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TREATMENT OF CASUALTIES FROM CHEMICAL AGENTS

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TREATMENT OF CASUALTIES FROM CHEMICAL AGENTS

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SECTION I

GENERAL

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1. General.—*a.* Until the introduction of chemical warfare, the weapons of war depended almost entirely for their effect on the force with which they hit enemy personnel or matériel. In contrast to this, chemical warfare agents need no terminal momentum or explosive force to produce their full effect but have only to come into bodily contact with personnel in either gaseous, liquid, or particulate form.

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Gas can penetrate into dugouts, emplacements, trenches, and similar locations which are protected from gunfire. The targets are groups and areas rather than individuals, and heavy concentration of chemicals is employed. Casualties, therefore, do not occur singly but may be expected in large numbers when they occur.

b. Chemical warfare agents are used to produce casualties among personnel and animals, to contaminate food and matériel, and to contaminate areas to deny their use to the enemy. It may be necessary to discard contaminated food because of the injurious effect its consumption may have on personnel. Incendiary agents will set fire to combustible material and produce heat burns on personnel.

c. In contrast to the first World War, because of the introduction of the airplane into chemical warfare, casualties may be expected in reserve and rear areas as well as in forward areas. Casualties in rear areas may be expected especially at ports, airfields, rail centers, and along lines of communication.

d. A greater use of persistent agents in heavy concentrations will probably be made to neutralize or force evacuation of areas. If these areas must be crossed or evacuated under heavy fire, troops will be kept close to the ground and in contact with the chemical agent and very high casualty rates will probably result.

e. Heavy concentration of nonpersistent agents will probably be employed against such targets as regimental or brigade reserve areas and other units deep within divisional areas.

f. Medical installations are subject to chemical attack, exactly as are other military establishments similarly located—chiefly mixed chemical agents from artillery fire, and vesicant and incendiary agents from airplanes. Necessary precautions for individual and collective protection should therefore be taken well in advance of possible attacks.

g. The medical officer should be familiar with manuals FM 3–5 and FM 21–40.

2. Classification.—Chemical agents are classified according to physiological action, persistency, and tactical use.

a. Classification by physiological action.—(1) *Lung irritant.*—An agent which, when inhaled, causes primarily irritation and damage the respiratory tract. *Example:* phosgene.

(2) *Vesicant.*—An agent which, on contact with the skin, produces erythema, blistering, or necrosis of the skin. Vesicant vapors act the respiratory tract like lung irritants. *Example:* mustard.

(3) *Lacrimator.*—An agent having its most pronounced action on the eyes, causing a copious flow of tears and intense, though temporary, eye pain. *Example:* chloracetophenone.

(4) *Irritant smoke or sternutator.*—An agent usually disseminated as an extremely fine smoke and which when inhaled, causes sneezing, coughing, lacrimation, headache, and nausea, all these effects adding up to produce temporary physical prostration. *Example:* diphenylaminechlorarsine (adamsite).

(5) *Systemic poison.*—An agent which, on absorption into the blood stream, directly interferes with physiological processes, such as utilization of oxygen by the body. *Example:* hydrocyanic acid.

(6) An agent may act on the body in more than one way, that is, mustard vapor when inhaled is a lung irritant, and when in contact with the skin is a vesicant.

b. Classification by persistency.—The length of time an agent will maintain an effective concentration in the air at the point of release is called the persistency of that agent.

(1) *Persistent agent.*—An agent which, under average conditions, produces effective concentrations for longer than 10 minutes. *Example:* mustard.

(2) *Nonpersistent agent.*—An agent against which, under average conditions, no protection is required after 10 minutes. *Example:* phosgene.

c. Classification by tactical use.—(1) *Casualty agent.*—An agent which, in the commonly used concentrations, will produce casualties among enemy personnel. *Example:* mustard.

(2) *Harassing agent.*—An agent used to force the wearing of masks and thus slow up enemy operations. *Example:* irritant smokes.

(3) *Screening agent.*—An agent which produces a dense obscuring smoke in air to deny hostile observation. *Example:* white phosphorus.

(4) *Incendiary.*—An agent which upon ignition generates sufficient heat to ignite combustible matériel with which it comes in contact. It may produce casualties due to heat burns.

3. Fundamentals of treatment.—*a.* Prophylactic measures are most important in reducing the incidence of casualties. Immediate treatment following exposure is usually much more beneficial than therapeutic measures applied after symptoms of injury appear. Preventive treatment is often specific but its effectiveness will depend upon the promptness of application.

b. The symptomatic treatment applied after injury has been produced is usually quite different from the specific prophylactic treat-

ment, and usually does little to prevent further damage. In general, the definitive treatment of injuries caused by chemical agents does not differ from that of similar conditions occurring from other causes; for example, the aftertreatment of a skin lesion caused by mustard is the same as that for any ulcerative lesion of the skin of like degree.

SECTION II

LUNG IRRITANTS

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4. General.—*a.* Most of the toxic agents are lung irritants to some degree. With certain of these, however, under concentrations encountered in the field, the power to produce lung irritation is their main characteristic. These primary pulmonary irritants are phosgene, chlorpicrin, and chlorine.

b. With all lung irritants a latent period of from 1 to 12 or more hours may intervene after exposure to phosgene and is likely to be longer than 12 hours, but it may be absent or very short after exposure to high concentrations of chlorine. During the latent period may be difficult to determine whether exposure has occurred. Common knowledge of the existence of the latent period may be a source of malingering. The fact that cigarette smoke is unpalatable, even during the latent period, may be of help in detecting malingering.

c. The most serious effect is pulmonary edema, which may be caused by any of the agents listed above. It is produced by irritation of the bronchioles, alveoli, and the adjacent capillary endothelium, and results in a tremendous out-pouring of fluid into the alveoli. Clinically this is manifested by decreased expansibility of the lungs, increased density (which may not be revealed by percussion note or transmission of breath or voice sounds), and the presence of various moist rales. Physiologically, pulmonary edema seriously interferes with the gaseous exchange in the lung and leads to anoxemia. Moreover, the edema, changes in the capillary wall, local thrombosis, and the increased viscosity of the blood all interfere with the circulation through the lung and add to the anoxemia. If this interference with the circulation is maintained, circulatory collapse may ensue.

d. The question may arise as to whether troops exposed to a lung irritant are to continue in combat during the latent period, at the risk of precipitating pulmonary edema, or to be evacuated immediately and placed at absolute rest. Decision must rest with the responsible field commander, but the surgeon should advise him of the additional hazards involved, so that all factors may be considered in making his decision. Similar action with regard to animal casualties is indicated.

e. Nitric oxides, generated by high explosives in shell holes and dugouts are also lung irritants and require the same treatment.

f. The service gas mask and collective protectors offer adequate protection in the field.

5. Phosgene (CG).—*a. Pathology.*—Since field concentrations of phosgene may be breathed without immediate irritation, the whole respiratory system is exposed. The effects are predominantly in the alveoli and bronchioles, the upper respiratory tract being little affected. Alveolar walls and capillaries are rendered more permeable, and the alveoli fill with fluid. Capillary thrombosis and hemorrhages may occur. Hemoconcentration results from the pulmonary edema. The skin is unaffected, but the eyes may show a mild conjunctival irritation. Retinal hemorrhages may occur secondary to anoxemia. Pulmonary edema, right-sided heart failure, and general circulatory collapse are the chief causes of death.

b. Symptoms.—There may be no respiratory symptoms until pulmonary edema develops suddenly. This latent period may last 6 to 24 hours and may be very deceptive because the individual may not realize that he has been gassed. Hence, he may not receive early enough the rest he requires. Physical examination of the chest at this stage may be negative. Sometimes there is a gradual development of symptoms with redness of the eyes, flushing of the face, increased respiration, and occasionally a painful cough. Transient nausea and vomiting may occur. In more severe cases the patient may develop flushing of the face and coughing followed rapidly by a deep cyanosis with engorgement of the neck veins (the blue type of asphyxia). He becomes very uncomfortable, coughing frequently with the production of bloody, frothy sputum. Even with the pulmonary edema and failure of the right side of the heart, the chest examination may or may not show changes in the percussion note; the breath sounds and voice sounds are not intense; fine rales may be heard over the back and sides and in axillae; and rough rhonchi over the upper chest. During this stage the patient may suddenly or gradually develop cardiac failure manifested by a grayish leaden hue of the skin, collapse of the neck veins, and cold, clammy skin (gray

type of asphyxia). He may simulate a shock case, his color, however, appearing more greenish gray than in the usual shock patient. this gray type of asphyxia, the chest examination may yield the same findings as occur with the blue type of asphyxia. The blood pressure, however, is lower and the heart sounds usually less intense. Instead of passing through the blue stage, the patient may suddenly into the gray stage immediately after the latent period. He may die during the gray period or some days afterward with a secondary broncho-pneumonia. If recovery occurs from the acute phase, he will weak and dyspneic, and because of his exhausted condition absolute rest must be continued. Phosgene produces only a mild irritation on the eye, which will clear uneventfully on symptomatic treatment.

c. Diagnosis.—Diagnosis is made from the history of exposure or the sudden onset of symptoms occurring some hours after exposure.

d. Immediate treatment.—(1) *General.*—Treatment must be started as soon as any symptoms of phosgene poisoning appear. This consists of absolute rest, application of heat (blankets, warmth, and hot drinks), inhalation of oxygen, and venesection in the "blue" cases. Even though rest may appear unnecessary, it is essential. Alcoholic drinks should not be used. Morphine should never be given. Restlessness and apprehension may be combated with guarded doses of the barbiturates, but the relief afforded by oxygen inhalation is the best means of quieting and reassuring the patient.

