistant gloves should be worn such as those conforming to BS EN 511:2006 or BS EN 407:2004

Reference

Dangerous Goods Emergency Action Code List, National Chemical Emergency Centre (NCEC) Part of Ricardo-AEA. The Stationery Office, 2017.

Classification, labelling and packaging (CLP)*

Bromine

Hazard class and category	Acute Tox. 2	Acute toxicity (inhalation), category 2	
	Skin Corr. 1A	Skin corrosive, category 1A	
	Aquatic Acute 1	Acute hazard to the aquatic environment, category 1	
Hazard statement	H330	Fatal if inhaled	
	H314	Causes severe skin burns and eye damage	
	H400	Very toxic to aquatic life	
Signal words	Danger		

* Implemented in the EU on 20 January 2009

Reference

European Commission. Harmonised classification – Annexe VI to Regulation (EC) No. 1272/2008 on Classification, Labelling and Packaging of Substances and Mixtures. http://echa.europa.eu/information-on-chemicals/cl-inventory-database (accessed 08/2018).

Physicochemical Properties

CAS number	7726-95-6
Molecular weight	159.82
Formula	Br_2
Common synonyms	-
State at room temperature	Dark red-brown fuming liquid
Volatility	Vapour pressure = 175 mm Hg (at 21ºC)
Specific gravity **Vapour density**	3.1 (water =1) 5.51 (air = 1)
Flammability	Non-combustible but enhances combustion of other substances
Lower explosive limit	-
Upper explosive limit	-
Water solubility	3.58 g/100 mL water (at 20ºC)
Reactivity	Strong oxidant. Reacts violently with combustible and reducing materials. ttacks metal and some forms of rubber, plastic and coatings
Reaction or degradation products	When heated will emit highly toxic fumes and will react with water or steam to produce toxic and corrosive fumes
Odour	Suffocating odour
Structure	Br — Br

References

Bromine (IBM HAZARDTEXT ®) In: IBM Micromedex® TOMES® System (electronic version). Truven Health Analytics, Greenwood Village, Colorado, USA. Available at: http://www.micromedexsolutions.com/ (accessed 08/2018).

Hazardous Substances Data Bank. Bromine HSDB No. 514 (last revision date 18/02/2015). US National Library of Medicine: Bethesda MD. http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB (accessed 08/2018)

International Programme on Chemical Safety. International Chemical Safety Card entry for Bromine. ICSC 0107, 2009. World Health Organization, Geneva.

Reported Effect Levels from Authoritative Sources

Exposure by Inhalation

ppm	mg/m^3	Signs and symptoms	Reference
> 1.0	> 6.5	Irritation level	a
40 – 60	260 - 390	Toxic pneumonitis and pulmonary oedema	a
1,000	6,500	Fatal within a few minutes	a

These values give an indication of levels of exposure that can cause adverse effects. They are not health protective standards or guideline values

References

a International Programme on Chemical Safety (IPCS) Poisons Information Monograph (PIM) 080: Bromine, 1999.

Published Emergency Response Guidelines

Emergency response planning guideline (ERPG) values

	Listed value (ppm)	Calculated value (mg/m^3)
ERPG-1*	0.1[1]	0.65
ERPG-2†	0.5	3.27
ERPG-3‡	5	32.7

* Maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing other than mild transient adverse health effects or perceiving a clearly defined, objectionable odour

† Maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action

‡ Maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects

1 Odour should be detectable near ERPG-1

American Industrial Hygiene Association (AIHA). 2016 Emergency Response Planning Guideline Values. https://www.aiha.org/get-involved/AIHAGuidelineFoundation/EmergencyResponsePlanningGuidelines/Documents/2016%20ERPG%20Table.pdf (accessed 08/2018).

