



Sulphur Mustard (Mustard Gas)

Incident Management

Key Points

Fire

- combustible under specific conditions, vigorously reacts with oxidising agents
- can form a reactive episulphonium ion on contact with water that reacts with a broad spectrum of biological molecules such as DNA and proteins
- slowly hydrolysed in water and will react with water and steam to produce fumes of hydrochloric acid
- releases highly toxic fumes of sulphur oxides and hydrogen chloride when heated to decomposition

Health

- following exposure there is a characteristic period of up to two hours during which exposed individuals are asymptomatic
- inhalation can cause rhinorrhoea, burning in the mouth and throat, nausea, fatigue and headache. Severe exposure may cause superficial damage to the vocal cords leading to hoarseness, cough, pain on coughing and aphonia
- dermal exposure to the liquid or the vapour can severely blister the skin
- ocular exposure causes irritation, lacrimation, conjunctival and lid oedema and erythema. In severe cases inflammation, intense pain, blepharospasm, photophobia and corneal damage can occur

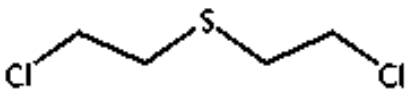
Environment

- avoid release to the environment; inform the Environment Agency where appropriate

Hazard Identification

Mustard gas is not subject to EU or UK classification and labelling requirements as it is a schedule 1 chemical warfare agent subject to international prohibition under the Chemical Weapons Convention. For more information visit: <http://www.opcw.org/chemical-weapons-convention/>

Physicochemical Properties

CAS number	505-60-2
Molecular weight	159
Formula	C ₄ H ₈ Cl ₂ S
Common synonyms	Mustard gas; HD; Bis(2-Chlorethyl)Sulphide; Dichloroethyl Sulphide
State at room temperature	Yellow-brown oily liquid
Volatility	Vapour pressure; 0.112 mmHg at 25°C
Specific gravity	1.27 at 20°C (water = 1)
Vapour density	5.4 (air = 1)
Flammability	Combustible under specific conditions
Lower explosive limit	-
Upper explosive limit	-
Water solubility	Solubility in water less than 0.1% w/v at 22°C. Freely soluble in organic solvents including ethanol, ether and chloroform
Reactivity	Vigorous reaction with oxidising agents
Reaction or degradation products	Emits sulphide and chloride fumes when heated to decomposition or when in contact with acid or acid fumes. Slowly hydrolysed in water and will react with water and steam to produce fumes of hydrochloric acid
Odour	Garlic, mustard, leeks
Structure	
References	<p>Hazardous Substances Data Bank. Bis(2-chloroethyl)sulfide HSDB No. 336 (last revision date 31/12/2013) US National Library of Medicine: Bethesda MD. http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB (accessed 08/2017).</p> <p>International Programme on Chemical Safety. International Chemical Safety Card entry for Sulphur Mustard. ICSC 0418, 2013. World Health Organization: Geneva.</p> <p>Mustard Gas (HAZARDTEXT™ Hazard Management). In Klasco RK (Ed): TOMES® System, Truven Healthcare Analytics Inc, Greenwood Village CO, US. RightAnswer.com Inc, Midland MI, US. http://www.rightanswerknowledge.com (accessed 08/2017).</p>

Reported Effect Levels from Authoritative Sources

Effects on the skin

Liquid exposure			
$\mu\text{g}/\text{cm}^2$	Time of exposure	Signs and symptoms	Reference
50	5 minutes	Slight erythema	a
250 – 500	5 minutes	Blistering	a
Vapour exposure			
$\text{mg}\cdot\text{min}/\text{m}^3$	Signs and symptoms		Reference
100 – 400	Erythema		a
200 – 1,000	Leads to blistering		a
750 – 1,000	Severe, incapacitating skin burns		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 Maynard, R. L. (2007) Chapter 19: Mustard Gas.T.C. Marrs, R.L. Maynard and D.R. Sidell, Chemical warfare agents: toxicology and treatment John Wiley and Sons Ltd, Chichester.			

Effects on the eyes

Vapour exposure		
$\text{mg}\cdot\text{min}/\text{m}^3$	Signs and symptoms	Reference
70	Mild reddening of the eyes	a
100	Partial incapacitation due to eye effects	a
200	Total incapacitation due to eye effects	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 Maynard, R. L. (2007) Chapter 19: Mustard Gas.T.C. Marrs, R.L. Maynard and D.R. Sidell, Chemical warfare agents: toxicology and treatment. John Wiley and Sons Ltd, Chichester.		

