



Chlorine

Incident Management

Key Points

General

- yellowish-green gas at room temperature
- pungent bleach odour
- readily dissolves in water
- stored as compressed gas and in aqueous solutions
- corrosive and a strong oxidant
- non-combustible but enhances combustion of other substances
- may combine with water or steam to produce toxic and corrosive fumes of hydrochloric acid

Health effects

- inhalation and ocular exposure are the most likely to occur route of exposure
- irritating to the eyes, respiratory system and skin
- inhalation may cause sore throat, cough, chest tightness, headache, fever, wheeze, tachycardia and confusion
- dermal exposure may cause erythema, pain, irritation and cutaneous burns
- dermal contact with liquefied gas can cause frostbite

Casualty decontamination at the scene

- decontamination may not be required; however, gaseous chlorine will irritate the skin at high concentrations and liquid chlorine may cause cutaneous burns
- this should be considered when deciding on the need for disrobe and decontamination




Environment

- hazardous to the environment; inform the Environment Agency where appropriate
- spillages and decontamination run-off should be prevented from entering watercourses

Hazard Identification

Standard (UK) dangerous goods emergency action codes

Chlorine

UN		1017	Chlorine	
EAC		2XE	Use fine water spray. Wear chemical protective clothing with liquid-tight connections for whole body in combination with breathing apparatus*. 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(c)	Gas-tight chemical protective suit with breathing apparatus‡ Liquefied gas with boiling point below -20°C	
Hazards	Class	2.3	Toxic gas	
	Sub-risks	8	Corrosive substance	
		5.1	Oxidising substance	
HIN		265	Toxic gas, oxidising (fire-intensifying)	

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 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, 2019.

Chlorine, absorbed

UN		3520	Chlorine, absorbed	
EAC		2XE ⁽¹⁾	Use fine water spray. Wear chemical protective clothing with liquid tight connections for whole body in combination with breathing apparatus*. 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		B	Gas-tight chemical protective suit with breathing apparatus [‡]	
Hazards	Class	2.3	Toxic gas	
	Sub-risks	5.1	Oxidising substance	
		8	Corrosive substance	
HIN		-	-	
<p>UN – United Nations number, EAC – emergency action code, APP – additional personal protection, HIN – hazard identification number</p> <p>* Chemical protective clothing with liquid-tight connections for whole body (type 3) conforming to relevant standards such as BS 8428 or EN 14605, in combination with breathing apparatus BS EN 137</p> <p>† 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</p> <p>‡ Chemical protective clothing should be gas tight conforming to BS EN 943 part 2, in combination with breathing apparatus conforming to BS EN 137</p> <p>⁽¹⁾ Not applicable to the carriage of dangerous goods under Regulations Concerning the International Carriage of Dangerous Goods by Rail (RID) and in the European Agreement Concerning the International Carriage of Dangerous Goods by Road (ADR)</p> <p>Reference Dangerous Goods Emergency Action Code List. National Chemical Emergency Centre (NCEC), Part of Ricardo-AEA. The Stationery Office, 2019.</p>				

Classification, labelling and packaging (CLP)*

Hazard class and category	Press. Gas	Gasses under pressure	
	Ox. Gas 1	Oxidising gases, category 1	
	Skin Irrit. 2	Skin irritation, category 2	
	Eye Irrit. 2	Eye irritation, category 2A	
	Acute Tox. 3	Acute toxicity (inhalation), category 3	
	STOT SE 3	Specific target organ toxicity following single exposure, category 3	
	Aquatic Acute 1	Acute hazard to the aquatic environment, category 1	
	Hazard statement	H270	May cause or intensify fire; oxidiser
H315		Causes skin irritation	
H319		Causes serious eye irritation	

	H331	Toxic if inhaled
	H335	May cause respiratory irritation
	H400	Very toxic to aquatic life
Signal words	DANGER	
* Implemented in the EU on 20 January 2009		
Reference		
European Commission. Harmonised classification – Annex VI of 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 03/2019).		

Physicochemical Properties

CAS number	7782-50-5
Molecular weight	70.9
Formula	Cl ₂
Common synonyms	–
State at room temperature	Yellowish-green gas
Volatility	Vapour pressure = 4,800 mmHg at 20°C
Specific gravity	2.5 (air = 1)
Flammability	Non-combustible but enhances combustion of other substances
Lower explosive limit	Not applicable
Upper explosive limit	Not applicable
Water solubility	0.7 g/100 mL at 20°C
Reactivity	Reacts violently with bases. Chlorine is corrosive and a strong oxidant. Reacts violently with combustible substances and reducing agents. Will react with most organic and inorganic compounds, causing fire and explosion hazard. Attacks metals, some forms of plastic, rubber and coatings
Reaction or degradation products	May combine with water or steam to produce toxic and corrosive fumes of hydrochloric acid
Odour	Pungent odour of bleach
<p>References</p> <p>Chlorine (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 03/2019).</p> <p>Hazardous Substances Data Bank. Chlorine. HSDB No. 206 (last revision date 22/09/2016). US National Library of Medicine: Bethesda MD. http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB (accessed 03/2019).</p> <p>International Programme on Chemical Safety. International chemical safety card entry for chlorine. ICSC 0126, 2009. World Health Organization: Geneva.</p>	

