



## White Phosphorus

### Incident Management

#### Key Points

##### Fire

- highly flammable, may spontaneously ignite on contact with air, reacts violently with oxidants, halogens, nitrates and sulphur, causing a fire and explosion hazard
- emits toxic fumes of phosphorus oxides and phosphine when heated to decomposition
- in the event of a fire involving phosphorus, use coarse water spray and gas-tight protective clothing with self-contained breathing apparatus

##### Health

- inhalation causes irritation of the upper respiratory tract and headache and systemic effects may occur
- ingestion: **stage 1**, may be delayed for 24 hours, nausea, vomiting, abdominal pain and burns to the pharynx, oesophagus and stomach; **stage 2**, symptom-free period during which the patient appears to recover; **stage 3**, multi-organ failure
- dermal exposure causes partial and full thickness burns (both chemical and thermal) and may cause systemic toxicity
- ocular exposure may cause irritation, blepharospasm, photophobia, lacrimation and conjunctivitis and particles may cause corneal perforation
- systemic effects include nausea, vomiting, diarrhoea, garlic odour to breath and stools, haematemesis, hypotension, headache, confusion, lethargy, convulsions and coma



##### Environment

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



## Hazard Identification

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





#### *Phosphorus, white or yellow, dry or under water or in solution*

|   |                  |      |   |  |
|---|------------------|------|---|--|
| <b>UN</b>   |                  | 1381 | Phosphorus, white or yellow, dry or under water or in solution  |  |
| <b>EAC</b>  |                  | 1WE  | Use coarse water spray. Wear chemical protective clothing with liquid-tight connections for whole body in combination with breathing apparatus*. Danger that the substance can be violently or explosively reactive. 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† |  |
| <b>APP</b>  |                  | –    | –   |  |
| <b>Hazards</b>  | <b>Class</b>     | 4.2  | Substances liable to spontaneous combustion   |   |
|   | <b>Sub-risks</b> | 6.1  | Toxic substances  |  |
| <b>HIN</b>  |                  | 46   | Flammable or self-heating solid, toxic  |  |
| <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 the 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 250m away from the incident</p> <p><b>Reference</b></p> <p>Dangerous Goods Emergency Action Code List, National Chemical Emergency Centre (NCEC), Part of Ricardo-AEA. The Stationery Office, 2015.</p> |                  |      |   |  |

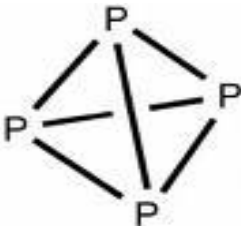
**Phosphorus, white molten**

|   |                  |      |   |  |
|---|------------------|------|---|--|
| <b>UN</b>   |                  | 2447 | Phosphorus, white molten  |  |
| <b>EAC</b>  |                  | 1WE  | Use coarse water spray. Wear chemical protective clothing with liquid-tight connections for whole body in combination with breathing apparatus*. Danger that the substance can be violently or explosively reactive. 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 <sup>†</sup> |  |
| <b>APP</b>  |                  | A(h) | Gas-tight chemical protective suit with breathing apparatus <sup>‡</sup><br>The substance may be carried above 100°C  |  |
| <b>Hazards</b>  | <b>Class</b>     | 4.2  | Substances liable to spontaneous combustion   |   |
|   | <b>Sub-risks</b> | 6.1  | Toxic substances  |  |
| <b>HIN</b>  |                  | 446  | Flammable solid, toxic in the molten state at an elevated temperature   |  |
| <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 the relevant standards such as BS 8428 or EN 14605, in combination with breathing apparatus BS EN 137</p> <p><sup>†</sup> 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><sup>‡</sup> 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</p> <p><b>Reference</b><br/>Dangerous Goods Emergency Action Code List, National Chemical Emergency Centre (NCEC), Part of Ricardo-AEA. The Stationery Office, 2015.</p> |                  |      |   |  |

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

|   |                 |  |   |
|---|-----------------|--|---|
| <b>Hazard class and category</b>  | Pyr. Sol. 1     | Pyrophoric solid, category 1   |    |
|   | Acute Tox. 2    | Acute toxicity (inhalation, oral), category 2                        |    |
|   | Skin Corr. 1A   | Skin corrosion, category 1A  |    |
|   | Aquatic Acute 1 | Hazardous to the aquatic environment, short term (Acute), category 1 |  |
| <b>Hazard statement</b>   | H250            | Catches fire spontaneously if exposed to air                         |   |
|   | H300            | Fatal if swallowed   |   |
|   | H314            | Causes severe skin burns and eye damage                              |   |
|   | H330            | Fatal if inhaled   |   |
|   | 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></p> <p>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 01/2016).</p> |                 |  |   |

