

# CHLORINE

## GUIDELINES FOR ACTION IN THE EVENT OF A DELIBERATE RELEASE

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# 1 Background

## 1.1 Introduction

- Chlorine is a greenish-yellow gas. It has a pungent, irritating odour which is familiar from household bleach and swimming pools. Chlorine exposure can result from occupational and domestic use.
- Chlorine is a respiratory and eye irritant which may cause coughing, choking, hypoxia and pulmonary oedema and in higher concentrations may be fatal. Contact with compressed liquid chlorine may cause frostbite or burns to skin and eyes.
- Chlorine is denser than air and may accumulate in low or confined areas. In the event of a release, stay upwind and out of low-lying areas. Ventilate closed contaminated spaces. Protective clothing, eye protection and breathing apparatus should be worn.
- Due to its gaseous nature, inhalation and ocular exposure to chlorine are most likely. Significant ingestion is unlikely.

## 1.2 Physical and chemical properties

- Chlorine is a greenish-yellow compound with a melting point of  $-101^{\circ}\text{C}$  and boiling point of  $-34.5^{\circ}\text{C}$ . It is a gas at room temperature and pressure but may be stored or transported as a liquid.
- Chlorine is denser than air and may accumulate in low-lying areas.
  - Common synonyms chlorine mol., dichlorine, molecular chlorine
  - CAS 7782-50-5
  - UN 1017
  - NIOSH/RTECS FO 2100000
  - Molecular formula  $\text{Cl}_2$
  - Molecular weight 70.91
- Chlorine is used as a disinfectant, for sterilising and purifying water and is widely used within the chemical industry. Chlorine is non-flammable but supports combustion, often forming irritant and toxic gases. It is extremely reactive and reacts violently with many materials. It may form explosive mixtures.

### 1.3 Summary of human toxicology

- Chlorine reacts with tissue water to form hydrochloric and hypochlorous acids, and thus is a potent irritant of the eyes, skin and mucous membranes. Injury is related to the concentration of the gas, duration of exposure and water content of exposed tissues. Evidence exists suggesting that patients with pre-existing respiratory disease, such as asthma, may be at greater risk from chlorine exposure.
- The extent of the injury depends upon the concentration and duration of the exposure, as well as the water content of the tissue involved
  - Industrial exposure:* Chlorine gas is corrosive to eyes, skin, respiratory tract and mucous membranes. Severe exposure may cause laryngospasm, airway obstruction, respiratory arrest, pulmonary oedema and cardiovascular collapse.
  - Household exposure:* The mixing of household cleaning agents (for example bleach and acids) may liberate chlorine gas. Single acute exposure commonly produces coughing, lacrimation, conjunctivitis and tachycardia. A few cases may develop vomiting, sweating and headache.
- One or two breaths of gas accumulating above swimming pool chlorinator tablets has caused marked respiratory distress and hypoxaemia in children.

### Toxicity of Chlorine<sup>1,2</sup>

Concentration	Clinical effects
1-3 ppm for 1 h	Mild mucous membrane irritation
5-15 ppm	Moderate irritation of upper respiratory tract, stinging and burning eyes
30 ppm	Immediate chest pain, vomiting, and coughing
40-60 ppm	Toxic pneumonitis and pulmonary oedema
430 ppm for 30 min	Lethal
1,000 ppm for few min	Fatal

Occupational Exposure Standards (UK)<sup>3</sup>:

Long-term exposure limit (8 hour): 0.5 ppm (1.5 mg.m<sup>-3</sup>)

Short-term exposure limit: 1 ppm (2.9 mg.m<sup>-3</sup>)

ERPG(1)	1ppm
ERPG (2)	3ppm
ERPG (3)	20ppm

## **1.4 Clinical Features**

### **1.4.1 Acute**

#### *Inhalation Effects*

- Symptoms include irritation of the eyes, nose and throat which occur very rapidly. These are followed by coughing, wheezing, dyspnoea, sputum production, bronchospasm and chest pain. Nausea and vomiting may occur.
- Metabolic complications range from mild alkalosis (due to hyperventilation) to respiratory acidosis with profound hypoxaemia, reflecting the extent of pulmonary involvement. Massive inhalation may be complicated by hyperchloraemic metabolic acidosis.
- Cardiorespiratory arrest may occur secondary to hypoxia.
- In severe cases chemical pneumonitis and pulmonary oedema may occur after a latent phase of up to 12-24 hours.

#### *Dermal Effects*

- Skin irritation may occur with burns at higher concentrations. Contact with compressed liquid gas may cause frostbite or burns.

#### *Eye Effects*

- Stinging and burning sensation of the eyes, with associated blepharospasm, redness, and watering. With continued exposure sensitivity may decrease and signs and symptoms diminish<sup>1</sup>.
- Contact with compressed liquid gas can cause frostbite.

#### *Oral Effects*

Not applicable.

