



# Chlorine Dioxide

## Incident Management

### Key Points

#### Fire

- not combustible, but enhances combustion of other substances
- oxidising agent
- reacts violently with organics, phosphorus, potassium hydroxide and sulphur, causing a fire and explosion hazard
- emits toxic fumes of chlorine when heated to decomposition; reacts with water to produce hydrochloric acid and chloric acid

#### Health

- major routes of exposure are inhalation or ocular
- inhalation causes 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 inhalation exposure
- corrosive damage to respiratory tract occurs in serious cases; severe injuries may result in persistent hoarseness, pulmonary fibrosis and chronic obstructive airway disease

#### Environment

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




## Hazard Identification

### Standard (UK) dangerous goods emergency action codes

Data not available

### Classification, labelling and packaging (CLP)\*




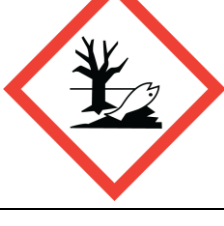
#### *Chlorine dioxide (in aqueous solution)*

<b>Hazard class and category</b>	Acute Tox. 3	Acute toxicity (oral), category 3	
	Skin Corr. 1B	Skin corrosion, category 1B	
	Aquatic Acute 1	Acute hazards to the aquatic environment, category 1	
<b>Hazard statement</b>	H301	Toxic if swallowed	
	H314	Causes severe skin burns and eye damage	
	H400	Very toxic to aquatic life	
<b>Signal words</b>	DANGER		
<p>* Implemented in the EU on 20 January 2009</p> <p><b>Reference</b>            European Commission. Harmonised classification – Annexe VI to Regulation (EC) No. 1272/2008 on Classification, Labelling and Packaging of Substances and Mixtures. <a href="http://echa.europa.eu/information-on-chemicals/cl-inventory-database">http://echa.europa.eu/information-on-chemicals/cl-inventory-database</a> (accessed 07/2015).</p>			

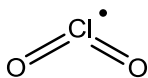
**Specific concentration limits**

Concentration	Hazard class and category	Hazard statement	
$3\% \leq C < 5\%$	Eye Dam. 1	H318	Causes serious eye damage
$C \geq 3\%$	STOT SE 3	H335	May cause respiratory irritation
$1\% \leq C < 5\%$	Skin Irrit. 2	H315	Causes skin irritation
$0.3\% \leq C < 3\%$	Eye Irrit. 2	H319	Causes serious eye irritation
$C \geq 5\%$	Skin Corr. 1B	H314	Causes severe skin burns and eye damage
<b>Reference</b> European Commission. Harmonised classification – Annexe VI to Regulation (EC) No. 1272/2008 on Classification, Labelling and Packaging of Substances and Mixtures. <a href="http://echa.europa.eu/information-on-chemicals/cl-inventory-database">http://echa.europa.eu/information-on-chemicals/cl-inventory-database</a> (accessed 07/2015).			

**Chlorine dioxide (in gaseous mixture)**

<b>Hazard class and category</b>	Press. Gas	Compressed gas	
	Ox. Gas 1	Oxidising gas, category 1	
	Acute Tox. 2	Acute toxicity (inhalation), category 2	
	Skin Corr. 1B	Skin corrosion, category 1B	
	Aquatic Acute 1	Acute hazards to the aquatic environment, category 1	
<b>Hazard statement</b>	H270	May cause or intensify fire; oxidiser	
	H330	Fatal if inhaled	
	H314	Causes severe skin burns and eye damage	
	H400	Very toxic to aquatic life	
<b>Signal words</b>	DANGER		
* Implemented in the EU on 20 January 2009			
<b>Reference</b>			
European Commission. Harmonised classification – Annexe VI to Regulation (EC) No. 1272/2008 on Classification, Labelling and Packaging of Substances and Mixtures. <a href="http://echa.europa.eu/information-on-chemicals/cl-inventory-database">http://echa.europa.eu/information-on-chemicals/cl-inventory-database</a> (accessed 07/2015).			

## Physicochemical Properties

<b>CAS number</b>	10049-04-4
<b>Molecular weight</b>	67.5
<b>Empirical formula</b>	ClO <sub>2</sub>
<b>Common synonyms</b>	Chlorine oxide, chlorine peroxide, chlorine(IV) oxide
<b>State at room temperature</b>	Yellow to reddish yellow gas
<b>Volatility</b>	Vapour pressure = 759 mmHg at 20°C
<b>Specific gravity</b>	2.3 (air = 1) 1.64 at 0°C (water = 1)
<b>Flammability</b>	Not combustible, but enhances combustion of other substances
<b>Lower explosive limit</b>	10%
<b>Upper explosive limit</b>	–
<b>Water solubility</b>	Soluble, 3.01 g/L at 25°C
<b>Reactivity</b>	May explode on heating, on exposure to sunlight or if subjected to shock or sparks. The substance is a strong oxidant and reacts violently with combustible and reducing materials. Reacts violently with organics, phosphorus, potassium hydroxide and sulphur, causing a fire and explosion hazard
<b>Reaction or degradation products</b>	When heated to decomposition, chlorine dioxide emits toxic fumes of chlorine. Reacts with water to produce hydrochloric acid and chloric acid
<b>Odour</b>	Pungent chlorine-like odour
<b>Structure</b>	
<b>References</b>	<p>Chlorine dioxide (HAZARDTEXT™ Hazard Management). In Klasco RK (Ed): TOMES® System, Truven Healthcare Analytics Inc, Greenwood Village CO, US. RightAnswer.com Inc, Midland MI, US. <a href="http://www.rightanswerknowledge.com">http://www.rightanswerknowledge.com</a> (accessed 07/2015).</p> <p>International Programme on Chemical Safety. International Chemical Safety Card for chlorine dioxide. ICSC 0127, 1999. World Health Organization: Geneva.</p>