Acute exposure guideline levels (AEGLs)

	ppm				
	10 min	30 min	60 min	4 hours	8 hours
AEGL-1*	0.033	0.033	0.033	0.033	0.033
AEGL-2†	0.55	0.33	0.24	0.13	0.095
AEGL-3‡	19	12	8.5	4.5	3.3

* Level of the chemical in air at or above which the general population could experience notable discomfort

† Level of the chemical in air at or above which there may be irreversible or other serious long-lasting effects or impaired ability to escape

‡ Level of the chemical in air at or above which the general population could experience life-threatening health effects or death

Reference

US Environmental Protection Agency. Acute Exposure Guideline Levels. http://www.epa.gov/oppt/aegl/pubs/chemlist.htm (accessed 08/2018).

Exposure Standards, Guidelines or Regulations

Occupational standards

	LTEL (8-hour reference period)		STEL (15-min reference period)	
	ppm	mg/m^3	ppm	mg/m^3
WEL	0.1	0.66	0.2	1.3

WEL – workplace exposure limit, LTEL – long-term exposure limit, STEL – short-term exposure limit

Reference

Health and Safety Executive (HSE). EH40/2005 Workplace Exposure Limits, 2nd Edition, 2011.

Public health guidelines

Drinking water standard **WHO Health based value – drinking water**	Values not given
Air quality guideline	
Soil guideline values and health criteria values	

Health Effects

Major route of exposure

- extremely irritating or corrosive to mucous membranes

Immediate signs or symptoms of acute exposure

Route	Signs and symptoms
Inhalation	Inhalation may cause irritation of eyes and nose with sore throat, cough, chest tightness and wheeze. It can also cause headache, fever, tachycardia and confusion. Chemical pneumonitis, tachypnoea, dyspnoea and stridor due to laryngeal oedema can occur. Pulmonary oedema with increasing breathlessness, wheeze, hypoxia and cyanosis may take up to 36 hours to develop.
Ingestion	Ingestion will cause immediate pain with burning in the mouth, throat and stomach, followed by abdominal pain, vomiting, haematemesis and dyspnoea. The lips, tongue and mucous membranes may become stained a brown colour. Pain and oedema may make swallowing difficult. Haemorrhagic or hypovolaemic shock and airway obstruction from laryngeal and/or epiglottic oedema are features of severe cases. Stridor and respiratory complications can develop following aspiration of corrosive materials.
Dermal	Skin contact with either liquid for fumes can cause burns which take a long time to heal and which can become deeply ulcerated if not decontaminated. Liquid spilt on the skin causes a cooling sensation on first contact followed by a burning sensation. Burns may initially cause no pain or visible effects and may develop 1 to 5 days after exposure. Burns initially appear as brown discolouration of the skin; subsequently blisters, vesicles and pustules develop. Third degree burns, deep ulcers, and scars can develop, depending on the severity of exposure Skin exposure to lower concentrations of bromine e.g. diluted in swimming pools can cause pruritic, blotchy, measles-like rashes in the face, trunk and extremities lasting up to two weeks Patients dermally exposed to lower concentrations of bromine tend to seek medical attention late. However, they can still sustain severe injury if treatment is delayed. Deep, penetrating burns develop over a period of days due to continued damage to untreated skin
Ocular	Ocular exposure to the vapour or liquid can cause severe burns to the eye. Lower concentrations cause inflammation of the eyelids, lacrimation, conjunctivitis and irritation. High concentrations can cause blepharospasm, palpebral oedema and photophobia

Reference

TOXBASE. Bromine, 05/2013. http://www.toxbase.org (accessed 08/2018)

Decontamination at the Scene

Summary

The approach used for decontamination at the scene will depend upon the incident, location of the casualties and the chemicals involved. Therefore, a risk assessment should be conducted to decide on the most appropriate method of decontamination.

Bromine is a highly corrosive substance. Therefore, following disrobe, improvised wet decontamination should be considered (see below for details).

People who are processed through improvised decontamination should subsequently be moved to a safe location, triaged and subject to health and scientific advice. Based on the outcome of the assessment, they may require further decontamination.