(2) *Oxygen therapy.*—Anoxemia should be relieved by the administration of oxygen as soon as pulmonary edema develops. Mixture of helium with the oxygen offers no advantage, since the difficulty is not bronchial obstruction but the filling of alveoli with fluid. Mixture of carbon dioxide with the oxygen is likewise not indicated since there is no decrease in the carbon dioxide of the blood. Oxygen administration should be started as soon as pulmonary edema develops. This is best accomplished by means of an efficient nasal mask. Oxygen administration for 3 or 4 minutes out of every 15 may suffice, provided this treatment is continued night and day as long as cyanosis tends to recur. The relief of cyanosis is the best criterion by which to regulate the supply of oxygen. When a nasal mask is not available, oxygen may be given by nasal catheter, or the less efficient funnel technique. If the supply of oxygen is limited, it should be reserved for the severe cases.

(3) *Venesection.*—Because it can be easily performed under field conditions, bleeding is valuable therapy for the cyanotic or blue stage of phosgene poisoning, but *it should never be employed in the gray*

or collapsed stage. Four hundred to six hundred cubic centimeters of blood should be withdrawn upon the appearance of cyanosis; another 500 cubic centimenters may be removed 6 hours later, and the procedure repeated once more if necessary. A large bore needle should be used unless the viscosity of the blood makes direct incision of the vein necessary.

e. Further treatment.—Absolute rest must be continued for some time after the acute respiratory symptoms disappear. Resumption of exercise should be undertaken very gradually, care being taken to avoid fatigue or exhaustion. At first, toilet privileges may be granted, then the patient may be allowed to sit up for brief intervals in a chair. Alternate walking and resting for short periods is the next step. Later the convalescent should march short distances and the point at which dyspnoea develops determined. Malingering should be ruled out by objective signs. Broncho-pneumonia is an uncommon complication and is more likely to occur in the first few days than during convalescence, and it is treated as broncho-pneumonia from any other cause. If anesthesia is required for surgical procedure, local infiltration or nerve block are the methods of choice (see par. 37).

f. Therapy contra-indicated in lung irritant casualties.—(1) The use of morphine and alcohol is contra-indicated as they increase the immediate mortality from phosgene.

(2) Atropine is of no value in diminishing or preventing edema, and its acceleration of the heart rate renders its use deleterious.

(3) Blood plasma is of no value in therapy of this type of edema, and concentrated plasma is definitely harmful.

(4) Expectorants have no place in the treatment of acute phosgene edema, though they may be helpful in the convalescent period.

(5) The sulfonamide drugs should not be administered during the first 24 hours after gassing as they may increase the initial mortality. A temperature rise after 24 hours justifies their use.

(6) Cardiac and respiratory stimulants such as adrenalin, ephedrine, coramine, and metrazol probably do more harm than good in the stage of pulmonary edema.

(7) Surgery, except emergency measures to save life, is contra-indicated in the active stage of pulmonary edema.

g. Prognosis.—Prognosis should always be guarded because of the insidious nature of the poisoning. The milder cases always recover. Most deaths occur within the first 24 hours. The prognosis is worse in the pallid or gray than in the blue cases. Later deaths are largely due to broncho-pneumonia. Rarely bronchitis and bronchiectasis are

caused by phosgene poisoning. Psychosomatic (pulmonary) complaints may continue for years.

6. Chlorpicrin (PS).—*a. Pathology.*—(1) Chlorpicrin damages the epithelium of the entire respiratory tract. In the trachea and large bronchi the damage is only slight and recovery occurs fairly rapidly. The medium-sized and smaller bronchi are more severely affected, there being more destruction and necrosis of the epithelium than in either phosgene or chlorine cases.

(2) The changes in the walls of alveoli, the degree of pulmonary edema, the dilated heart, the circulatory collapse, and the anoxemia are all similar to those changes found following phosgene gassing. Edema develops earlier than with phosgene, and edema of the mediastinal tissues is more frequent than in phosgene or chlorine cases. Chlorpicrin vapor may produce conjunctivitis, while the liquid may cause corneal ulceration. Liquid chlorpicrin produces deep skin burns which are prone to become septic. The vapors irritate the skin and abrasions tend to become secondarily infected and are slow to heal. An acute nephritis may follow exposure to this agent.

b. Symptoms.—Chlorpicrin is a strong lacrimator though less effective than the true lacrimators, and the flow of tears is the first symptom noted. It is the most irritant member of this group. Pain in the chest, paroxysmal attacks of coughing, abdominal discomfort, and violent attacks of vomiting are more marked than in phosgene or chlorine casualties, and persistent for a long time after removal from the contaminated area. Exposure to very high concentrations may rarely cause unconsciousness and sudden death. In severe cases muscular weakness is marked. This is accompanied by weak, rapid, and irregular heart action. Frequent exposure to small doses may lead to an increased susceptibility, making such individuals liable to nocturnal attacks of asthma when exposed to traces of chlorpicrin. Pulmonary edema causes symptoms similar to those found in phosgene.

c. Diagnosis.—The cardinal points are history of exposure; symptoms referable to the eyes, nose, and lungs; nausea and vomiting; characteristic stinging flypaper odor on clothing.

d. Treatment.—The therapy in general is the same as for phosgene. If hot drinks aggravate the nausea and vomiting they should be withheld temporarily. The eyes may be irrigated with 2 percent sodium bicarbonate solution or plain water, and the pain relieved by eye and nose drops. Irritation and congestion of the nose may be

similarly treated. Steam inhalations of compound tincture of benzoin and menthol relieve the irritation and allay the cough. Codeine may be used when the cough cannot be controlled by other measures. Following the acute stage and when bronchitis develops, expectorant cough mixtures are indicated. Broncho-pneumonia may develop on or after the second day and is treated as other broncho-pneumonia.

e. Prognosis.—Increasing cardiac embarrassment and progressive hemoconcentration indicate a bad prognosis. A good cardiac response and a falling hemoconcentration indicates that the peak of the pulmonary edema has been passed and that the prognosis is good. The majority of deaths occur during the first 24 hours. Late deaths are due to broncho-pneumonia, purulent bronchitis, and lung abscess. Little permanent disability results. A few cases develop cardiac neurosis and emphysema.

7. Chlorine (Cl).—*a. Pathology.*—There is a marked irritation of the upper respiratory tract, trachea, and bronchi, which may progress to extensive necrosis of the mucous membrane of the trachea and bronchi. With equal exposure, chlorine produces less alveolar damage than phosgene, probably because of its greater solubility in the moisture of the upper air passages and spasmodic closure of the upper air passages preventing the gas from reaching the alveoli. When alveolar damage with pulmonary edema occurs, it is similar to that caused by phosgene.

b. Symptoms.—Chlorine is violently irritating to the upper respiratory tract. Rarely, sudden death may occur after the first inhalation of a very heavy concentration due to reflex action. After exposure to usual field concentrations, the first symptoms are a burning sensation in the throat, violent paroxysmal coughing, and a feeling of suffocation. The signs and symptoms of pulmonary edema then appear, sometimes as soon as 20 minutes after exposure. This stage is like phosgene poisoning, plus a choking cough. Bronchitis may persist for several weeks.

c. Diagnosis.—The cardinal points are history of exposure, odor on clothing, intense irritation of upper respiratory tract with paroxysmal cough, and persistent bronchitis during convalescence.

d. Treatment.—Same as that for chlorpicrin.

e. Prognosis.—Prognosis is poor when pulmonary edema has been established. Chronic bronchitis may be persistent. Some pulmonary emphysema may be permanent. Most patients surviving pulmonary edema ultimately make a complete recovery.

SECTION III

VESICANTS

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8. General.—*a.* While the vesicants are employed primarily for their action on the skin, vesicant vapors function also as lung irritants. Conversely, some other agents not primarily employed to irritate the skin may nevertheless function in this manner, as for example certain of the irritant and screening smokes and lacrimators. There are two forms of blistering agents: those which cause only local irritation and those which cause local irritation plus internal poisoning. These latter compounds usually contain arsenic.

b. Vesicants, more than any other type of chemical agents, will poison food and water and render other supplies dangerous to handle until they have been decontaminated.

c. Contact with casualties contaminated with liquid vesicants will result in vesicant injury to unprotected attendants. Litter bearers moving into dangerously contaminated areas to handle such patients should be protected by protective aprons and heavy rubber gloves. Depending upon the degree of contamination, other protective clothing should be worn (see FM 21–40). Aid station attendants as a rule do not require as complete protection as the litter bearers.

d. Special precautions should be taken for the reception and disposal of vesicant cases in order to guard against exposure of medical personnel. Such cases must not be admitted to confined places until the bulk of the liquid contaminant is removed, since dangerous concentrations of vapor may accumulate. Undressing is best done in the open or on a covered porch. Contaminated litters, blankets, and equipment should also be left outdoors until decontaminated. Contaminated cases must be separated from other patients until decontamination is complete. They should be tended in a separate section of the aid station. Once completely decontaminated they may be hospitalized with other types of patients. The necessity for decontamination of litters and ambulances transporting such casualties should always be borne in mind (see FM 21–40).

e. Knowledge of the type of vesicant used should be obtained from the unit gas officer, local intelligence officer, and arriving patients, since immediate treatment varies with the agent.

f. The service gas mask protects only the face, eyes, and respiratory tract. Protective clothing for skin protection will be issued in the theater of operations (see FM 21–40).