## Physicochemical Properties

|   |  |
|---|--|
| <b>CAS number</b>                       | 7723-14-0 / 12185-10-3   |
| <b>Molecular weight</b>                 | 124  |
| <b>Formula</b>                          | P <sub>4</sub>   |
| <b>Common synonyms</b>                  | White phosphorus, yellow phosphorus  |
| <b>State at room temperature</b>        | Solid  |
| <b>Volatility</b>                       | Vapour pressure: 0.026 mmHg at 20°C  |
| <b>Specific gravity</b>                 | Vapour density: 4.42 at 20°C (air = 1)   |
| <b>Flammability</b>                     | Highly flammable   |
| <b>Lower explosive limit</b>            | Not listed   |
| <b>Upper explosive limit</b>            | Not listed   |
| <b>Water solubility</b>                 | Low solubility in water  |
| <b>Reactivity</b>                       | May spontaneously ignite on contact with air. Reacts violently with oxidants, halogens, nitrates and sulphur, causing a fire and explosion hazard  |
| <b>Reaction or degradation products</b> | Produces fumes of phosphorus oxides, phosphine and phosphoric acid (in the presence of water) when heated to decomposition. Reacts with strong bases producing phosphine gas   |
| <b>Odour</b>                            | Garlic-like  |
| <b>Structure</b>                        |   |
| <b>References</b>                       | <p>International Programme on Chemical Safety. International Chemical Safety Card entry for phosphorus (yellow). ICSC 0628. 2004. World Health Organization: Geneva.</p> <p>Phosphorus (HAZARDEXTM 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 08/2015).</p> |

## Reported Effect Levels from Authoritative Sources

### Exposure by ingestion

| mg/kg   | Signs and symptoms                      | Reference |
|---|---|-----------|
| ≥1  | Significant toxicity expected in adults | a         |
| mg  | Signs and symptoms                      | Reference |
| 3   | Fatal in a child                        | 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><b>Reference</b></p> <p>a TOXBASE. Phosphorus white/yellow, 2015. <a href="http://www.toxbase.org">http://www.toxbase.org</a> (accessed 01/2016)</p> |   |           |

## Published Emergency Response Guidelines

### Emergency response planning guideline (ERPG) values

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

### Acute exposure guideline levels (AEGLs)

|   | ppm                |        |        |         |         |
|---|--------------------|--------|--------|---------|---------|
|   | 10 min             | 30 min | 60 min | 4 hours | 8 hours |
| <b>AEGL-1*</b>  | Data not available |        |        |         |         |
| <b>AEGL-2<sup>†</sup></b>   |                    |        |        |         |         |
| <b>AEGL-3<sup>‡</sup></b>   |                    |        |        |         |         |
| <p>* Level of the chemical in air at or above which the general population could experience notable discomfort</p> <p><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</p> <p><sup>‡</sup> Level of the chemical in air at or above which the general population could experience life-threatening health effects or death</p> |                    |        |        |         |         |

## Exposure Standards, Guidelines or Regulations

### Occupational standards

| Yellow phosphorous  | 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               | –                              | 0.3               |
| WEL – workplace exposure limit, LTEL – long-term exposure limit, STEL – short-term exposure limit<br><b>Reference</b><br>Health and Safety Executive (HSE). EH40/2005 Workplace Exposure Limits, 2 <sup>nd</sup> Edition, 2011. |                                |                   |                                |                   |

### Public health guidelines

|   |                              |
|---|------------------------------|
| <b>Drinking water standard</b>                          | No guideline value specified |
| <b>Air quality guideline</b>                            | No guideline value specified |
| <b>Soil guideline values and health criteria values</b> | No guideline value specified |



## Health Effects

### Major route of exposure

- effects may occur following exposure by all routes (ingestion, inhalation, dermal or ocular exposure)

### Immediate signs or symptoms of acute exposure

| Route             | Signs and symptoms   |
|-------------------|--|
| <b>Inhalation</b> | Headache, upper respiratory tract irritation and non-cardiogenic pulmonary oedema (which may be delayed in onset). Acute hepatic damage and systemic toxicity may occur  |
| <b>Ingestion</b>  | <p>The clinical course of poisoning may occur in three stages; however stages 1 or 2 may be absent or difficult to recognise.</p> <p>The lack of classical features (garlic odour on breath, mucosal burns, phosphorescent (photoluminescent) or smoking vomitus/faeces) does not exclude poisoning.</p> <p><b>Stage 1</b></p> <p>The onset of symptoms after ingestion can occur after a few minutes but may be delayed for up to 24 hours. Features may include nausea, vomiting, abdominal pain, garlic odour on breath and faeces, photoluminescent or smoking vomitus/faeces. Burns to pharynx, oesophagus and stomach. Restlessness, irritability, lethargy and drowsiness. Rarely, early cardiovascular collapse or death may occur.</p> <p><b>Stage 2</b></p> <p>Symptom-free period, 1–7 days (occasionally up to 10 days), during which the patient appears to recover. <b>(Early improvement should not be interpreted as meaning that serious exposure has not occurred.)</b></p> <p><b>Stage 3</b></p> <p>Multi-organ failure from the action of the absorbed phosphorus. Coma and shock, often followed by death</p> |
| <b>Dermal</b>     | Severely painful, partial and full thickness burns (both chemical and thermal) that are slow to heal. Phosphorus may be absorbed through broken skin and cause systemic toxicity   |
| <b>Ocular</b>     | Irritation, blepharospasm, photophobia, lacrimation and conjunctivitis. Particles may cause corneal perforation  |