## Reported Effect Levels from Authoritative Sources

### Exposure by inhalation

ppm	mg/m <sup>3</sup>	Signs and symptoms	Reference
5	14	Irritating	a

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

**Reference**

a US Environmental Protection Agency. Toxicological Review of Chlorine Dioxide and Chlorite, in Support of Summary Information on the Integrated Risk Information System (IRIS), 2000.

## Published Emergency Response Guidelines

### Emergency response planning guideline (ERPG) values

	Listed value (ppm)	Calculated value (mg/m <sup>3</sup> )
ERPG-1*	NA	–
ERPG-2 <sup>†</sup>	0.5	1.38
ERPG-3 <sup>‡</sup>	3	8.28

\* 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

<sup>†</sup> 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

<sup>‡</sup> 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

NA Not appropriate

**Reference**  
American Industrial Hygiene Association (AIHA). 2015 Emergency Response Planning Guideline Values. <https://www.aiha.org/get-involved/AIHAGuidelineFoundation/EmergencyResponsePlanningGuidelines/Documents/2015%20ERPG%20Levels.pdf> (accessed 09/2015).

### Acute exposure guideline levels (AEGs)

	ppm				
	10 min	30 min	60 min	4 hours	8 hours
AEG-1*	0.15	0.15	0.15	0.15	0.15
AEG-2 <sup>†</sup>	1.4	1.4	1.1	0.69	0.45
AEG-3 <sup>‡</sup>	3.0	3.0	2.4	1.5	0.98

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

<sup>†</sup> 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

<sup>‡</sup> 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 08/2015).

## Exposure Standards, Guidelines or Regulations

### Occupational standards

	LTEL (8-hour reference period)		STEL (15-min reference period)	
	ppm	mg/m <sup>3</sup>	ppm	mg/m <sup>3</sup>
<b>WEL</b>	0.1	0.28	0.3	0.84
<p>WEL – workplace exposure limit, LTEL – long-term exposure limit, STEL – short-term exposure limit</p> <p><b>Reference</b> HSE. EH40/2005 Workplace Exposure Limits, 2<sup>nd</sup> Edition, 2011.</p>				

### Public health guidelines

<b>Drinking water standard WHO provisional guideline value</b>	Chloride ions 250 mg/L Chlorite and chlorate ions 0.7 mg/L
<b>Air quality guideline</b>	No guideline value specified
<b>Soil guideline values and health criteria values</b>	No guideline value specified
<p><b>References</b> WHO. Guidelines for Drinking-Water Quality, 4<sup>th</sup> Edition, 2011. World Health Organization: Geneva. The Water Supply (Water Quality) Regulations 2000 (England) and the Water Supply (Water Quality) Regulations 2001 (Wales). The Private Water Supplies Regulations 2009 and The Private Water Supplies Regulations (Wales) 2010.</p>	



## Health Effects

### Major route of exposure

- highly irritating to eyes and respiratory tract

### Immediate signs or symptoms of acute exposure

Route	Signs and symptoms
<b>Inhalation</b>	<p>Inhalation causes 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. Pulmonary oedema with increasing breathlessness, wheeze, hypoxia and cyanosis may take up to 36 hours to develop. Optic neuropathy may occur</p> <p>In serious cases corrosive damage to the mucous membranes of both the upper and lower respiratory tract occurs. Severe inhalation injuries may result in persistent hoarseness, pulmonary fibrosis and chronic obstructive airway disease</p>
<b>References</b>	
TOXBASE. Chlorine dioxide, 06/2014. <a href="http://www.toxbase.org">http://www.toxbase.org</a> (accessed 11/2016).	

## 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.

Chlorine dioxide in solution or as the gas is corrosive. Therefore, following disrobe, improvised wet decontamination should be considered (see below for details).

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
- 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

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 persons individually.

Detailed information on clinical management can be found on TOXBASE – [www.toxbase.org](http://www.toxbase.org).

### Important notes

- if the patient has not been decontaminated following surface contamination, secondary carers must wear appropriate NHS PPE for chemical exposure to avoid contaminating themselves
- carry out decontamination after resuscitation; resuscitate the patient according to standard guidelines

### 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 (eg by an infusion bag with a giving set). A Morgan lens may be used if anaesthetic has been given. Irrigate for 10–15 minutes irrespective of initial conjunctival pH. 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
- perform a 12 lead ECG and measure the QRS duration and QT interval
- other supportive measures as indicated by the patient's clinical condition

## Clinical decontamination and first aid references

TOXBASE	<a href="http://www.toxbase.org">http://www.toxbase.org</a> (accessed 11/2016)
TOXBASE	Chlorine dioxide, 06/2014
TOXBASE	Corrosives – ingestion, 08/2013
TOXBASE	Chemicals splashed or sprayed into the eyes, 02/2014

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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First published: January 2016

Update: November 2016 Health Effects, Decontamination at the Scene & Clinical Decontamination and First Aid