9. Mustard (HS).—*a. Properties.*—Mustard is an oily liquid only slightly soluble in water, but soluble in organic solvents (gasoline, kerosene, acetone, carbon tetrachloride, and alcohol). It is also soluble in animal fats and oils. It is slowly absorbed by rubber gloves and clothing and thus contaminates these articles. It has an odor like garlic or horseradish. It is destroyed only by strong chemicals. It is persistent in the summer, for 4 to 5 days in the open, 1 week in woods; in the winter, several weeks both in the open and in woods. However, after much shorter periods liquid mustard soaks into and partially evaporates from the terrain, and the danger of contamination by liquid practically ceases. The hazard is then largely vapor, and it becomes safe for men to pass quickly through the area in an upright position. A longer time must elapse before it is safe to occupy the area (see par. 5*b*, app. V). Prolonged exposure to a concentration just detectable by odor will produce casualties in man.

b. Pathology.—(1) The rapidity with which skin lesions are produced and the extent and severity are greatly influenced by weather conditions. Vesicle formation is more severe and extensive and occurs more rapidly during hot, humid weather. The typical mustard blister is translucent, has sloping sides, and is surrounded by a zone of erythema. The blister fluid is usually clear and does not coagulate early. Severe exposure, especially to liquid mustard, may produce an annular or doughnut shaped blister arranged about a central whitish indurated area.

(2) The vesicles collapse in about 50 hours. Severe lesions are followed by progressive necrosis into the lower portion of the dermis. Sloughing occurs in about 3 weeks followed by slow healing, leaving a thin scar. Mustard burns are frequently followed by pigmentation which may persist for long periods. There is marked irritation of the nasal passages, trachea, and bronchi followed by edema, shedding of the mucous membrane, and ulceration. This is frequently followed by secondary infection and broncho-pneumonia, which is responsible for the vast majority of deaths. Conjunctivitis is usually present, and corneal ulceration, iritis, and iridocyclitis with exudation into the anterior chamber may occur in severe cases.

c. Symptoms.—(1) Symptoms following exposure are delayed, the latent period depending on the weather, concentration, and individual sensitivity. In personnel unprotected by masks, eye symptoms are generally the first to appear. These may begin 2 or 3 hours after expo-

sure to vapor, at first consisting of a sensation of grit in the eye and lacrimation, then proceeding to acute conjunctivitis. Sneezing and increased nasal secretion are early symptoms. Skin burns from vapor may not appear for 12 or more hours, but may occur within 1 hour after contact with liquid mustard. The first symptom may be severe itching of the skin, followed by a sunburnlike erythema, upon which blisters develop. Shortly before the development of visible blisters, the surface of the reddened skin can be rubbed raw with slight pressure and friction. Upon removal of the skin or vesicle covering, a raw, weeping, exquisitely tender surface is exposed. Because of the depth of skin destruction, mustard lesions require some weeks to heal, and secondary infection is very prone to occur. There is little systemic reaction except with extensive burns or secondary infection. Skin hypersensitivity to mustard may follow repeated exposure. If clothing has been removed soon after exposure to either vapor or liquid drops, little or no burning of the protected areas occurs. However, if the contaminated clothing has been worn for some hours after the exposure, burning of the skin under the clothing may be severe. Areas of thin or moist skin such as the perineum, external genitalia, axillae, elbows, knees, and neck are particularly susceptible. Deep burns are produced by liquid mustard. Mustard blister fluid is not irritating to normal skin.

(2) Vapor concentrations as low as 1:10,000,000 will severely damage the unprotected eye. Mustard burns of the eye closely resemble those due to alkali. The ocular injuries caused by mustard in the first World War have been divided into three groups.

(*a*) Mild conjunctival irritation which will respond to symptomatic treatment in 1 to 2 weeks. (Seventy-five percent of cases.)

(*b*) Severe conjunctival injury, showing horizontal band of white chemosis between the lids, with orange skin roughing of the cornea. Recovery, 4 to 6 weeks. (Fifteen percent of cases.)

(*c*) Corneal erosion detected by the use of 2 percent fluorescein. This group requires base hospital care. Convalescence, 2 to 3 months. (Ten percent of cases.) In casualties due to liquid mustard a greater percentage falls into this group.

(3) Irritation of the upper respiratory tract is shown by hoarseness progressing to aphonia, possibly cough, and later mucopurulent sputum. The cough is usually nocturnal and is likely to be very persistent.

(4) Pain, nausea, and vomiting may follow the ingestion of mustard contaminated saliva. Nausea and vomiting following vapor exposure is usually transient.

d. Diagnosis.—Diagnosis is based upon—

(1) History of exposure.

(2) Mustard or garlic odor on skin and clothing.

(3) Itching of skin with little or no pain at first.

(4) Irritation of conjunctiva.

(5) Erythema of skin followed by blistering, which develops some time after exposure.

(6) Blisters surrounded by zone of erythema (differential diagnosis from lewisite).

e. Prophylaxis.—(1) To be effective, prophylactic measures must be instituted *within a few minutes.* Immediate prophylaxis is effective following liquid contamination, but of little use after exposure to vapor since in this case practically all of the agent has already penetrated the skin. Contaminated clothes must be quickly removed, using the proper precautions. The continued wearing of clothing contaminated with mustard, liquid or vapor, will cause severe burning of the skin. The clothes removed should be segregated until decontaminated. A careful technique must be followed for the removal of liquid mustard from the skin, otherwise such attempts merely serve to spread the agent. Three steps are necessary.

(*a*) *First.*—Dry pads are gently applied to absorb any mustard remaining on the skin. This action is one of dabbing, not rubbing. Fresh pads should be used for each dabbing so as not to spread the agent to uncontaminated areas.

(*b*) *Second.*—The treatment agent is applied. The following four methods of prophylaxis are recommended:

1. Protective ointment.—Protective ointment gives excellent prophylaxis if used properly and immediately. It is to be used by the individual soldier on himself as soon after contamination as possible. A small amount of ointment is squeezed onto a piece of gauze, cotton waste, handkerchief, piece of shirt, or similar material and rubbed vigorously on and around the affected area for 10 to 20 seconds. The ointment is then wiped off. This procedure of applying, rubbing, and removing the ointment is repeated three or four times. With this procedure available to every soldier few cases of contamination with liquid mustard should come to the attention of the medical service, unless the man is a casualty from another cause.

2. Dichloramine-T in triacetin.—Gently and repeatedly dab the affected areas with gauze (or other similar material) moistened with a 20 percent solution of dichloramine-T in triacetin (see par. 6, app. I).

3. Solvents.—Solvents such as gasoline, kerosene, carbon tetrachloride, or alcohol may be used. A very careful technique must be followed. The solvent must not be allowed to run from the contaminated to the unaffected skin as it will carry the vesicant and extend the damage. The sponging material should be dampened but not saturated with the solvent. The cleaning action should be that of dabbing, not rubbing.

4. Hypochlorites.—Products containing active chlorine, such as bleach, H. T. H. (grade A calcium hypochlorite), or sodium hypochlorite (Dakin's solution) may be used. Bleach or H. T. H. may be used as a paste, 1 part to 1 or 2 parts of water. Because of the irritant properties of bleach paste, it must be washed off with water in 3 minutes.

(*c*) *Third.*—Following methods in *2*, *3*, and *4* above, the skin area is washed with soap and water and patted dry. Following method in *1* above, the ointment is washed off with soap and water when the tactical situation permits. The sponging materials contaminated in the process must be burned or buried.

(2) If the hair has been contaminated with liquid mustard, it may be decontaminated by rubbing strong bleach paste (1 part H. T. H. to 1 or 2 parts water) into the hair and washing off the bleach 3 minutes later. Otherwise, the hair must be clipped off. Great care should be exercised in handling mustard contaminated hair to avoid burning the hands of the medical attendant.

(3) Liquid mustard in the eye demands *immediate* irrigation with 2 percent sodium bicarbonate solution, saline, or plain water, continued for 10 minutes. If irrigation cannot be instituted within 5 minutes, it should not be done at all. Washing the eye with water from his canteen should be accomplished by the soldier as a first-aid measure, unless he is in the immediate vicinity of medical aid, since time is the controlling factor. The cap of the canteen may be used as an eye cup. Rubbing of the eye must be avoided. Vapor burns of the eye should not be irrigated.

(4) If mustard has entered the buccal or nasopharyngeal cavities, the mouth should be rinsed and the throat gargled repeatedly with a 2 percent sodium bicarbonate solution or water.

f. Immediate treatment.—(1) *Eye.*—If necessary, eye and nose drops (item No. 91090, Medical Department Supply Catalog) (see par. 8, app. I) or a 2 percent butyn sulfate solution may be instilled to relieve pain. Cocaine should *not* be used since it causes corneal irritation. The eyes should not be bandaged due to the danger of pressure necrosis of the cornea. Infection must be prevented to avoid a bad end result. To accomplish this, 2 drops of an aqueous solution of sodium sulamyd (1 gram per 30 cubic centimeters; see app. I) is instilled into the eye every 2 hours for 48 hours and four times daily thereafter until all acute symptoms have subsided. If the eye is already infected, a double or even a triple strength solution may be used and the frequency of application increased, as indicated. Treatment with atropine should be begun early and continued until healed. A 1 percent solution of atropine sulfate is instilled into the eye once daily. Dark glasses or a brown paper eyeshade (one which shades the eye from above and not a so-called shade which completely covers the eye) may be worn to give relief from photophobia.