### **1.4.2 Long term/Persistent Sequelae**

- Long-term sequelae are rare. Reactive airway disorder has been described following exposure. Decreased residual volume has been described for up to 12 years following an acute exposure. Patients at greatest risk were older and had marked airflow obstruction and air trapping immediately following exposure<sup>4</sup>.

## **2 Clinical procedures**

### **2.1 Decontamination and First aid**

- **Adequate self-protection should be ensured before rescuers attempt to aid casualties.** Rescuers should wear appropriate protective clothing including respiratory and eye protection. Self contained breathing apparatus and impermeable suits are required to protect against high concentrations.
- The priority is to remove the casualty from further exposure and maintain vital functions. Management of acute chlorine inhalation is symptomatic and supportive.
- Chlorine is a volatile gas and secondary contamination from individuals exposed to gas alone is unlikely, though chlorine gas can condense on the skin and contaminate others dermally, unless protected. Exposure to liquid agent will result in off-gassing and a secondary hazard.
- Remove contact lenses if present and easily removable. Irrigate eyes with lukewarm water or sodium chloride 0.9% solution. Patients with eye injuries should be referred to an ophthalmologist. If eye tissue is frozen seek urgent specialist advice.
- All clothing should be removed unless covering an area of frostbite. Whenever possible the affected individual should remove contaminated clothing for him/herself.
- Chlorine does not remain liquid for long, except in very cold climates. Skin decontamination is therefore not usually required following exposure to gas alone. If required, this should be carried out using a rinse-wipe-rinse regime with dilute detergent (10ml washing up liquid to a 10 litre bucket of water).
- Contaminated clothing should be placed in clear, labelled, sealed bags to prevent further contamination. They should be stored in a secure area away from staff and patients.
- Establish and maintain a clear airway and administer supplemental oxygen as required.

### **2.2 Sample collection and monitoring**

- There is no analysis available to measure blood chlorine concentrations. Concentrations in the air may be measured.
- Clinical samples will be required according to the patient's condition. Consider obtaining arterial blood gases.

## 2.3 Treatment

**In the event of an incident causing release of chlorine, additional resuscitation equipment will be available. This should be requested EARLY in the course of the incident. The 'trigger' for obtaining it will be released by DH separately.**

### *Inhalation Management*

- Management of acute chlorine inhalation is symptomatic and supportive.
- Symptomatic patients should be kept at rest. Give oxygen for dyspnoea and bronchodilators (e.g. inhaled salbutamol) for bronchospasm.
- Monitor arterial blood gases and pulmonary function and obtain a chest X-ray.
- Mechanical ventilation with positive end-expiratory pressure may be necessary if non-cardiogenic pulmonary oedema develops.
- Rarely, tracheostomy may be necessary for life-threatening laryngeal oedema.
- The role of prophylactic corticosteroids (inhaled or systemic) is unproven. Antibiotics will be required if pneumonia develops.
- Follow-up lung function tests should be obtained following recovery from the acute illness.

### *Dermal Management*

- Dermal features usually occur only from exposure to concentrated chlorine gas or in the immediate vicinity of a release of pressurised liquid.
- *If frostbite has occurred :* Remove clothes carefully: these may need to be soaked off. Irrigate the area. Surgical referral may be necessary.
- *If frostbite has not occurred:* Irrigate exposed skin with copious amounts of water. Treat burns symptomatically.
- Place any clothes removed in double, sealed, clear bags; and store in a secure area away from patients and staff.
- Skin burns should be treated as a thermal injury.

### *Eye Management*

- Irrigate eyes immediately. Stain with fluorescein and refer to an ophthalmologist if there is any uptake of the stain.

### *Oral Management*

Not applicable.

## **2.4 Admission criteria**

- Exposed individuals who have not developed symptoms do not require admission but should be told to seek medical advice if they develop respiratory problems.
- All patients showing immediate effects should be assessed carefully in hospital.
- Patients with respiratory symptoms persisting beyond the period of exposure should be admitted to hospital as delayed pulmonary oedema may occur.

### *Mild symptoms:*

- Patients with mild, local effects only may be discharged, but should be advised to return if symptoms recur or develop over the following 24-36 hours.

### *Moderate or severe symptoms:*

- All patients showing **immediate** moderate or severe effects should be admitted for at least 24 hours, as there is a risk of developing delayed pulmonary oedema.
- Assess and consider admitting all patients with pre-existing respiratory disease for at least 24 hours.
- All patients who have developed moderate or severe clinical effects, even if pulmonary oedema did not occur, should be reviewed for lung function tests.

## **2.5 Protection of health care workers**

- All medical staff should wear full personal protective equipment when decontaminating patients.

### **3 Laboratory procedures**

- There is no analysis available to measure blood chlorine concentrations. Air sampling at the site of exposure may confirm the nature of the exposure. Clinical samples, including blood gases should be taken according to the patient's clinical condition.

