

PHOSGENE

GUIDELINES FOR ACTION IN THE EVENT OF A DELIBERATE RELEASE

Contents

1.	Background	2
	1.1 Introduction	2
	1.2 Physical and chemical properties	2
	1.3 Summary of human toxicology	3
	1.4 Clinical features	4
	1.4.1 Acute	4
	1.4.2 Long term/persistent sequelae	6
2	Clinical procedures	6
	2.1 Decontamination and first aid	6
	2.2 Sample collection and monitoring	7
	2.3 Treatment	7
	2.4 Admission criteria	8
	2.5 Protection of health care workers	8
3	Laboratory procedures	9
4	Public health procedures	9
	4.1 Surveillance and detection of deliberate release	9
	4.2 Case definition	9
	4.2.1 Possible case	9
	4.2.2 Probable case	9
	4.2.3 Confirmed case	9
	4.3 Public Health action	10
	4.3.1 Removal from exposure	10
	4.3.2 Decontamination	10
	4.3.3 Epidemiological investigation	10
	4.4 Environmental hazard summary	10
5	National specialists	11
	5.1 Treatments	11
6	References	12

1 Background

1.1 Introduction

- Phosgene is a colourless gas with an odour like musty hay. Inhalation may be fatal.
- Phosgene, and its decomposition product, hydrochloric acid, causes direct irritation to mucous membranes including the eyes and respiratory tract. Exposure to concentrations above 3ppm may cause burns, and contact with liquid phosgene may cause frostbite.
- Following initial symptoms there may be an asymptomatic period before the onset of non-cardiogenic pulmonary oedema with severe breathlessness and a productive cough. These features may be delayed 24 (or rarely 48) hours.

The presence or absence of initial symptoms does not accurately reflect the severity of poisoning.

- Phosgene is heavier 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.

1.2 Physical and Chemical Properties

- Phosgene is a colourless gas at room temperature. When refrigerated or compressed it is easily liquefied to a colourless or pale yellow liquid. At low concentrations it has an aroma of musty hay. Higher concentrations are irritant.
- *Common synonyms* carbonyl chloride, carbon oxychloride and chloroformyl chloride
- CAS 75-44-5
- UN 1076
- NIOSH/RTECS SY 5600000
- Molecular formula CCl_2O
- Molecular weight 98.92
- Phosgene is widely used by industry, including the manufacture of isocyanates, polyurethane and polycarbonate resins, pesticides, herbicides and dyes¹.
- Phosgene was used as a chemical weapon by Germany during WW1 and was the major cause of chemical deaths during that conflict. When first used

against British troops, in December 1915, 88 tons were released, causing 1069 casualties and 120 deaths².

- Phosgene is denser than air and may accumulate in low-lying areas. It is non-combustible, but reacts violently with anhydrous ammonia, strong oxidants and many other substances. It hydrolyses forming hydrochloric acid and carbon dioxide and attacks many metals in moist environments. When phosgene is heated to decomposition it gives off oxides of carbon, chloride and hydrochloric acid.
- Although volatile (vapour pressure 1418 mm Hg at 25°C), phosgene degrades slowly in the atmosphere and can therefore be transported in plumes a relatively long way from a release. Phosgene hydrolyses in water.
- It is slightly soluble in water and is freely soluble in benzene, chloroform, glacial acetic acid, toluene and most liquid hydrocarbons^{3, 4}.

1.3 Summary of human toxicology

- Phosgene is absorbed by inhalation. Local effects may occur in the eyes and on the skin. Ingestion is unlikely.
- The effects of phosgene exposure may have three phases:
 - Initial phase, at or soon after exposure.
 - Latent phase
 - Oedema phase
- During the initial phase irritant symptoms may occur. However, changes within the respiratory tract may be initiated, which, following a latent phase, may progress to a devastating non-cardiogenic (permeability) pulmonary oedema which may be fatal. **Early signs and symptoms are not a reliable indicator of the severity of exposure.**
- Whilst prolonged exposure to low concentrations may produce delayed pulmonary oedema, exposure to high concentrations is rapidly fatal.
- Olfactory fatigue occurs with repeated or prolonged exposure, hence phosgene is considered to have poor odour warning properties.