(2) *Skin.—Protective ointment or chlorinating agents should not be used after erythema appears as they will increase the irritation.* If the skin has been contaminated with liquid mustard, it should first be treated with solvents by the technique described in *e* above, but vapor burns should not be treated with solvents. Blistered areas should be cleansed gently with soap and water, avoiding breaking of the blisters, and patted dry. Sterile gauze should be dampened with amyl salicylate and placed over the blistered areas. This is then covered with a dry sterile dressing. The itching of areas of erythema may be relieved by the application of pontocain compound ointment (item No. 1K61100), or antipruritic ointments Nos. 71 or 88 (see pars. 2 and 3, app. I).

(3) *Respiratory.*—Nasal pain and irritation may be treated by the instillation of eye and nose drops (item No. 91090).

g. Further treatment.—(1) *Eyes.*—Treatment of the eyes with sodium sulamyd and atropine as indicated in *f*(1) above must be continued. To prevent the eyelids from sticking, liquid petrolatum (heavy), glycerin, acriflavine 1:15,000 in castor oil, or cod-liver oil made alkaline with sodium bicarbonate may be instilled at 4- to 6-hour intervals. Cocaine must *not* be used. Severe cases with corneal involvement, iritis, or marked photophobia should be treated by the ophthalmologist. Dark glasses or eyeshades are useful for photophobia, but should be removed when keratitis and iritis subside to prevent neurasthenic symptoms.

(2) *Skin burns.*—(*a*) Fully developed lesions are treated like burns of equal degree from other causes. Mustard burns are prone to secondary infection; special attention must be given to asepsis. Prior to definitive treatment, denuded areas may be treated with sulfadiazine ointment (5 percent) (Medical Department item No. 14619, 4-ounce tube; or No. 14620, 1-pound jar). Areas except face and genitalia may be covered with sterile dressings.

(*b*) Application of amyl salicylate daily for several days gives immediate analgesia and lessens edema. The application is made either by spraying or by dipping gauze into the drug and applying it to the lesion. Blisters may be evacuated but the top of the blister should not be removed.

(*c*) Burns are thereafter treated as similar lesions from other causes. The usual accepted treatments include cleansing with detergents, debridement, and bacteriostatic ointments, or preparations forming sterile eschars, such as triple dye (par. 16, app. I) or tannic acid (see compound tannic acid powder, par. 5, app. I) and silver nitrate.

(*d*) Pontocaine compound ointment (Medical Department item No. 1K61100) or antipruritic ointments 71 or 88 (pars. 2 and 3, app. I) may be used to control itching.

(*e*) Sluggish lesions may be treated with crude cod-liver oil or cod-liver oil ointment (par. 4, app. I).

(*f*) Infected burns are treated as infected wounds with Dakin's solution, sulfonamide drugs, etc.

(3) *Respiratory.*—The persistent nocturnal cough may last for several weeks and is best treated with codeine.

h. Prognosis.—The death rate from mustard gassing is low. The British rate was 2.2 and the American rate was only 1.75 per 1,000 in the first World War. Nearly all deaths are due to respiratory effects, chiefly broncho-pneumonia. Skin burns heal slowly, severe burns requiring months for recovery. Burns are prone to infection, and infection greatly prolongs the healing time. Mild eye cases recover in 2 to 4 weeks without complication, if secondary infection is prevented. Severe eye cases may require months to heal and leave permanent residual damage. Secondary infection of the eye greatly increases the healing time and residual damage. Nocturnal cough may persist for several weeks and interfere with sleep.

10. Lewisite (M–1).—*a. Properties.*—Lewisite is a liquid, poorly soluble in water but readily soluble in organic solvents (gasoline, kerosene, alcohol, etc.) and animal fats and oils. Crude lewisite has a geraniumlike, stinging odor. With water it hydrolyzes readily to

form an oxide which retains vesicant and systemic poisonous properties and vaporizes very slowly. Lewisite penetrates fabrics and rubber, making it dangerous to wear clothing or ordinary rubber gloves previously contaminated. It is more volatile and less persistent than mustard, making it more effective in cold weather. The vesicant oxide formed in damp weather or on wet ground may contaminate soil for a long time and produce injury on direct contact with the skin.

b. Pathology.—Skin lesions are produced more rapidly by lewisite than by mustard and blistering and necrosis are more severe. The lewisite blister is more opaque than the mustard blister, is very steep sided, and is surrounded by little or no erythema. Its fluid is vesicant. There may be signs of toxic changes in the viscera; arsenic may be found in all tissues. Inhalation produces ulceration of the upper respiratory tract and secondary broncho-pneumonia may follow. Liquid lewisite in the eye causes marked chemosis of the conjunctiva, ulceration of the cornea, and marked iritis. The deep involvement of the cornea often leads to its rupture with subsequent phthisis bulbi. Blood vessels invading the cornea are straight and brushlike, in contrast to the tortuous vessels of the mustard lesion.

c. Symptoms.—(1) Symptoms develop earlier and are more severe than with mustard. Conjunctivitis, sneezing, and nasal irritation may occur but the irritating vapor will compel wearing of the gas mask so that few cases will occur. Stinging pain is felt by most people immediately on contact of liquid lewisite with the skin. Erythema develops 5 to 30 minutes after exposure, depending upon the weather conditions, and bullae next appear, reaching their peak in 12 hours or less. At first the contents of the lewisite blisters are more opaque than those of mustard. There is little, if any, erythema around the early vesicle. Arsenical poisoning may occur, manifested by dryness and soreness of the throat, diarrhea, and restlessness; later other structures, such as the liver and nervous system, may show involvement. Lewisite shock closely resembling traumatic shock may follow, in a few hours, a severe lewisite burn.

(2) Liquid lewisite causes instantaneous severe pain on contact with the eye and marked blepharospasm results. Severe eye lesions are produced by even small drops of liquid lewisite. In general, lewisite acts more quickly and more painfully than mustard.

d. Diagnosis.—Diagnosis is based upon the following factors:

(1) History of exposure.
(2) Stinging geraniumlike odor on skin and clothing.
(3) Prompt irritation of eyes and conjunctiva.
(4) Rapid onset of skin injury with pain and blistering.

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(5) Lack of erythema about the early vesicle.
(6) Associated nasal irritation.
(7) Presence of arsenic in the blister fluid.

e. Prophylaxis.—(1) *Skin.*—Prophylaxis against skin contaminations with liquid lewisite should be instituted within 1 minute after exposure, since skin penetration is rapid. Contaminated clothing must be quickly removed with usual precautions and treatment, if possible, started at the same time. The same three steps as for prophylactic treatment of mustard are used, though the specific remedies differ.

(*a*) *First.*—Liquid drops are removed by quickly blotting with dry absorbent material (see par. 9*e* for technique).

(*b*) *Second.*—Neutralization and removal by one of the following methods:

1. Protective ointment.—Protective ointment gives effective prophylaxis if used properly and *immediately*. It is to be used by the individual soldier on himself as soon as possible after contamination. The method is identical with its use for mustard (see par. 9*e*). It should *not* be used after erythema has developed.

2. Hydrogen peroxide.—Eight percent hydrogen peroxide is the best available prophylactic for lewisite skin contaminations; if not available, use U. S. P. 3 percent hydrogen peroxide. Fresh swabs should be used for each application and a careful technique used to prevent increase of the injured area due to careless swabbing.

3. Sodium hydroxide.—A 10 percent solution of sodium hydroxide in 30 percent glycerin (par. 1, app. I) may be used if hydrogen peroxide is not available. The skin should be swabbed alternately with this solution and alcohol. If the glycerin solution is not available, a 5 percent aqueous solution of sodium hydroxide may be used, and water may be used as a less effective substitute for the alcohol.

4. Solvents.—If none of the foregoing materials are available, the same solvents and technique described for mustard (par. 9*e*) may be used.

(*c*) *Third.*—Protective ointment is removed with soap and water when the tactical situation permits. After swabbings described in *2*, *3*, and *4* above, the skin should be thoroughly washed with soap and water. Swabs must be burned or buried.

(2) *Eye.*—Lewisite vapor causes marked injury to the eye but because the irritant vapor compels wearing of the gas mask, few eye casualties from vapor are anticipated. Liquid drops, however, may destroy an eye unless properly treated. Two to four drops of eye solution M–1 must be instilled into a contaminated eye as soon as possible. For maximum effectiveness this solution must be used when and where the injury occurs, by the soldier himself, or he should be treated by the man nearest him. This solution may prevent residual damage if used up to 30 minutes after contamination with lewisite liquid. This solution is of no value for mustard contaminations but *should* be used for contaminations by mixtures of lewisite and mustard and for all other arsenical vesicants. In case of blepharospasm the solution may have to be placed in the inner canthus and allowed to spread over the cornea as best it may. The eye solution M–1 is used once only and is *not repeated*. In the absence of eye solution M–1 the eye must be promptly washed out with water in the manner described for mustard (see par. 9*e*).

f. Immediate treatment.—(1) *Skin.*—For skin burns from lewisite liquid or vapor, 8 percent hydrogen peroxide solution should be freely applied. Itching may be relieved by the application of antipruritic ointments as recommended for mustard (par. 9). If burns are produced by liquid lewisite *and no other treatment is available*, complete excision of the burned area may save life if done within 4 to 6 hours. Multiple scarification of the contaminated area with immediate suction is an alternate procedure with limited application.

(2) *Eye.*—Following prophylactic treatment of the eye with eye solution M–1, the eye is treated as for mustard (see par. 9*f*(1)).