### **4 Public health procedures**

#### **4.1 Surveillance and detection of deliberate release**

- A deliberate release should be considered in the event of any cases where there is no clear history of occupational or other exposure to chlorine. The likelihood of a deliberate release increases with the number of cases that are linked in time and place.
- Expert advice may be required in order to confirm the occurrence of a covert release and epidemiological investigations may be required to define the exposed zone in time and space.

#### **4.2 Case definition**

- A record should be kept of all patients attending as the result of a chlorine release.

##### **4.2.1 Possible case**

- Patient reporting possible exposure with mild or moderate symptoms, probably not admitted for continuing medical care.

##### **4.2.2 Probable case**

- Patient reporting exposure and is symptomatic, likely to have required hospital care.

##### **4.2.3 Confirmed case**

- All patients showing immediate moderate or severe effects should be admitted for at least 24 hours.

## **4.3 Public Health action**

### **4.3.1 Removal from exposure**

- Minimisation of harm by removal from exposure is probably the most important public health measure. Evacuation from contaminated area is essential and is likely to be undertaken by the emergency services (or by self-evacuation).

### **4.3.2 Decontamination**

- Adequate self-protection should be ensured before rescuers attempt to aid casualties. Rescuers should wear appropriate protective clothing including respiratory and eye protection. Self contained breathing apparatus and impermeable suits are required to protect against high concentrations.
- Chlorine is a volatile gas and secondary contamination from exposed individuals is unlikely, though chlorine gas can condense on the skin and contaminate others dermally, unless adequately protected.
- All clothing should be removed. Chlorine does not remain liquid for long, except in very cold climates. Skin decontamination is therefore not usually required. If required, this should be carried out using a rinse-wipe-rinse regime with dilute detergent (10ml washing up liquid to a 10 litre bucket of water).
- Contaminated clothing should be placed in clear, labelled, sealed bags to prevent further contamination.

### **4.3.3 Epidemiological investigation**

- The value of obtaining epidemiological data from patients attending is immense. A draft questionnaire has been provided to hospital trusts (Hospital Chemical Incident Response) and further advice may be issued. Health Authorities may wish to collaborate with acute trusts in collating these data.

## **4.4 Environmental hazard summary**

- Chlorine is denser than air and may accumulate in low-lying areas.
- Free chlorine released into water is extremely unstable; it will oxidise inorganic compounds rapidly and oxidise organic compounds at a slower rate<sup>4</sup>.
- Chlorine is harmful to many forms of aquatic life in concentrations below 0.1 ppm; it is not expected to accumulate in the food chain.
- Drinking Water Standards: 5 mg.l<sup>-1</sup> (<sup>5</sup>).

- Soil Guidelines: no data available.
- Air Quality Standards: no data available

## 5 National specialists

### 5.1 Laboratory diagnosis

- There is no analysis available to measure blood chlorine concentrations. Air sampling at the site of exposure may confirm the identity of the agent.

### 5.2 Treatment

- **Further advice on treatment is available from the agencies below and also on TOXBASE ([www.spib.axl.co.uk](http://www.spib.axl.co.uk)).**

<b>Agency</b>	<b>24 hour number</b>	<b>Area served</b>
National Poisons Information Service	0870 600 6266	UK
<b>Regional Service Provider Units</b>		
Chemical Incident Response Service, London	0207 635 9191	Eastern, London, South East, South West, North West, Trent Regions
Chemical Hazard Management and Research Centre, Birmingham	0207 394 5112	West Midlands Region
Chemical Incident Service, Newcastle	0191 222 7195 (office) 0191 230 3761 (out of hours)	Northern and Yorkshire Region
Chemical Incident Management Support Unit, Cardiff	029 2071 5278	Wales and Northern Ireland
Scottish Centre for Infection and Environmental Health	0141 300 1100 (office hours – ask for on call consultant) 0141 211 3600 (out of hours)	Scotland
<b>Other</b>		
National Focus for Chemical Incidents	08701 545654	UK
Regional Health Emergency Planning Advisers		

<b>Agency</b>	<b>24 hour number</b>	<b>Area served</b>
Emergency Planning Co-ordination Unit, Department of Health, England	020 7210 5771	UK

## **6. References**

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- 1 Grant MW & Schuman JS. Toxicology of the Eye, 4th edn. Charles C Thomas, Springfield, 1993.
- 2 Hathaway GJ, Proctor NH & Hughes JP. Proctor and Hughes' Chemical Hazards of the Workplace, 4th edn. Van Nostrand Reinhold, New York, 1996.
- 3 Health & Safety Executive. *EH40/2000 Occupational Exposure Limits 2000*. Stationery Office, London, 2000.
- 4 Hall AH & Rumack BH (Eds). TOMES System ® Micromedex, Englewood, Colorado. CD ROM. Vol 50 (February 2001).
- 5 WHO. Guidelines for drinking-water quality, 2nd edn. WHO, Geneva, 1996.