Emergency services and public health professionals can obtain further advice from Public Health England (Centre for Radiation, Chemical and Environmental Hazards) using the 24-hour chemical hotline number: 0344 892 0555.

Disrobe

The disrobe process is highly effective at reducing exposure to HAZMAT/CBRN material when performed within 15 minutes of exposure.

Therefore, disrobe must be considered the primary action following evacuation from a contaminated area.

Where possible, disrobe at the scene should be conducted by the casualty themselves and should be systematic to avoid transferring any contamination from clothing to the skin. Consideration should be given to ensuring the welfare and dignity of casualties as far as possible.

Improvised decontamination

Improvised decontamination is an immediate method of decontamination prior to the use of specialised resources. This should be performed on all contaminated casualties, unless medical advice is received to the contrary. Improvised dry decontamination should be considered for an incident involving chemicals **unless the agent appears to be corrosive or caustic**.

Improvised dry decontamination

- any available dry absorbent material can be used such as kitchen towel, paper tissues (eg blue roll) and clean cloth
- exposed skin surfaces should be blotted and rubbed, starting with the face, head and neck and moving down and away from the body

- rubbing and blotting should not be too aggressive, or it could drive contamination further into the skin
- all waste material arising from decontamination should be left in situ, and ideally bagged, for disposal at a later stage

Improvised wet decontamination

- water should only be used for decontamination where casualty signs and symptoms are consistent with exposure to caustic or corrosive substances such as acids or alkalis
- wet decontamination may be performed using any available source of water such as taps, showers, fixed installation hose-reels and sprinklers
- when using water, it is important to try and limit the duration of decontamination to between 45 and 90 seconds and, ideally, to use a washing aid such as cloth or sponge
- improvised decontamination should not involve overly aggressive methods to remove contamination as this could drive the contamination further into the skin
- where appropriate, seek professional advice on how to dispose of contaminated water and prevent run-off going into the water system

Additional notes

- following improvised decontamination, remain cautious and observe for signs and symptoms in the decontaminated person and in unprotected staff
- if water is used to decontaminate casualties this may be contaminated, and therefore hazardous, and a potential source of further contamination spread
- all materials (paper tissues etc) used in this process may also be contaminated and, where possible, should not be used on new casualties
- the risk from hypothermia should be considered when disrobe and any form of wet decontamination is carried out
- people who are contaminated should not eat, drink or smoke before or during the decontamination process and should avoid touching their face
- consideration should be given to ensuring the welfare and dignity of casualties as far as possible. Immediately after decontamination the opportunity should be provided to dry and dress in clean robes/clothes

Interim wet decontamination

Interim decontamination is the use of standard fire and rescue service (FRS) equipment to provide a planned and structured decontamination process prior to the availability of purpose-designed decontamination equipment.

Decontamination at the scene references

National Ambulance Resilience Unit. Joint Emergency Services Interoperability Programme (JESIP). Initial operational response to a CBRN incident. Version 1.0, September 2013.

NHS England. Emergency Preparedness, Resilience and Response (EPRR). Chemical incidents: planning for the management of self-presenting patients in healthcare settings. April 2015.

Clinical Decontamination and First Aid

Clinical decontamination is the process where trained healthcare professionals using purpose-designed decontamination equipment treat contaminated people individually.

Detailed information on clinical management can be found on TOXBASE – www.toxbase.org.