(3) *Systemic.*—Lewisite shock may be treated by measures applicable to traumatic shock.

g. Later treatment.—(1) *Skin.*—Blisters must be treated by draining or removal of the cover to prevent absorption of arsenic from the blister fluid. The blister fluid is vesicant and precautions must be taken to protect surrounding areas. The later treatment does not differ from deep burns from mustard (see par. 9*g*(2)).

(2) *Eyes.*—Later treatment of the eyes is identical with that for mustard (see par. 9*g*(1)).

(3) *Respiratory.*—If pulmonary irritation is present, sulfonamide drugs are indicated as a preventive measure against broncho-pneumonia. Respiratory pain and discomfort may be relieved by measures similar to those employed for chlorpicrin (see par. 6*d*).

(4) *Systemic.*—General measures to combat arsenical poisoning should be instituted in cases with extensive burns. These include

adequate fluid intake, intravenous glucose, high carbohydrate diet, and vitamin intake.

h. Prognosis.—Lewisite is much more dangerous than mustard. Fatal arsenical intoxication may result from an extensive burn. Burns from liquid require longer to heal than vapor burns. With liquid burns of the eyes, the prognosis is serious. Broncho-pneumonia is a dangerous sequel.

11. Ethyldichlorarsine (ED).—*a. Pathology.*—Irritation of the nose, nasopharynx, and lungs occurs. Vesiculation of the skin is less marked than with lewisite or mustard. Arsenical involvement of the viscera and varied post arsenical neuritides may occur. Paronychial swellings of the finger may also be present.

b. Symptoms.—In high concentrations there is immediate irritation of the nose. In lower concentrations the typical nasal irritation may be delayed. When the reaction is delayed until after the gas mask has been put on, the untrained individual may remove his mask, believing it to be inefficient, and will thus get a larger dose of the agent. Other symptoms are sneezing, a burning sensation in the throat, photophobia, lacrimation, nausea, and vomiting, and perhaps blistering of the skin.

c. Diagnosis.—The following factors should be considered in making the diagnosis:

(1) History of exposure.
(2) Pungent odor of skin and clothing.
(3) Intense sternutatory irritant, and early vesicant symptoms.
(4) Disappearance of the nasal irritation within an hour.
(5) Presence of arsenic in the blister fluid.

d. Prophylaxis.—Prophylactic measures must be applied very rapidly but it may be impossible to avoid nasal irritation. Inhalation of low concentrations of chlorine from bleach powder in a wide-mouthed bottle may relieve the respiratory symptoms. Prophylaxis of the skin is identical to that for lewisite (see par. 10*e*(1)). Prophylaxis of the eyes is identical to that for lewisite (see par. 10*e*(2)).

e. Immediate and later treatment.—Treatment in general is the same as that described above for lewisite (see par. 10*f* and 10*g*).

f. Prognosis.—There are usually no serious complications from exposure to ordinary field concentrations, but neurological disturbances and arsenical poisoning may follow exposure to high vapor concentrations or to the liquid. Liquid contamination to the eye may cause blindness unless prompt prophylactic measures are applied.

12. Mixed vesicant agents.—*a. General.*—The use of vesicant agent mixtures may be expected either as premixed agents or as a combination of two agents directed simultaneously on one objective. Such mixtures complicate specific prophylaxis and treatment. Attack first the agent capable of doing the greatest damage, as quickly as possible. It will often be necessary to use more than one therapeutic agent.

b. Treatment of mustard and lewisite mixture.—Lesions produced by a mixture of mustard and lewisite show characteristics of both agents. The area surrounding the site of contact develops an erythema very similar to that of mustard while the vesicle that forms is rather sharply demarked and similar to lewisite. The action of this mixture is rapid and pain will be noticed within 5 minutes after contact with the skin.

(1) *Skin.*—Protective ointment M–4 should be used by the soldier himself as rapidly as possible, as directed in paragraph 9*e*. When available, the use of hydrogen peroxide followed by dichloramine-T in triacetin or protective ointment is considered the treatment of choice. The site of contamination is dabbed repeatedly with swabs moistened (but not dripping) with hydrogen peroxide. This procedure is followed by dabbing the same area with swabs moistened in dichloramine-T in triacetin or by applying the ointment as previously directed in paragraph 9.

(2) *Eyes.*—If the eyes are contaminated, eye solution M–1 should be used immediately, as directed in paragraph 10, followed as soon as possible by thorough irrigation with a 2 percent sodium bicarbonate solution, normal saline or plain water. Eye and nose drops (Medical Department item No. 91090) may be used to relieve pain. Otherwise the treatment is that for mustard, described in paragraph 9.

SECTION IV

LACRIMATORS

Paragraph
Symptoms and treatment 13

13. Symptoms and treatment.—*a.* The more important lacrimators are chloracetophenone (CN), chloracetophenone solutions (CNS and CNB), and brombenzyl cyanide (CA).

b. General symptoms produced by the lacrimators include lacrimation, photophobia, and blepharospasm, also some irritation of the nose and of the freshly shaven face and in hot weather to the moist skin. In addition, chloracetophenone solutions CNS and CNB may

cause some mild papulo-vesicular dermatitis, especially in warm weather, and occasional vomiting. Direct contact of the eyes with these solutions may cause corneal ulceration. Lacrimator cases ordinarily should not come to the attention of the medical service.

c. Treatment.—(1) *Prophylaxis.*—The mask should be put on and rapid breathing maintained to aid removal of the agent from the eyes, which are kept open as much as possible. The eyes should not be rubbed. If liquid or solid agent has entered the eye it should be promptly washed out with water from the canteen.

(2) *Immediate treatment.*—(*a*) *Eyes.*—Lacrimators produce a marked but self-limited irritation of the conjunctiva. When liquid lacrimators are splashed into the eye, the action is corrosive and resembles the burn of a strong acid. The instillation of a solution of sodium sulfite (for eyes) at frequent intervals dissolves and neutralizes the irritating agent. For the formula for the sodium sulfite eye solution, see paragraph 14, appendix I.

(*b*) *Skin.*—For skin burns caused by the lacrimators a 4 percent solution of sodium sulfite in 50 percent alcohol is advised. Do not use this solution in the eyes.

(3) *Further treatment.*—(*a*) *Eyes.*—Eye pain may be treated by instilling eye and nose drops (Medical Department item No. 91090). The further treatment is symptomatic as for other burns of the eye.

(*b*) *Skin.*—The further treatment is the same as for other burns.

Section V

IRRITANT SMOKES (STERNUTATORS)

	Paragraph
General	14
Diphenylaminechlorarsine (DM) (adamsite)	15
Diphenylchlorarsine (DA)	16

14. General.—*a.* The most important irritant smokes are diphenylaminechlorarsine (DM, Adamsite) and diphenylchlorarsine (DA); they produce sensory irritation of the nose, throat, and eyes. Because of delayed action, symptoms may not appear in slightly exposed individuals until after the gas mask has been put on. The uninformed, believing his mask to be inefficient, may then remove it and become a casualty from further exposure to this agent or others accompanying it.

b. Adequate protection against the irritant smokes is afforded by the service gas mask and by collective protectors.

15. Diphenylaminechlorarsine (DM) (Adamsite).—*a. Pathology.*—DM produces local irritation of the nose and nasal accessory sinuses, throat, and eyes.

b. Symptoms.—These consist of pain and a feeling of fullness in the nose and sinuses accompanied by severe headache, followed by sensations of intense burning in the throat and tightness and pain in the chest. Irritation of the eyes and lacrimation are produced. Sneezing is violent and persistent; the nasal secretion is greatly increased and quantities of ropy saliva flow from the mouth. Nausea and vomiting may also occur. Mental depression may be so marked that the individual will have to be restrained forcibly to prevent self-injury.

c. Diagnosis.—This is made from the history of exposure, and the relatively rapid spontaneous improvement which occurs despite the miserable appearance and condition of the individual.

d. Treatment.—The mask must be worn in spite of vomiting and salivation but it may be lifted from the face during actual vomiting. Inhalation of dilute chlorine from bleach in a wide-mouthed bottle is the most effective therapeutic measure. Inhalation of chloroform, ether, or alcohol vapor gives some relief, but is less effective. Aspirin may be given to relieve the headache and general discomfort. Few cases should reach the medical service for treatment since recovery is prompt and the soldier can carry out his battle mission in spite of sternutators.

e. Prognosis.—Ordinarily all symptoms disappear in about 1 or 2 hours, leaving no permanent injury.

16. Diphenylchlorarsine (DA).—The pathology, symptoms, diagnosis, treatment, and prognosis are similar to those of diphenylaminechlorarsine (DM).

Section VI

SCREENING SMOKES

	Paragraph
General	17
White phosphorus (WP)	18
Titanium tetrachloride (FM)	19
Sulfur trioxide-chlorsulfonic acid solution (FS)	20
HC mixture (HC)	21

17. General.—The more important of these agents are white phosphorus (WP), sulfur trioxide-chlorsulfonic acid (FS), titanium tetrachloride (FM), and HC mixture (HC). These smokes are not toxic in field concentrations, but may be dangerous in the heavy con-

centrations formed at the immediate site of dispersion. FS smoke is more irritant and corrosive to the eyes, skin, and respiratory tract than is FM or HC.