Reported Effect Levels from Authoritative Sources

Exposure by inhalation

ppm	mg/m ³	Signs and symptoms	Reference
1–3	2.9–8.7	Mild mucous membrane irritation, tolerable for up to 1 hour	a
5	14.5	Eye irritation	a
5–15	14.5–43.5	Eye and more general moderate irritation	a
<20	58	General irritation but no serious long-term respiratory effects expected	a
30	87	Respiratory effects, immediate chest pain, dyspnoea and cough	a
40–60	116–174	Toxic pneumonitis and pulmonary oedema	a
430	1,247	Fatal over 30 minutes	a
1,000	2,900	Fatal within minutes	a
<p>These values give an indication of levels of exposure that can cause adverse effects. They are not health protective standards or guideline values</p> <p>Reference</p> <p>a Agency for Toxic Substances and Disease Registry. Toxicological Profile for Chlorine, 2010.</p>			

Published Emergency Response Guidelines

Emergency response planning guideline (ERPG) values

	Listed value (ppm)	Calculated value (mg/m ³)
ERPG-1*	1 ⁽¹⁾	3
ERPG-2†	3	9
ERPG-3‡	20	58

* 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

Reference

American Industrial Hygiene Association (AIHA). 2016 Emergency Response Planning Guideline Values.

[https://www.aiha.org/get-](https://www.aiha.org/get-involved/AIHAGuidelineFoundation/EmergencyResponsePlanningGuidelines/Documents/2016%20ERPG%20Table.pdf)

[involved/AIHAGuidelineFoundation/EmergencyResponsePlanningGuidelines/Documents/2016%20ERPG%20Table.pdf](https://www.aiha.org/get-involved/AIHAGuidelineFoundation/EmergencyResponsePlanningGuidelines/Documents/2016%20ERPG%20Table.pdf)

(accessed 03/2019).

Acute exposure guideline levels (AEGLs)

	Concentration (ppm)				
	10 min	30 min	60 min	4 hours	8 hours
AEGL-1*	0.5	0.5	0.5	0.5	0.5
AEGL-2†	2.8	2.8	2.0	1.0	0.71
AEGL-3‡	50	28	20	10	7.1

* 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 03/2019).

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	–	–	0.5	1.5
<p>WEL – workplace exposure limit, LTEL – long-term exposure limit, STEL – short-term exposure limit</p> <p>Reference Health and Safety Executive (HSE). EH40/2005 Workplace Exposure Limits, 3rd Edition, 2018.</p>				

Public health guidelines

WHO guideline value – drinking water	5 mg/L
Air quality guideline	No guideline values specified
Soil guideline values and health criteria values	No guideline values specified
<p>Reference WHO. Guidelines for Drinking-Water Quality, 4th Edition Incorporating the First Addendum, 2017. World Health Organization: Geneva.</p>	

Health Effects

Major route of exposure

- due to its gaseous nature, inhalation and ocular exposure to chlorine are most likely routes of exposure
- dermal features usually occur only from exposure to concentrated chlorine gas or in the immediate vicinity of a release of pressurised liquid
- significant ingestion is unlikely because chlorine is a gas at room temperature

Immediate signs or symptoms of acute exposure

Route	Signs and symptoms
Inhalation	<p>Irritation of eyes and nose with sore throat, cough, chest tightness, headache, fever, wheeze, tachycardia and confusion. Chemical pneumonitis, tachypnoea, dyspnoea and stridor due to laryngeal oedema may follow</p> <p>Pulmonary oedema with increasing breathlessness, wheeze, hypoxia and cyanosis may take up to 36 hours to develop. Optic neuropathy has been reported following acute inhalation</p> <p>In serious cases, corrosive damage to the mucous membranes of both the upper and lower respiratory tract occurs</p>
Dermal	<p>Dermal exposure may cause erythema, pain, irritation and cutaneous burns. Liquid chlorine may cause cutaneous burns. Gaseous chlorine will irritate the skin and may cause burns in high concentrations</p>
Ocular	<p>Splashes in the eye may cause significant damage</p>
<p>Reference TOXBASE. Chlorine, 09/2018. http://www.toxbase.org (accessed 03/2019).</p>	

Decontamination at the Scene

Chemical specific advice

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.

Chlorine is a volatile gas at room temperature, therefore decontamination may not be required. However, gaseous chlorine will irritate the skin at high concentrations and liquid chlorine may cause cutaneous burns. This should be considered in the risk assessment when deciding on the need for disrobe and 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.

General advice on disrobe and decontamination

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 (e.g. 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
- 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

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

Home Office. Initial operational response to a CBRN incident. Version 2.0, July 2015.

NHS England. Emergency Preparedness, Resilience and Response (EPRR). Guidance for the initial management of self presenters from incidents involving hazardous materials. February 2019.

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; excision or skin grafting may be required
- 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 (e.g. 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 (e.g. by an infusion bag with a giving set) for a minimum of 10-15 minutes irrespective of initial conjunctival pH. Amphoteric solutions are available and may be used. 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 discussed urgently with an ophthalmologist**
- other supportive measures as indicated by the patient's clinical condition

Inhalation

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

Clinical decontamination and first aid references

TOXBASE	http://www.toxbase.org (accessed 03/2019)
TOXBASE	Chlorine, 09/2018
TOXBASE	Chemicals splashed or sprayed into the eyes, 06/2017
TOXBASE	Skin decontamination – corrosives, 01/2018
TOXBASE	Corrosives – inhalation, 11/2018

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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