Toxicity of Phosgene⁴

Concentration	Clinical effects
0.125 ppm	Workers exposed long time (time not specified), no effects
0.5-1 ppm	Odour detected
3 ppm	Throat irritation
3 ppm (for 170 min)	May be fatal
4 ppm	Immediate eye irritation
4.8 ppm	Cough
25 ppm	Short exposures may cause lower respiratory tract irritation
50 ppm	Brief exposures may be rapidly fatal

Occupational Exposure Standards⁵:

Long-term exposure limit: 0.02 ppm (0.08 mg.m⁻³)

Short-term exposure limit: 0.06 ppm (0.25 mg.m⁻³)

ERPG2 0.2 ppm

ERPG3 1 ppm

1.4 Clinical Features

1.4.1 Acute

Inhalation Effects

In many cases the course of phosgene toxicity following inhalation can be divided into three phases: **the severity of the initial phase is no indication of the severity of the poisoning.**

Initial Phase

Symptoms include some or all of the following:

- irritation to the eyes, lacrimation and blepharospasm.
- nausea and vomiting.
- tight chest, retrosternal discomfort, bronchoconstriction.
- hypotension, bradycardia or tachycardia.
- Severe exposure: haemolysis, rapid death.

Latent Phase

- Patient may appear completely well.
- Symptoms may be precipitated by exercise. Collapse of patients exposed to phosgene was reported in WW1 following exposure².

Oedema Phase

- Non-cardiogenic pulmonary oedema.
- Dyspnoea, bronchospasm, frothy sputum.
- Bronchial necrosis.
- Hypotension, tachycardia, hypoxia.
- Secondary infection (pneumonia).
- ARDS.
- Death.

Long term sequelae

Following recovery from an acute exposure blood gases may remain abnormal for a month. Reactive airway dysfunction syndrome may occur: dyspnoea and increased bronchial resistance may be present for several months⁶ Rarely, residual chronic emphysema, chronic bronchitis, bronchiectasis, and pulmonary fibrosis are described.⁷

Dermal Effects

On contact with liquid phosgene, burns and frostbite may occur which may lead to necrosis.

Eye Effects

Gas: Irritation, lacrimation, swelling and pain.

Liquid: Severe irritation, photophobia, corneal opacification and perforation have been reported.⁶

Oral Effects

Ingestion is considered unlikely.

1.4.2 Long term/ Persistent sequelae

- Reactive airways disorder may occur following exposure. Chronic bronchitis and emphysema may occur following phosgene exposure.²

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 phosgene inhalation is symptomatic and supportive.
- Phosgene is a volatile gas and secondary contamination from individuals exposed to gas alone is unlikely. However, in cold weather, phosgene gas can condense and contaminate others dermally, unless they are 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.
- Phosgene 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 10litre bucket of water).
- Contaminated clothing should be placed in clear, labeled sealed bags to prevent further contamination. It 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 phosgene concentrations. Concentrations in air may be measured.
- Clinical samples will be required according to the patient's condition. Consider obtaining arterial blood gases and chest X-rays. These may need to be repeated.

2.3 Treatment

In the event of an incident causing release of phosgene, 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.

The severity or duration of the initial phase does not reliably indicate the potential for severe clinical effects.

If exposure is suspected the patient should be observed for 24 hours.

Those exposed should undertake no exercise – remaining on bed rest as exercise may precipitate pulmonary oedema and collapse.