18. White phosphorus (WP).—*a. Pathology.*—Particles of burning white phosphorus may produce deep burns of the skin and underlying tissues, but systemic poisoning does not follow such injuries. The smoke is nontoxic.

b. Symptoms.—Skin burns are produced, the phosphorus particles continuing to burn in the tissue until air is excluded by a film of moisture or other material.

c. Diagnosis.—Diagnosis is made from the history of exposure, odor, and burns. Smoking or flaming particles may be present on or in the skin.

d. Treatment.—Smother the burning phosphorus particles immediately with water from canteen, or other noninflammable air-impervious materials. Keep the burn under water until 5 to 10 percent copper sulfate solution can be applied which forms a protective coating on the particles, excluding air. The particles should be removed with forceps or hemostat under water, or in air if the copper sulfate solution has been applied. In addition, all burned surfaces should be kept covered with wet dressings until it is certain that all particles of the agent have been removed. Further treatment is that of ordinary heat burns.

e. Prognosis.—Prognosis is the same as that of any heat burn of like severity.

19. Titanium tetrachloride (FM).—*a. Pathology.*—The liquid produces acidlike burns of the skin and eyes.

b. Symptoms.—Smoke generated by liquid FM is unpleasant to breathe and may cause irritation of the nose and throat, but it is not dangerous. Exposure of the eyes to spray will cause conjunctivitis with lacrimation and photophobia. Acid skin burns are produced by contact with the liquid.

c. Treatment.—The eyes or skin should be washed freely with water and then with 2 percent sodium bicarbonate solution.

d. Prognosis.—No permanent injuries are produced.

20. Sulfur trioxide-chlorsulfonic acid solution (FS).—*a. Pathology.*—Acid burns of skin or mucous membranes are produced by contact with the liquid.

b. Symptoms.—These are usually limited to an irritation of the skin, manifested by a biting and prickling sensation; direct contact with the liquid or concentrated vapor may cause corrosive burns of the skin and eyes.

c. Treatment.—Irrigation of eye burns with water should be instituted at once, followed by flushing with 2 percent sodium bicarbonate solution. Aqueous mercurochrome solution will detect corneal ulceration. If painful, eye and nose drops (Medical Department item No. 91090) may be instilled. Cod-liver oil ointment, castor oil, or yellow-oxide-of-mercury ointment should then be instilled and the injured area covered with a light pad. Skin burns should be washed with water and then with sodium bicarbonate solution; later treatment should be that of ordinary burns.

d. Prognosis.—The prognosis is good except for severe eye burns where the outlook depends on the degree of corneal ulceration.

21. HC mixture (HC).—*a. Pathology.*—Under field conditions there is insufficient absorption of the zinc salts or other components to produce systemic effects.

b. Symptoms.—There are no symptoms other than a slight suffocating sensation from high concentrations of the smoke.

c. Treatment.—None is needed.

d. Prognosis.—There are no lasting effects.

Section VII

INCENDIARY AGENTS

	Paragraph
General	22
Thermite (TH)	23
Combustible oil incendiaries	24
Combustible metal incendiaries	25

22. General.—*a.* The principal agents of this group are thermite (TH), white phosphorus (WP), combustible oil, and combustible metal incendiaries. While used primarily to cause fires, they will produce severe burns if they come in contact with the body.

b. Chemical fire extinguishers using carbon tetrachloride (pyrene) are likely to produce toxic gases, mainly phosgene, when this liquid comes in contact with flame or highly heated metal. In combating incendiaries in inclosed spaces the danger from these byproducts must be kept in mind and the gas mask used if necessary.

c. The treatment of injuries from white phosphorus, which is also a screening smoke, is discussed in paragraph 18.

23. Thermite (TH).—*a. Pathology.*—Very deep burns of the skin and underlying tissues are produced by thermite.

b. Symptoms.—The symptoms are those of deep, exquisitely tender burns.

c. Treatment.—Treatment is that used for any other burn of like degree.

d. Prognosis.—This is the same as that for any heat burn of like degree and extent.

24. Combustible oil incendiaries.—*a. Pathology.*—Deep burns are produced, and inhalation of the combustion gases may cause pulmonary irritation.

b. Symptoms.—The symptoms are those of heat burns produced by fire and hot oil. A productive cough may follow inhalation of the combustion fumes.

c. Treatment.—After the skin has been cleansed, burns should be treated as ordinary burns.

d. Prognosis.—Serious with extensive burns and with pulmonary irritation.

25. Combustible metal incendiaries.—*a. Pathology.*—Deep burns are caused by contact with the hot fragments.

b. Symptoms, treatment, and prognosis.—These are the same as for other heat burns.

Section VIII

SYSTEMIC POISONS

	Paragraph
General	26
Hydrocyanic acid	27
Arsine	28
Hydrogen sulfide	29

26. General.—Systemic poisons produce their injurious effects only after absorption into the body and cause little or no local injury. The most important are hydrocyanic acid, arsine, and hydrogen sulfide. Adequate protection against these gases is afforded by the service mask.

27. Hydrocyanic acid.—*a. Physical properties.*—Hydrocyanic acid is a colorless, highly volatile liquid. Its vapor disperses rapidly in air. It is very soluble in water and alcohol and has an odor of bitter almonds or peach kernels. Aqueous solutions do not turn litmus red.

b. Pathology.—Hydrocyanic acid produces asphyxia by hindering the oxidative processes of the tissues, and depresses and paralyzes the central nervous system, beginning with the medulla.

c. Symptoms.—Following inhalation of high concentrations, vertigo, headache, palpitation, and dyspnoea appear very rapidly, followed shortly by coma, convulsions, and death. Low concentrations may produce headache, vertigo, and nausea.

d. Diagnosis.—The diagnosis is made from the odor of bitter almonds and the rapid onset of symptoms.

e. Treatment.—Under battle conditions, treatment will seldom be practical. The gas mask should be put on as promptly as possible. An amyl nitrite ampoule should be crushed in its cloth container and placed in the gas mask facepiece for 15 to 30 seconds. This is repeated every 3 minutes for three or four times. Meanwhile articificial respiration should be begun and continued until the patient breathes naturally. Sodium nitrite and sodium thiosulfate may be given intravenously. Sodium nitrite should be injected as a 1-percent solution slowly in 10-cubic-centimeter doses to a total of 50 cubic centimeters an hour, and if necessary, epinephrine should be employed against excessive fall of blood pressure. Between the nitrite injections, 20-cubic-centimeter doses of 5 percent sodium thiosulfate should be given intravenously and continued if necessary to a total of 500 cubic centimeters. In place of sodium nitrite, methylene blue may be given intravenously as a 1 percent solution in 1.8 percent sodium sulfate in 50-cubic-centimeter doses to a total of 200 cubic centimeters. If the patient becomes too greatly cyanosed from the methemoglobin produced by this treatment, blood transfusions should be given.

f. Prognosis.—The mortality of acute cyanide poisoning is very high—about 95 percent. Efficacy of treatment is limited by the rapid course of the poisoning and by the gravity of tissue asphyxia. If the patient survives an hour he will generally recover. After effects are rare but may resemble those following carbon monoxide poisoning.

28. Arsine.—*a. Physical properties.*—This is a colorless, inflammable gas. It can be produced by the action of water on the arsenides of calcium, magnesium, or sodium. High concentrations of arsine are accompanied by a garlic or rotten-cabbage-like odor which is due to impurities associated with the gas. Low concentrations are relatively odorless. This odor may vary slightly depending on the source of the agent. Pure arsine is odorless; the possibility exists that its inhalation in concentrations not detectable by odor may cause toxic symptoms.

b. Pathology.—Arsine is rapidly absorbed from the respiratory tract and causes hemolysis of the red blood cells; damage to the erythrocytes occurs almost immediately after exposure as shown by increased fragility to hypotonic saline, but the cells hemolyze over a period of several days. Destruction of red blood cells may be

extreme. The kidney tubules may be filled with casts of hemoglobin and red cell debris. Anuria and uremia may result. Hepatitis is a common complication.

c. Symptoms.—In mild cases there may be lassitude, headache, and malaise. With increased exposure, chills, nausea, and vomiting occur. In severe cases, in addition, prostration, bloated abdomen, weak and rapid pulse, and abdominal pains described as burning and associated with thirst are found; as the hemolysis progresses dyspnoea, oliguria, hemoglobinuria, and later bilirubinuria are observed. A slatelike cyanosis appears shortly after exposure, changing later to the color of hemolytic jaundice. The liver and spleen are swollen and the blood appears laked. A tenderness of the nerves appears at the beginning of the intoxication and from 1 to 4 weeks after the exposure polyneuritis may develop. Anemia appears early in severe cases, the red cell count frequently falling below 2 million. In fatal cases death may be due to anemia, uremia, or to poisoning of metabolic catalysts; all three factors are no doubt interrelated.

d. Diagnosis.—The diagnosis is made from the history of exposure, anemia, hemoglobinemia, and hemoglobinuria. Differential diagnosis from paroxysmal hemoglobinuria or blackwater fever may be necessary in isolated cases.

e. Treatment.—(1) Treatment is directed mainly against the anemia and the toxic action on the kidney. If the red cell count falls below 4,000,000 or the hemoglobin below 60 percent, 500 cubic centimeters of blood should be given by transfusion; since hemolysis may continue for several days, repeated transfusions are necessary. The loss of red cells is not accompanied by loss of plasma as in hemorrhage.

(2) Diuretic fluids should be given freely by mouth up to 4,000 cubic centimeters in 24 hours, or by rectum if fluids are not retained by mouth. Mercurial diuretics are contra-indicated.

(3) Divided doses of sodium bicarbonate up to 20 grams daily or, preferably, sodium citrate or acetate up to 50 grams daily aid diuresis. Administration should be started early and continued as long as excretion of hemoglobin lasts.

(4) Glucose is indicated for liver involvement, with or without insulin, and intravenously if necessary.

(5) Iron and liver extract are indicated for anemia during convalescence.

