J R Army Med Corps 2002; **148**: 395-397

Smokes, Fuels, and Incendiary Materials

SMOKES

Introduction

Smokes are used to obscure troops and equipment on the battlefield. They are liquid or solid particulate aerosols that diffuse electromagnetic radiation at wavelengths ranging from the infrared through the visible to the ultraviolet end of the spectrum. They achieve this by absorption of atmospheric water.

Not all smokes are hazardous at concentrations necessary for obscuration. However, exposure to heavy smoke concentrations for extended periods, particularly if near the source of emission, may cause ill-effects or even death. Medical personnel should be prepared to treat reactions to military smokes once they have been introduced to the battlefield. With the exception of oil smoke, high concentrations of smoke generated in closed spaces are extremely dangerous. High concentrations of zinc oxide/hexachloroethane (HC) smoke under these conditions have caused fatalities. Under no circumstances should HC munitions be used indoors or in closed compartments.

In the open air, the air passages should be protected by a respirator if the smoke irritates the airway, if it is very thick or if a stay of longer than 5 minutes in a diluted cloud is necessary. The standard respirator gives the respiratory tract and eyes adequate protection against all smokes and should always be worn when smokes are used in confined spaces. However, it will not protect against carbon monoxide, a common by-product of smoke generation.

Zinc Oxide/Hexachloroethane (HC) Smokes

Several methods of producing smoke by dispersing fine particles of zinc chloride have been developed. The mixture in common use contains zinc oxide and hexachloroethane. Upon burning, the mixture produces zinc chloride, zinc oxychlorides and HCl vapour which rapidly absorb moisture from the air to form a greyish white smoke. HC mixtures can be dispersed by several methods, including grenades, candles, smoke pots, cartridges, and air-delivered bombs.

Protection

Some countries require the use of a respirator whenever HC smokes are used.

Clinical-Pathological Effects

Toxicity

The production of grey-white smoke clouds is based on the reaction between powdered zinc or zinc oxide and hexachloroethane at the point of combustion of the pyrotechnic mixture. The reaction produces a number of compounds including zinc chloride and zinc oxychloride. Phosgene may also be produced although the concentration in the cloud is likely to be low. Other intermediates and products may include hydrogen chloride, tetrachloroethylene, carbon tetrachloride and carbon monoxide. Many of these products and intermediates have been implicated in the toxic reactions seen following exposure to such smokes but experimental studies clearly indicate that zinc chloride and oxychloride inhalation produce a pattern of pulmonary injury that is identical to that seen following smoke inhalation.

Acute Effects

In high concentration or following prolonged exposure, HCE smoke is highly irritating and generalised chemical pneumonitis has been reported following accidental overexposure of human subjects. Symptoms following inhalation of high concentrations of HCE smoke include dyspnoea, hoarseness of the voice, retrosternal pain, cough, lacrymation and occasionally haemoptysis. In many cases reported in the literature, the latter development of pulmonary oedema has been a consistent finding.

Chronic Effects

Following the resolution of the initial pulmonary inflammatory reaction and oedema, there is evidence of several additional chronic effects following inhalation of HCE smoke. These include focal atelectasis, bronchiolar-alveolar hyperplasia and pulmonary fibrosis. More recently, concerns have been raised regarding the possible mutagenicity/carcinogenicity of some of the components of the smoke, and in particular unburnt hexachloroethane and tetrachloroethylene. Studies of both *in vitro* and *in vivo* unscheduled DNA synthesis have, however, confirmed an overall lack of genotoxic effects in smoke condensates.

Treatment

The casualties should put on their respirator or be removed from the source of exposure.

Oxygen should be administered in cases of hypoxia. Bronchospasm should be treated appropriately. Early steroid therapy has been considered efficacious by some and when used, should be given in high doses. Adequate analgesia is recommended.

Prognosis

The prognosis is related entirely to the extent of the pulmonary damage. All exposed individuals should be kept under observation for 8 h. Most individuals recover in a few days. At moderate exposures, some symptoms may persist for 1 to 2 weeks. In severe exposures, survivors may have reduced pulmonary function permanently if pulmonary fibrosis results. The severely exposed patient may progressively develop pulmonary oedema, resulting in dyspnoea, cyanosis and possibly death.

Chlorosulphonic Acid (CSA)

Chlorosulphonic acid (CSA) is a heavy, strongly acidic liquid which, when dispersed in air, absorbs moisture to form a dense white fog consisting of small droplets of hydrochloric and sulphuric acids. In moderate concentrations it is highly irritating to the eyes, nose and skin. The respirator should be worn in all concentrations which are sufficient to cause any cough, irritation of the eyes or prickling of the skin. A risk exists when CSA comes in contact with water due to the generation of intense heat and the scattering of acid in all directions. It is highly corrosive and careful handling is required.

Symptoms

The symptoms are usually limited to a prickling sensation of the skin. Exposure to high concentrations or long exposures to lower concentrations (such as may occur in the field), may result in severe irritation of the eyes, skin and respiratory tract. Conjun-ctival irritation and oedema, lachrymation and mild photophobia may occur. Mild cough and soreness in the chest and moderate chemical dermatitis of the exposed skin are occasionally seen. Splashes of liquid in the eye are extremely painful and cause acid burns with corneal erosions. Liquid CSA solution on the skin may cause painful acid burns.