Important note

- **once body surface contaminants have been removed or if your patient was exposed by ingestion or inhalation the risk that secondary care givers may become contaminated is very low.** Secondary carers should wear standard hospital PPE as a precaution against secondary contamination from vomit and body fluids
- if the patient has not been decontaminated following surface contamination, secondary carers must wear appropriate NHS PPE for chemical exposure to avoid contaminating themselves. The area should be well ventilated

Clinical decontamination following surface contamination

- carry out decontamination after resuscitation
- this should be performed in a well-ventilated area, preferably with its own ventilation system
- do **not** apply neutralising chemicals as heat produced during neutralisation reactions may cause thermal burns, and increase injury
- contaminated clothing should be removed, double-bagged, sealed and stored safely
- decontaminate open wounds first and avoid contamination of unexposed skin
- any particulate matter adherent to skin should be removed and the patient washed with copious amounts of water under low pressure for at least 10–15 minutes, or until the pH of the skin is normal (pH of the skin is 4.5–6, although it may be closer to 7 in children, or after irrigation). **The earlier irrigation begins, the greater the benefit**
- pay particular attention to mucous membranes, moist areas such as skin folds, fingernails and ears

Dermal exposure

- decontaminate (as above) the patient following surface contamination
- following decontamination recheck the pH of affected areas after a period of 15–20 minutes and repeat irrigation if abnormal; burns with strong solutions may require irrigation for several hours or more
- once the pH is normal and stabilised, treat as for a thermal injury

- burns totalling more than 15% of body surface area in adults (more than 10% in children) will require standard fluid resuscitation as for thermal burns
- moderate/severe chemical burns should be reviewed by a burns specialist
- other supportive measures as indicated by the patient's clinical condition

Ocular exposure

- remove contact lenses if present
- anaesthetise the eye with a topical local anaesthetic (eg oxybuprocaine, amethocaine or similar); **however, do not delay irrigation if local anaesthetic is not immediately available**
- immediately irrigate the affected eye thoroughly with 1,000 mL 0.9% saline or equivalent crystalloid (for example via an infusion bag with a giving set) for a minimum of 10 – 15 minutes irrespective of the initial conjunctival pH. A Morgan Lens may be used if anaesthetic has been given. Aim for a final conjunctival pH of 7.5–8.0. The conjunctivae may be tested with indicator paper. Retest 20 minutes after irrigation and use further irrigation if necessary
- repeated instillation of local anaesthetics may reduce discomfort and help more thorough decontamination; however, prolonged use of concentrated local anaesthetics is damaging to the cornea
- patients with corneal damage, those who have been exposed to strong acids or alkalis and those whose symptoms do not resolve rapidly should be referred **urgently** to an ophthalmologist
- other supportive measures as indicated by the patient's clinical condition

Inhalation

- maintain a clear airway and ensure adequate ventilation
- give oxygen if required
- perform a 12-lead ECG in all patients who require assessment
- other supportive measures as indicated by the patient's clinical condition

Ingestion

- **maintain airway and establish haemodynamic stability**
- in severely affected patients critical care input is essential. Urgent assessment of the airway is required. A supraglottic-epiglottic burn with erythema and oedema is usually a sign that further oedema will occur that may lead to airway obstruction
- do **not** attempt gastric lavage
- do **not** give neutralising chemicals as heat produced during neutralisation reactions may increase injury

- the use of water or milk (maximum initial volume = 100 - 200 mL in an adult; 2 mL/kg in a child) as diluents in the management of corrosive ingestion may be of some symptomatic benefit (but caution is necessary following large ingestions where mucosal damage / perforation may have already developed). There is experimental evidence to suggest that early dilution therapy with water or milk reduces acute alkali injury of the oesophagus but administration of large volumes of fluid should be avoided as they may induce vomiting and increase the risk of oedema
- monitor blood pressure, pulse and oxygen saturation
- perform a 12 lead ECG
- other supportive measures as indicated by the patient's condition

Health effects and decontamination references

TOXBASE http://www.toxbase.org (accessed 08/2017)

TOXBASE Bromine, 05/2013

TOXBASE Chemicals Splashed or Sprayed in the Eyes – features and management, 06/2017

TOXBASE Personal protective equipment and decontamination at the scene or in hospital

This document from the PHE Centre for Radiation, Chemical and Environmental Hazards reflects understanding and evaluation of the current scientific evidence as presented and referenced here.

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