(6) Resumption of physical activity should be gradual. The diet should be light as long as evidence of liver or kidney damage persists.

f. Prognosis.—The mortality is about 30 percent. Recovery may occur even with severe cases; others may die within 2 to 6 days. Marked anemia and anuria are grave signs.

29. Hydrogen sulfide.—*a. Physical properties.*—This is a colorless gas, heavier than air. It has an odor of rotten eggs and may be detectable at a harmless concentration, but the sense of smell becomes dulled quite rapidly and even high concentrations may not be recognized. Hydrogen sulfide is almost as toxic as hydrocyanic acid.

b. Pathology.—Hydrogen sulfide produces local irritation of eyes, nose, and throat, and high concentrations may produce pulmonary edema and paralysis of the respiratory center.

c. Symptoms.—These consist of local irritation of the eyes, exposed mucous membranes, and respiratory tract. Pulmonary edema may result from the respiratory irritation. Effective concentrations produce an increased, panting respiration, quickly followed by unconsciousness and cessation of breathing which may be accompanied by convulsions.

d. Diagnosis.—This may be made from the odor, rapid loss of consciousness, cessation of respiration before the heart fails, and the blackening of lead acetate paper or of a moistened silver coin by exposure to the expired air.

e. Treatment.—Adjust gas mask quickly and apply artificial respiration for long periods even though the procedure may for some time appear hopeless. Inhalation of oxygen-carbon dioxide mixtures if available should also be employed; otherwise oxygen may be employed.

f. Prognosis.—Mortality from exposure to high concentration is high. Most deaths occur soon after exposure.

SECTION IX

INCIDENTAL GASES

	Paragraph
General	30
Carbon monoxide	31
Nitric (nitrous) fumes	32
Ammonia	33

30. General.—*a.* This group includes carbon monoxide, nitric fumes, and ammonia, which may be met with indirectly in confined or poorly ventilated spaces, or in the bombing of industrial installations. Carbon monoxide and, to a lesser extent, nitric fumes are combustion products which may remain for some time in freshly formed shell holes, and may seep into underground shelters and passages. Carbon

monoxide may also be formed in collective shelters from incomplete combustion in heating devices such as charcoal braziers. Ammonia may be liberated accidentally in refrigeration plants or as the result of enemy bombing.

b. Protection against incidental gases.—The service mask and collective protection devices furnish protection against nitric fumes, but not against carbon monoxide or ammonia, for which special canisters are necessary.

c. Oxygen deficiency.—Ordinary air normally contains about 21 percent oxygen. However, the proportion of oxygen may be reduced to a dangerous degree in closed or poorly ventilated spaces such as shelters, compartments, or underground tunnels, by human consumption, combustion by fire, or dilution with other gases such as carbon dioxide, methane, etc. The reduction in the partial pressure of oxygen in rarefied air at high altitudes, while mainly of concern to aviation, may also be a factor deserving consideration in land operations at high altitudes. When the oxygen content of air falls below 17.5 percent a lighted candle will be extinguished, and this is a good test for the safety of the air as far as the oxygen content is concerned, since human symptoms of oxygen deficiency are not noticeable until an even lower oxygen level has been reached. It is obvious that the service gas mask is of no value in oxygen deficiency, and that in this condition either an oxygen breathing apparatus or a mask with a hose reaching the outside air is necessary.

31. Carbon monoxide.—*a. Physical properties.*—Carbon monoxide is a colorless, odorless gas, lighter than air, into which it diffuses rapidly.

b. Occurrence in military operations.—Carbon monoxide is formed by gun blasts, bursting shells, and internal combustion engine exhausts. Dangerous concentrations are apt to occur in confined spaces such as poorly ventilated gun turrets or emplacements, in mining operations, or in recently formed shell holes.

c. Pathology.—Asphyxiation is produced by the union of carbon monoxide with hemoglobin, for which it has an affinity 300 times greater than oxygen, thus replacing the latter. (Carbon monoxide can in turn be displaced from the compound by a sufficient concentration of oxygen.) As a result of oxygen deficiency, nervous system changes occur. Post mortem examinations reveal little beyond the characteristic cherry red color of the blood and mild hemorrhagic changes in the brain.

d. Symptoms.—The symptoms progress from headache, throbbing of the temples, vertigo, yawning, dyspnoea, dullness, and lack of visual

acuity, to the development of bright pink patches on the skin, marked weakness and coma with subnormal temperature, low tension pulse, and death.

e. Diagnosis.—The diagnosis is made from the cherry red color of the venous blood and bright red patches on the skin.

f. Protection.—The service canister does not protect against carbon monoxide, a special canister being required. Adequate ventilation should be provided for all inclosed spaces where carbon monoxide may be produced. The safety of the air in a space may be tested by introducing a cage containing a small animal such as a mouse, rat, or much better, a canary. The air will be safe for man to breathe for at least as long as these animals remain unaffected.

g. Treatment.—Remove to pure air, give pure oxygen or oxygen-carbon dioxide mixture, and artificial respiration if necessary. Rest, blankets, and warm drinks are also indicated. Blood transfusions are valuable in desperate cases.

h. Prognosis.—The longer the period of coma the less the chances of recovery. Most of the cases recover with early treatment. Tachycardia and dyspnoea may continue for months along with central nervous disturbances ranging from simple neuritis to mental deterioration.

32. Nitric (nitrous) fumes.—*a. Physical properties.*—Nitric fumes or vapors consist chiefly of mixtures of the oxides of nitrogen. They are orange yellow to reddish brown in color, soluble in water, and react with water and oxygen to form nitrous and nitric acids.

b. Occurrence in military operations.—These gases are produced wherever nitro explosives are used and incompletely detonated or subjected to slow combustion. This may occur in gun pits, armored cars, tanks, ship magazines, and in mining and tunneling operations.

c. Pathology.—Irritation of the lungs is produced, followed by the development of pulmonary edema. (Some local ulceration of the lungs may be caused by nitric acid, formed where the fumes come in contact with moist areas in these organs.) In general, the pathological findings are similar to those produced by phosgene.

d. Symptoms.—There may be a slight conjunctivitis, rhinitis, and pharyngitis, followed by a latent period of 4 to 8 hours with few other symptoms. The slight sensory irritation and long latent period are responsible for exposed individuals failing to realize the serious danger following inhalation of these fumes. Yellowish discoloration of the

mucous membranes occurs only if the gaseous concentration is high. The picture of lung irritation and edema, similar to that following phosgene, is the last to develop.

e. Diagnosis.—The diagnosis is made from the the history of exposure, pungent odor, yellowish discoloration of the exposed mucous membranes, irritation of nose, throat, and lungs, and later pulmonary edema.

f. Treatment.—Same as for phosgene.

g. Prognosis.—Casualties usually die within 24 to 48 hours from pulmonary edema. Broncho-pneumonia is a serious complication. Convalescence is prolonged, especially when complicated with simultaneous exposure to carbon monoxide.

33. Ammonia.—*a. Physical properties.*—Ammonia is a colorless gas, lighter than air, with a pungent, characteristic odor, and is exceedingly soluble in water.

b. Occurrence in military operations.—This gas has not been used in warfare but may be encountered in industrial accidents and bombings.

c. Pathology.—Exposure to high concentrations of ammonia produces prompt and violent irritation of the eyes and respiratory tract. There may be edema of the glottis and a yellowish, purulent, pseudomembranous laryngitis.

d. Symptoms.—The symptoms following inhalation of high concentrations consist of a violent burning pain of the eyes and nose accompanied by lacrimation and sneezing, pain in the chest, severe coughing, spasm of the glottis, and signs of a terminal lung infection. Often there is temporary reflex stoppage of respiration, and asphyxia may result from the spasm and edema of the glottis or from swelling of the mucous membrane of the larynx and trachea. Concentrations of 0.1 percent are insupportable for man. Rubefaction and sometimes vesication of the skin may follow direct contact with liquid ammonia or ammonium hydroxide.

e. Treatment.—First-aid treatment consists of prompt removal to pure air, and artificial respiration if necessary. Inhalation of the fumes of weak acetic acid or vinegar may be of some benefit. Later measures are directed toward the prevention or treatment of bronchitis and pneumonia.

f. Prognosis.—The mortality is high following the inhalation of high concentrations; with lower concentrations recovery is usually rapid, although bronchitis may persist.

SECTION X

SPECIAL CASES

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Vesicant contaminated wounds	36
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34. General.—In the care of chemical casualties, conditions may arise which indicate the use of special supplies, equipment, or methods of treatment. These will not always be available and medical officers must exercise their ingenuity. Examples include cases where wounds of the head and face preclude the wearing of the service mask, casualties where wounds are contaminated with vesicants, and the use of general anesthesia for gas casualties.

35. Protection for head injury casualties.—A special head wound mask has been developed for patients in gas contaminated areas when head injuries or dressings prevent the use of the service mask. This mask is in the form of a hood sufficiently large to cover the entire head and neck and allow room for any type of head dressing. Since there is more dead space in the special head mask than in the service mask, this space must be eliminated by the use of tape. The purified air supply is furnished through a tube and canister similar to that of the service mask. The edges of mask must be taped securely to the body to prevent leaking.

