

## CHAPTER 8

## SMOKES, FUELS, AND INCENDIARY MATERIALS

## SECTION I - SMOKES

**801. Introduction.**

- a. Smokes are used to hide troops, equipment and areas from detection by obscuring vision. The smokes consist of small solid or liquid particles which become hydrated in contact with air and intercept or diffuse the light.
- b. Most smokes are not hazardous in concentrations which are useful for obscuring purposes. However, exposure to heavy smoke concentrations for extended periods, particularly if near the source of emission, may cause illness or even death. Medical personnel should, therefore, be prepared to treat potential reactions to military smokes once such smokes have been introduced to the battlefield. Except with oil smoke, high concentrations of smoke generated in closed spaces are extremely dangerous. High concentrations of zinc chloride smoke generated under these conditions have caused fatalities. Under no circumstances should zinc chloride munitions be used indoors or in closed compartments.
- c. 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. It will not, however, protect against carbon monoxide.

**802. Zinc Chloride Smokes.**

Several methods of producing smoke by dispersing fine particles of zinc chloride have been developed. The mixture in common use is zinc chloride smoke mixture (HC), which contains hexachloroethane, grained aluminium and zinc oxide. 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 bombs.

**803. Protection.**

Some countries require the use of a respirator to protect the respiratory tract whenever zinc chloride smokes are used.

**804. Clinical-Pathological Effects.**

- a. *Toxicity.* The toxicity of zinc chloride is mainly due to the formation of the strongly acidic HCl, but is also to a lesser extent due to thermal lesions. These are caused by

the exothermic reaction of zinc chloride with water. The acidic HCl vapour causes lesions of the mucous membranes of the upper airways. The damage and clinical symptoms following zinc chloride exposure therefore appear immediately after the start of the exposure. However, damage to the lower airways also occurs and may result in delayed effects. These have been attributed to the presence of fine zinc chloride particles and phosgene.

- b. *Acute Effects.* In high concentrations or with prolonged exposure HC smoke is highly irritating and may be very dangerous when inhaled. Symptoms following inhalation of high concentration of zinc chloride smoke include dyspnoea, retrosternal pain, hoarseness, stridor, lachrymation, cough, expectoration and occasionally haemoptysis. Cyanosis and bronchopneumonia may develop. Due to the irritant and astringent nature of the compound, delayed pulmonary oedema may occur even in the presence of distinct and short-lasting initial symptoms. It is caustic to mucous membranes and can also cause subacute interstitial fibrosis.
- c. *Chronic Effects.* Recent studies of the HC canister and of HC smoke reaction by-product gases indicate the presence of suspected carcinogens. Metal analysis of HC canisters showed, besides zinc, small amounts of cadmium and trace amounts of lead, arsenic and mercury. The by-product gases include chlorinated compounds, phosgene, HCl, carbon monoxide and chlorine. Although zinc chloride, the main constituent, is not felt to be a carcinogenic hazard, certain of the other by-products are known carcinogens in laboratory animals or in humans.

### 805. Treatment.

The casualty should don his or her respirator or be removed from the source of exposure. Oxygen should be administered in cases of hypoxia. Bronchospasm should be treated appropriately as should secondary bacterial infection. Early steroid therapy has been considered efficacious by some and, when used, steroids should be given in high doses similar to those used in the treatment of phosgene exposure and exposure to other lung damaging agents. Adequate analgesia is recommended.

### 806. Prognosis.

The prognosis is related entirely to the extent of the pulmonary damage. All exposed individuals should be kept under observation for 8 hours. 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 for some months after exposure. The severely exposed patient may progressively develop marked dyspnoea, cyanosis and die.

### 807. Chlorosulphonic Acid (CSA).

- a. 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.

- b. A risk exists when chlorosulphonic acid comes in contact with water due to the generation of intense heat and the scattering of acid in all directions. Owing to its highly corrosive nature careful handling is required.

### **808. Symptoms.**

The symptoms are usually limited to a prickling sensation of the skin, but exposure to high concentrations or long exposures to lower concentrations as found in the field, may result in severe irritation of the eyes, skin and respiratory tract. Conjunctival 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 mineral acid burns with corneal erosions. Liquid chlorosulphonic acid solution on the skin may cause painful acid burns.