Published Emergency Response Guidelines

Emergency response planning guideline (ERPG) values

	Listed value (ppm)	Calculated value (mg/m ³)
ERPG-1*	Data not available	
ERPG-2†		
ERPG-3‡		
<p>* 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</p> <p>† 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</p> <p>‡ 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</p>		

Acute exposure guideline levels (AEGLs)

	mg/m ³				
	10 min	30 min	60 min	4 hours	8 hours
AEGL-1*	0.4	0.13	0.067	0.017	0.008
AEGL-2†	0.6	0.2	0.1	0.025	0.013
AEGL-3‡	3.9	2.7	2.1	0.53	0.27
<p>* Level of the chemical in air at or above which the general population could experience notable discomfort</p> <p>† 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</p> <p>‡ Level of the chemical in air at or above which the general population could experience life-threatening health effects or death</p> <p>Reference US Environmental Protection Agency. Acute Exposure Guideline Levels. http://www.epa.gov/oppt/aegl/pubs/chemlist.htm (accessed 08/2017).</p>					

Exposure Standards, Guidelines or Regulations

There are no occupational standards or guidelines for sulphur mustard as it is a schedule 1 chemical warfare agent subject to international prohibition under the Chemical Weapons Convention.

Health Effects

Major route of exposure

- inhalation and ocular or dermal exposure to sulphur mustard vapour or spray are the most likely routes
- sulphur mustard vapour can rapidly penetrate clothing to damage the skin beneath

Important note

- following exposure there may be a period during which individuals remain asymptomatic. The duration of this is dependent on the mode of exposure, temperature and individual sensitivity
- features following exposure to sulphur mustard may be delayed by up to two hours

Immediate signs or symptoms of acute exposure

Route	Signs and symptoms
Inhalation	Inhalation of mustard vapour damages mainly the upper respiratory tract, causing damage to the vocal cords leading to hoarseness, cough, pain on coughing and aphonia. More extensive exposure may also damage the lungs and predisposes to respiratory tract infections. Pulmonary oedema can be delayed in onset up to 24-72 hours in some cases
Ingestion	Nausea, vomiting, abdominal pain, haematemesis and diarrhoea, and in severe cases shock and prostration, may occur within a few hours. Ocular, dermal and respiratory features may also ensue
Dermal	Exposure to the liquid or vapour can produce erythema and blisters. Erythema usually appears within 8 hours but may take up to 24 hours; blistering begins 2-18 hours after onset of erythema. Tender skin, mucous membranes and perspiration covered skin are more sensitive to the effects. Development of blisters may be delayed and fresh blisters may appear up to two weeks after exposure
Ocular	Exposure to liquid or vapour causes lacrimation, irritation, burning, redness, and oedema of the eyelids. Damage to the cornea and conjunctivae, photophobia and blindness may occur
Systemic features	Mustard gas absorption causes bone marrow depression. CNS effects such as confusion, ataxia, hyporeflexia, and amnesia, have been reported
Reference	
TOXBASE. Sulphur Mustard, 11/2013. http://www.toxbase.org (accessed 08/2017).	

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.

Sulphur mustard will cause vesicles and blisters in contact with the skin. 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

- 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 neutralization 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
- to reduce the potential for systemic toxicity decontamination can be done as late as 2-3 hours after exposure (the skin reaction may however be increased by decontamination at this time)

Dermal exposure

- decontaminate the patient
- pay special attention to mucous membranes, moist areas such as skin folds, fingernails and ears. 10% povidone-iodine ointment post-irrigation may protect against skin lesions
- skin lesions should be managed as thermal burns. Do **not** derroof intact blisters initially as this can increase the risk of infection
- 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; excision or skin grafting may be required
- although blisters may be extensive and appear severe they tend to be superficial and heal slowly without surgical intervention
- other supportive measures as indicated by the patient's clinical condition

Ocular exposure

- remove contact lenses if present and immediately irrigate the affected eye thoroughly with water or 0.9% saline for at least 10-15 minutes
- any particles lodged in the conjunctival recesses should be removed
- repeated instillation of local anaesthetics may reduce discomfort and help more thorough decontamination. An anaesthetised eye should be covered to protect from traumatic injury
- sterile petroleum jelly applied to the eyelids helps prevent eyelids sticking together
- symptomatic patient should be referred for urgent ophthalmological assessment
- patients may develop photophobia and dark glasses may provide symptomatic relief
- patients with eye damage should be reassured that eye problems should resolve, but this may take several weeks
- other supportive measures as indicated by the patient's clinical condition

Inhalation

- **maintain a clear airway and ensure adequate ventilation**
- other supportive measures as indicated by the patient's clinical condition

Health effects and decontamination references

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

TOXBASE Nitrogen and sulphur mustard – features and management, 10/2013

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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For queries relating to this document, please contact chemcompendium@phe.gov.uk

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