Inhalation Management

- Treatment is symptomatic and supportive. 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.
- Monitor for the development of secondary infection and ARDS.
- 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 after exposure to concentrated phosgene gas or contact with liquid phosgene.
- *If frostbite has occurred:* remove clothing carefully; these may need to be soaked off with tepid water; irrigate the area. Surgical referral may be necessary.
- *If frostbite has not occurred:* Remove any remaining contaminated clothing. Irrigate with copious amounts of water.
- Treat burns symptomatically.
- Place any contaminated clothes in double, sealed, clear bags, label and store in a secure area away from patients and staff.

Eye Management

- Remove contact lenses if required. 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 criteria⁸

- If exposure is suspected, the patient **must** be observed for 24 hours due to the possibility of delayed, potentially fatal, pulmonary oedema occurring. Patients should undertake no exercise and should be placed on strict bed rest as soon as possible.

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 phosgene 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 phosgene. The likelihood of a deliberate release increases with the number of cases, which 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 defined exposed zone in time and space.

4.2 Case definition

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

4.2.1 Possible case

- Patient reporting possible exposure with or without mild symptoms, probably not admitted for continuing medical care.

4.2.2 Probable case

- Patient reporting exposure, with some symptoms consistent with exposure, likely to have required hospital care.

4.2.3 Confirmed case

- Characteristically symptomatic patient, with history of exposure requiring hospital care.

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.
- Phosgene is a volatile gas and secondary contamination from exposed individuals is unlikely, though liquid phosgene can contaminate others dermally, unless they are adequately protected. Off-gassing from liquid agent may pose a secondary vapour hazard.
- All clothing should be removed. Phosgene evaporates quickly except in cold weather and therefore tends not to remain liquid for long, except in very cold climates. Skin decontamination may not be required. If required, it 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.

Epidemiological investigation

- It is vitally important to try and obtain epidemiological data on this patient group. 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

- Phosgene is denser than air and may accumulate in low-lying areas.
- It has a high vapour pressure (vapour pressure 1418 mm Hg at 25C).
- Phosgene degrades slowly in the atmosphere.
- In water phosgene is hydrolysed and is rapidly lost by volatilisation.
- If released into damp soil phosgene will hydrolyse and be lost by volatilisation. It has a high K_{co} and is expected to be highly mobile.

- Drinking Water Standards: no data available. Immiscible with water
- Soil Guidelines: no data available.
- Air Quality Standards: no data available.

5 National specialists

5.1 Treatment

Further advice on treatment is available from the agencies listed below and also on TOXBASE (www.spib.axl.co.uk)

Agency	24 hour number	Area served
National Poisons Information Service	0870 600 6266	UK
Regional Service Provider Units		
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
Other		
National Focus for Chemical Incidents	08701 545654	UK
Regional Health Emergency Planning Advisers		
Emergency Planning Co-ordination Unit, Department of Health, England	020 7210 5771	UK

6 References

- 1 Sax NI & Lewis RJ. Hawley's Condensed Chemical Dictionary, 11th edition. Van Nostrand Reinhold Company, New York, 1987.
- 2 Marrs TC, Maynard RL & Sidell FR. Chemical Warfare Agents. John Wiley & Sons, Chichester, 1996.
- 3 Budevari S, O'Neil MJ, Smith A, Heckelman PE & Kinneary JF (eds). The Merck Index, 12th edition. Merck & Co., Inc., Whitehouse Station, 1996.
- 4 Clayton GD & Clayton FE (eds). Patty's Industrial Hygiene and Toxicology, 4th ed. John Wiley & Sons, Inc, New York, 1994.
- 5 Health & Safety Executive. *EH40/2000 Occupational Exposure Limits 2000*. Stationery Office, London, 2000.
- 6 Wyatt JP & Allister CA, 1995. Occupational phosgene poisoning: a case report and review . J Accid Emerg Med; 12(3): 212-213.
- 7 Hall AH & Rumack BH (Eds). TOMES System Micromedex, Englewood, Colorado. CD ROM. Vol 50 (February 2001).
- 8 Maynard R, 2001. Personal communications. Department of Health, London.