### **809. Treatment.**

- a. *Eye.* Irrigate the contaminated eye with water or saline as soon as possible. Examine the cornea 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.
- b. *Skin.* Irritated skin or skin burns should be washed with water and then with sodium bicarbonate solution. The burns are then treated as for thermal burns of like severity.

### **810. Prognosis.**

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

### **811. 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.

### **812. Mode of Action.**

Liquid FM produces acid burns of the skin or eyes.

## SECTION II - FLAME MATERIALS

**813. General.**

- a. Incendiary agents are used to burn supplies, equipment and structures. The main agents in this group are thermite (TH), magnesium, white phosphorus (WP) and combustible hydrocarbons (including oils and thickened gasoline).
- b. Chemical fire extinguishers containing carbon dioxide should not be used in confined spaces to extinguish thermite or magnesium types of incendiaries. When carbon tetrachloride is in contact with flame or hot metal, it produces a mixture of phosgene, chlorine, carbon monoxide and hydrochloric acid. The standard respirator with normal canister does not protect against some agents such as carbon monoxide.

**814. Red and White Phosphorus.**

- a. 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 persons close to a bursting projectile, producing burns which are multiple, deep and variable in size. The fragments continue to burn unless oxygen is excluded by flooding or smothering.
- b. 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.
- c. 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.
- d. 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.

**815. Self Aid.**

- a. 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.
- b. If burning phosphorus strikes the skin, smother the flame with water, a wet cloth, or mud. Keep the phosphorus covered with the wet material to exclude air until the phosphorus particles can be removed.
- c. Try to remove the phosphorus particles with a knife, bayonet, stick or other available object. It may be possible to remove some particles by rubbing with a wet cloth.

**816. Medical Aid.**

- a. At the earliest opportunity all phosphorus should be removed from the skin and placed in a container so as to prevent further contamination and secondary injuries. The affected part should be bathed in a bicarbonate solution to neutralise phosphoric acid, which then allows removal of visible phosphorus. Remaining fragments will be observed in dark surroundings as luminescent spots.
- b. Some nations recommend washing the skin with a 0.5-2.0% copper sulphate solution or a copper sulphate impregnated pad. Wounds may be rinsed with a 0.1%-0.2% copper sulphate solution, if available. Dark coloured deposits may be removed with forceps. Prevent prolonged contact of any copper sulphate preparations with the tissues by prompt, copious flushing with water or saline, as there is a definite danger of copper poisoning. It may be necessary to repeat the first aid measures to completely remove all phosphorus.
- c. The burn should be debrided promptly, if the patient's condition will permit, to remove bits 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.
- d. 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 anesthetic instilled to aid in the removal of all embedded particles. In eyes with severe ulceration once all particles have been removed, atropine should be instilled. The patient should be transferred to the care of an ophthalmologist as soon as possible.

**817. Thermite.**

Thermite incendiaries are a mixture of powdered aluminium metal and ferric oxide and are used in bombs for attacks on armoured fighting vehicles. Thermite burns at about 2000°C and scatters molten metal, which may lodge in the skin producing small multiple deep burns.

**818. Treatment.**

The wound should be cooled immediately with water and the particles removed. Afterwards the treatment is that used for other thermal burns.

**819. Magnesium.**

Magnesium (Mg) burns at about 2000°C with a scattering effect similar to that of thermite. Its particles produce deep burns. Healing is slow unless these particles are removed quickly. Removal is usually possible under local anesthesia. When explosive charges have been added to a magnesium bomb, the fragments may be embedded deep in the tissues, causing the localised formation of hydrogen gas and tissue necrosis.

### SECTION III - HYDROCARBON FUMES

#### 820. General.

- a. Fuels consist largely of hydrocarbons which may have a narcotic effect. In this respect, because of their lower volatility, diesel and paraffin (kerosene) fuels are less dangerous than petrol (gasoline).
- b. Fumes from the combustion of these fuels in internal combustion or jet engines contain a proportion of carbon monoxide, nitrous fumes, etc., which varies with the characteristics of the engine and the rate at which it is being run. The overheating of lubricant oils may result in the production of acrolein which is an aldehyde with intense irritant properties. A concentration of  $5 \text{ mg.m}^3$  is immediately detectable by odour but a concentration of  $50 \text{ mg.m}^3$  causes death in a short time from pulmonary oedema.