|  |  |
|--|--|
| <p><b>Systemic</b></p>   | <p><b>Gastrointestinal:</b> nausea, vomiting, abdominal pain, diarrhoea, garlic odour to breath and stools. Vomitus and stools may be luminescent or evening smoking. Burns to pharynx, oesophagus and stomach. Haematemesis, massive upper alimentary tract bleeding and DIC</p> <p><b>Cardiovascular:</b> tachycardia or bradycardia, hypotension, cyanosis, cardiovascular collapse, QRS and QT prolongation, abnormal T waves and ST depression, absent P waves, right bundle branch block, torsade de pointes, ventricular fibrillation and cardiac arrest. Cardiovascular collapse may occur in the first 24 hours.</p> <p><b>CNS:</b> agitation, confusion, depressed consciousness and coma. Headache, rarely convulsions and cerebral oedema. Cerebral symptoms may persist for a long time.</p> <p><b>Hepatic:</b> jaundice, hepatomegaly, hepatic necrosis, fulminant hepatic failure and hepatic encephalopathy. Deranged LFTs and INR, hypoglycaemia.</p> <p><b>Renal:</b> acute kidney injury, often acute tubular necrosis.</p> <p><b>Other:</b> hyperventilation, respiratory distress, pulmonary oedema, initially hyperglycaemia followed by hypoglycaemia, metabolic acidosis, bone marrow suppression, hypocalcaemia and hypophosphatemia or hyperphosphatemia. Haemorrhage into skin, mucous membranes and viscera may occur due to injury of blood vessels and inhibition of blood clotting.</p> |
| <p><b>References</b></p> <p>TOXBASE. Phosphorus White/Yellow, 11/2015. <a href="http://www.toxbase.org">http://www.toxbase.org</a> (accessed 11/2016).</p> |  |

## 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.

Phosphorus spontaneously ignites in air. It may cause deep and painful burns (thermal and chemical) and may be absorbed through the skin. 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

- **white/yellow phosphorus represents a toxic, fire and explosive hazard**
- 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
- prior to decontamination, any solid particles adhering to the skin should be brushed away and stored under water. Adherent liquid should be blotted away
- 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
- 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
- **the earlier irrigation begins, the greater the benefit**
- pay particular attention to mucous membranes, moist areas such as skin folds, fingernails and ears
- **soiled clothing should be placed in a water-filled sealed container clearly labelled as a biohazard**

### Dermal exposure

- meticulous surgical debridement of all embedded phosphorus particles is required; consult a burns specialist (store any removed solid particles under water)
- continuous irrigation can prevent further oxidation and allow removal of particles from the skin surface without re-ignition. Alternatively, phosphorus will fluoresce under ultraviolet (UV) light, with the exposed areas immersed in water, loose or imbedded phosphorus

particles that are visualised under UV light can be mechanically but delicately removed safely under water

- water- or saline-soaked dressings applied to the affected area will allow transportation of patients without re-ignition of the remaining particles
- burns totalling more than 15% of body surface area (more than 10% in children) will require standard fluid resuscitation as for thermal burns
- chemical burns should be reviewed by a burns specialist, excision or skin grafting may be required
- manage systemic toxicity as for ingestion/inhalation
- 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 0.9% saline 1000 mL (for example via 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/Ingestion

- maintain a clear airway and ensure adequate ventilation
- avoid giving milk to drink or other fatty substances since this may enhance the absorption of phosphorus
- consider the need for high flow oxygen via a high flow mask with a rebreather bag, or endotracheal tube
- monitor vital signs, cardiac rhythm and measure blood sugar (BM).
- perform 12 lead ECG
- other supportive measures as indicated by the patient's clinical condition

## Clinical decontamination and first aid references

- TOXBASE <http://www.toxbase.org> (accessed 11/2016)  
TOXBASE Phosphorus white/yellow, 11/2015  
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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