Treatment

Eye

The contaminated eye should be irrigated with water or saline as soon as possible, and the cornea examined for erosion by staining it with fluorescein. If corneal erosion is present, the casualty should be transferred to the care of an ophthalmologist. If this is not practicable, mydriasis should be induced by the use of atropine sulphate eye drops or ointment. Conjunctival lesions should heal readily, but corneal erosions may lead to residual scarring.

Skin

Irritated skin or skin burns should be washed with water and then with sodium bicarbonate solution; the burns should then be treated as thermal burns.

Prognosis

The skin burns, conjunctival lesions and respiratory irritation heal readily. Corneal erosions are more serious and may lead to residual scarring.

Titanium Tetrachloride (FM)

This is a yellow non-inflammable and corrosive fluid which on contact with damp air gives off a heavy dense white cloud. It is disseminated by aircraft for the production of vertical smoke curtains extending down to ground and sea level. The smoke consists of fine particles of free hydrochloric acid and titanium oxychloride. The smoke is unpleasant to breathe. Goggles or a respirator should be worn when the spray is falling due to the risk of droplets entering the eyes. Full protective clothing should be worn when handling the liquid to avoid contamination of eyes and skin.

Mode of Action

Liquid FM produces acid burns of the skin or eyes.

FLAME MATERIALS AND INCENDIARIES

Introduction

Incendiary weapons are used for antipersonnel and antimateriel operations and military operations in urban territory. An incendiary agent is a chemical, or mixture of chemicals, that liberates a large quantity of heat upon combustion. The reaction is that of a fuel with oxygen; the oxygen incorporated into the agent in the form of an oxidizing agent or drawn from the air.

Incendiary agents can be classified according to their composition:

- hydrocarbon fuels with or without thickeners - normally gasoline with a napalm aluminum soap thickener (mixed aluminum soap co-precipitated from a mixture of coconut oil and oleic and naphthenic acids) with or without polymer thickeners.
- metal fuels (magnesium incendiaries, thermite or thermate incendaries).
- hydrocarbon-metal fuel combinations.
- pyrophoric aluminum alkyls with thickeners (e.g. triethylaluminum thickened with polyisobutylene).
- white phosphorus.
- experimental or improvised compositions.

Thickeners are added to fuels to increase the range of flamethrowers, to impart slower burning properties, to impart clinging qualities and to cause flames to rebound off surfaces and go around corners.

Management

The principal action of flame and incendiary weapons is to cause burns. Casualties should be treated as burn casualties not as chemical casualties.

Red and White Phosphorous

Introduction

At ordinary temperatures, white phosphorus (WP) is a solid which can be handled safely under water. When dry, it burns fiercely in air, producing a dense white smoke. Fragments of melted particles of the burning substance may become embedded in the skin of personnel close to a bursting projectile. The burns are multiple, deep and variable in size. The WP fragments continue to burn unless oxygen is excluded by flooding or smothering.

WP may be used to produce a hot dense white smoke composed of particles of phosphorus pentoxide which are converted by moist air to droplets of phosphoric acid. The smoke irritates the eyes and nose in moderate concentrations. Field concentrations of the smoke are usually harmless although they may cause temporary irritation to the eyes, nose or throat. The respirator provides adequate protection against white phosphorus smoke.

In an artillery projectile, white phosphorus is contained in felt wedges which ignite immediately upon exposure to air and fall to the ground. Up to 15% of the white phosphorus remains within the charred wedge and can re-ignite if the felt is crushed and the unburned white phosphorus exposed to the atmosphere.

Red phosphorus (RP) is not nearly as reactive as white phosphorus. It reacts slowly with atmospheric moisture and the smoke does not produce thermal injury, hence the smoke is less toxic.

Self Aid

If burning particles of phosphorus strike and stick to the clothing, contaminated clothing should be removed quickly before the phosphorus burns through to the skin. If burning phosphorus strikes the skin, the flame should be smothered with water, a wet cloth, or mud. The phosphorus should be kept covered with the wet material to exclude air until the phosphorus particles can be removed. The phosphorus particles may be removed with a knife, bayonet, stick or other available object. It may be possible to remove some particles by rubbing with a wet cloth.

Medical Aid

At the earliest opportunity all phosphorus should be removed from the skin and placed in a container to prevent further contamination and secondary injuries. The affected part should be bathed in a bicarbonate solution to neutralise phosphoric acid; this will then allow removal of visible phosphorus - remaining fragments will be observed in dark surroundings as luminescent spots.

Some NATO nations recommend washing the skin with a 0.5-2.0% copper sulphate solution; wounds may be rinsed with a 0.1%-0.2% copper sulphate solution. Dark coloured deposits may be removed with forceps. Prolonged contact of any copper sulphate preparations with the tissues should be avoided by prompt, copious flushing with water or saline - there is a definite danger of copper poisoning. It may be necessary to repeat the first aid measures to completely remove all phosphorus.

The burn should be debrided promptly (if the patient's condition will permit) to remove pieces of phosphorus which might be absorbed later and possibly produce systemic poisoning. An ointment with an oily base should not be applied until it is certain that all phosphorus has been removed. Further treatment should be carried out as for thermal burn.

If the eyes are affected, treatment should initially be commenced by irrigation with a 1% solution of copper sulphate or sodium bicarbonate 5%, followed by repeated lavage using water or saline. The lids must be separated and a local anaesthetic instilled to aid in the removal of all embedded particles. In eyes with severe ulceration and once all particles have been removed, a mydriatic should be instilled. The patient should be transferred to the care of an ophthalmologist as soon as possible.

Further Reading - Smokes

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