#### 821. Physical and Chemical Properties.

Petrol, diesel and paraffin vapours are heavier than air and as a result of this may be encountered in fuel tanks, in vehicles or in spaces where fuels have been stored. As far as their chemical properties are concerned, the hydrocarbons are inert, except when in an oxidising atmosphere, which is capable of supporting combustion.

#### 822. Protection.

Although respirators provide full protection against these hydrocarbon fumes, there is a significant hazard from combustion products in confined spaces due to the presence of asphyxiant gases, e.g., carbon monoxide. In this case, self contained breathing apparatus is required.

#### 823. Mechanism of Action.

Hydrocarbon fumes are preferentially absorbed into lipid rich tissue, for instance, the central nervous system. Their action is narcotic and they produce unconsciousness and death in concentrations over 1% (10,000 ppm) in the case of petrol fumes. The exact dangerous concentrations depend on the volatility of the hydrocarbons in question, and on their aromatic content. Swallowed fuels produce unconsciousness, and permanent brain damage has been reported. Aspiration pneumonia may follow as a complication.

#### 824. Signs and Symptoms.

- a. Drowsiness and unconsciousness proceeding to death are encountered in severe poisoning. Less severe exposures may cause dizziness, headache, nausea, vomiting and muscular incoordination. Acute emotional disturbances following hydrocarbon poisoning have been reported.
- b. Lead poisoning from tetraethyl lead additives is very rare except among those who manufacture blended fuels. The risk of leucopenia has also been reported, in particular from workers using the aromatic hydrocarbon benzene.

**825. Treatment.**

Removal to fresh air is the only treatment necessary in cases of mild exposure. When severe poisoning has occurred, oxygen should be administered and positive pressure ventilation may be required.

**SECTION IV - INCENDIARY DEVICES - COMBUSTIBLE HYDROCARBON  
INCENDIARIES****826. Introduction.**

Burns may be produced by flame-throwers, oil incendiary bombs which may also contain phosphorus and sodium, and fire bombs containing thickened gasoline. Lung damage from heat and irritating gases may be a complication added to the injuries from incendiaries, especially in confined spaces.

**827. Flame-Thrower Attack.**

As flame and burning fuel fills an enclosed fortification, the oxygen content of the air is reduced and a hot toxic atmosphere containing large amounts of carbon monoxide, unburned hydrocarbons and smoke is produced. The coolest and least contaminated air is found at floor level.

**828. Casualties.**

Deaths may occur during or shortly after a flame attack due to the heat, the toxic atmosphere or suffocation caused by laryngeal or glottic oedema. Survivors may have thermal burns of the skin and upper respiratory tract, as well as pulmonary damage from the hot gases.

**829. Protection.**

The floor level is the safest area during a flame attack. Any kind of cover affords some protection from heat. A wool blanket is excellent. The mask may give partial protection against smoke.

**830. Treatment.**

Casualties should be removed to fresh air as soon as possible. Assisted ventilation (using oxygen, if available) should be administered if breathing has ceased. Burns of the skin are treated as thermal burns. If there are burns about the face, laryngeal burning with subsequent oedema-producing respiratory obstruction may occur, so that intubation, tracheotomy or cricothyroid cannulation can be performed in an emergency. The general treatment of the casualty produced by flame attack does not differ from the treatment of one with extensive thermal burns.

**831. Fire-Bomb Attack.**

A fire-bomb is a large tank containing thickened (gelled) gasoline that is air dropped. When it strikes the ground, the fuel is ignited by phosphorus igniters and a large fireball of intense heat is produced, lasting about 4 to 6 seconds. Also, a wide area of ground is covered with burning thickened gasoline, which may continue to burn for as long as 10 to 12 minutes.

**832. Casualties.**

Deaths may be caused by the intense heat or by suffocation from oedema of the larynx or glottis. Thermal burns of the skin and upper respiratory tract may occur in the survivors. Danger from a toxic atmosphere is small in fire-bomb attacks in an open or in a well-ventilated enclosure.

**833. Treatment.**

Burning clothing should be removed or the flames smothered. In general, treatment is similar to that used after flame-thrower attacks.