36. Vesicant contaminated wounds.—*a.* Operating personnel should consider the possibility that chemical contamination may exist in penetrating or extensive wounds, such as those of the abdomen. If there is an odor of the vesicant about the wound, members of the team should use appropriate measures to protect themselves from the vesicant, especially if the operating room is small, confined, or poorly ventilated. Instruments should be decontaminated by boiling in several changes of sodium carbonate solution, or by the use of CWS noncorrosive decontamination agent, chloramine-T, dichloramine-T, Dakin's solution, or calcium hypochlorite solution. Instruments and gloves should be changed after the contaminated tissue has been debrided. Since vesicants may penetrate the surgical rubber glove in a few minutes, it is suggested that the hands be covered with protective ointment before the gloves are put on. Special protective

gloves are heavy and awkward for operating work but may be worn if the circumstances warrant.

b. If the vesicant has penetrated deeply, the wound must first be irrigated repeatedly with 0.5 percent sodium hypochlorite (Dakin's solution), followed by debridement. Subcutaneous and muscle tissues contaminated by arsenicals must be extensively debrided to prevent or minimize arsenical intoxication. Where wounds of the abdominal cavity are contaminated by arsenicals, systemic poisoning will follow, and general therapy in the form of administration of intravenous fluids, especially glucose solutions, must be started at once. The surgeon should avoid touching contaminated areas with his gloves, using instruments instead. Special precautions must be taken for disposal of the discarded contaminated tissues. Nonvesicant casualties should not be touched until the surgeon and assistants have decontaminated themselves.

37. Employment of anesthesia for chemical casualties.—*a.* When anesthesia is necessary for wounded casualties who have been exposed to lung irritant gases, local infiltration or nerve block are the methods preferred, but the intravenous or spinal routes may be employed. When these methods are not available nor desirable, inhalation anesthesia may be necessary.

b. During the acute phase of pulmonary irritation, surgical interference must be confined to life-saving measures, and if anesthesia is necessary it should be as brief as possible. When inhalation anesthesia must be used, ether should be avoided in favor of less irritant anesthetics. Spinal anesthesia may predispose to cardiovascular collapse, which often follows exposure to pulmonary irritants.

c. If pulmonary edema has developed, the treatment of this condition will be more important than surgical treatment of any accompanying injuries, and *general anesthesia is absolutely contra-indicated.* If the patient survives the edema, surgical interference should be deferred for at least 48 hours.

d. When it is impossible to furnish collective protection for surgical operating installations, patients and operating personnel must be protected by masking during a chemical attack. While the surgeon and his assistants can operate when masked, it is not possible similarly to protect a patient requiring inhalation anesthesia. When operations are necessary despite the presence in the air of chemical agents, and inhalation anesthesia is mandatory, a closed system should be used to furnish both oxygen and the anesthetic.

SECTION XI

ANIMAL CASUALTIES

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Vesicants	40
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Systemic poisons	44
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38. General.—*a.* The prevention of gas casualties in Army animals is important in order to eliminate lost working days for both the animals and the attending personnel. Horse gas masks, protective leggings, and individual covers offer horses (and mules) the best individual protection. The horse gas masks M4 and M5 provide protection comparable to that afforded by the service mask. While using the mask, a horse is safe from injury by nonpersistent agents and may stand considerable exposure to vesicant *vapors* without developing incapacitating injury. Due to his mobility, the horse can often avoid contaminated terrain but, if forced through an area within a very short time after contamination with liquid vesicants, his legs should be protected by impermeable leggings or incapacitating burns of the lower legs may result. When only vapors of vesicants are encountered, horses may receive extensive exposures without developing incapacitating injuries, especially when protected with the gas mask. Individual covers may be required to protect from airplane spray. Strategic protection of animals and veterinary installations is best afforded by the avoidance of locations likely to be gassed, particularly important lines of communication, supply and transportation areas, and strategic positions close to the front lines. Animals should be prevented from drinking from water holes, trenches, or shell craters and from pasturing in areas which have recently been contaminated until the forage and water in such localities is determined to be suitable for animal consumption. Water in deep wells or large running streams and lakes, where the factor of dilution is great, can usually be considered to be nontoxic.

b. In general, the preceding chapters concerning human casualties resulting from exposure to chemical warfare agents are applicable to animals. Only those agents of most concern to horses (and mules) will be stressed. Animals, particularly horses, do not differ

materially from men in susceptibility to most chemical agents. However, the horse and mule show a relative immunity to irritant smokes and lacrimators under ordinary field conditions. When pathology and general symptoms previously given for human casualties are similar in animals, they will not be repeated in this section.

39. Lung irritants.—*a. General.*—A similar over-all picture is presented by animal casualties on exposure to lung irritants as is seen with man.

b. Phosgene.—(1) *Pathology.*—Same as that reported for man (par. 5).

(2) *Symptoms.*—There may be no respiratory symptoms until pulmonary edema develops suddenly. The latent period may last for as long as 12 to 24 hours, and physical examination of the chest at this stage may be negative. Exertion during this period will bring on and aggravate the condition; absolute rest is therefore essential. Usually symptoms develop gradually, the animal becoming uncomfortable, coughing frequently with the production of a bloody, frothy nasal exudate. The pulse is at first full but becomes rapid, thin, and later difficult to detect. Dyspnoea increases as pulmonary edema develops. Respirations become hurried and labored. Little change occurs in the conjunctiva, but the nasal mucosa is at first injected, and as dyspnoea develops it takes on a pale bluish gray tinge. The change from the blue to the gray stage seen in humans is not easily distinguished in animals.

(3) *Diagnosis.*—Diagnosis is made from the history of exposure and onset of symptoms some hours after exposure.

(4) *Immediate treatment.*—This consists of the following measures:

(*a*) *Rest.*—Exercise or the lightest work will aggravate the condition, especially after pulmonary edema develops. Treatment should be carried out locally to avoid fatigue of evacuation. If evacuation cannot be avoided, horse ambulance or motor conveyance should be used to evacuate affected animals, if available.

(*b*) *Heat.*—Heat in the form of warmth or blankets should be supplied so as to diminish oxygen requirements.

(*c*) *Stimulants.*—Caffeine sodium benzoate might be given during the critical stage. Oxygen therapy for animals is not practicable under field conditions.

(*d*) *Venesection.*—Early and drastic blood letting should be practiced, 6 to 8 pints being taken once in 24 hours. It should be carried out as soon as the first signs or symptoms of exposure to phosgene appear. Bleeding is contra-indicated in the later stages. When the

blood is concentrated (thick) and the hemoglobin content high, a lesser amount should be taken. Venesection reduces the intravascular pressure, relieves the heart, and accelerates reabsorption of plasma from the alveoli.

(*e*) *Useless procedures.*—The infusion of normal saline, and injections of atropine and especially adrenalin are useless or harmful. Contra-indication of morphine for restless animals is based upon experience of the first World War.

(5) *Prognosis.*—If the animal survives 4 days, recovery may be expected, unless broncho-pneumonia supervenes. Convalescence should not be hurried and the animal should be slowly brought back to work.

c. Chlorpicrin.—(1) *Pathology.*—Chlorpicrin irritates not only the alveoli but also the upper bronchi and trachea. Pulmonary edema may appear. Because of the involvement of the upper bronchi, plugging and consequent pulmonary emphysema may develop. Nephritis may also be produced.

(2) *Symptoms.*—The clinical picture is similar to that of phosgene.

(3) *Diagnosis.*—Diagnosis is made from the history of exposure and from any symptoms in man (exposed with the animals) referable to irritation of eyes, nose, and lungs, which is sometimes associated with nausea and vomiting.

(4) *Prevention, protection, and immediate treatment.*—These are the same as for phosgene.

d. Chlorine.—Paragraph 7 pertaining to chlorine casualties with man is also applicable to animals.

40. Vesicants.—*a. General.*—(1) The terms "blister" and "vesicant" agents are misnomers in the case of animals. Vesication of the skin does not ordinarily occur. While the vesicants will irritate any part of the body with which they come in contact, they also function as lung irritants. In general, there are two forms of vesicant agents: those which cause local surface irritation and those which cause local surface irritation plus internal poisoning. These latter compounds usually contain arsenic. More than any other type of agent, the vesicants, especially the arsenicals, will contaminate forage, water, and grain, and render other supplies dangerous to handle until they have been decontaminated.

(2) Before treating vesicant agent casualties, veterinary personnel must apply to themselves those measures of individual and collective protection which are necessary to prevent themselves from becoming casualties from contact with the contaminated animals or matériel.

b. Mustard.—(1) *Injury caused by mustard.*—(*a*) Incapacitating injury to animals will be produced from contamination with liquid

mustard, by spray from aircraft, by splashing from bomb and shell bursts, or by traversing recently contaminated ground. Vapors of mustard produce less injury to animals than to man. Liquid mustard contamination of the horse's skin is followed in 10 to 20 minutes by a local erection of the hair coat. This is followed by edema, serous exudation, and in some cases necrosis and ulceration. The latter is more likely in areas partially or wholly devoid of hair. A full coat of hair causes lateral spread of the agents and results in a shallower lesion with a shorter healing time. When horses traverse ground upon which glistening areas of liquid mustard can be seen upon the foliage, the exposure results in an edematous filling around the pastern and fetlock regions, leading to intense lameness. The fine skin at the hollow of the heel is particularly susceptible and sepsis may be expected. However, the danger period for horses to cross contaminated terrain is less than that for man (see par. 9*a* and app. V). The horny hoof including the frog is sufficiently resistant to be relatively unaffected.

(*b*) The eye of the horse is less susceptible to mustard vapor than that of man, but the smallest drop of liquid in the eye causes serious injury with acute conjunctivitis, keratitis, and temporary blindness. There may be a mucopurulent discharge. Necrosis of the cornea may result in its rupture.

(*c*) The respiratory tract may be less susceptible to vapor injuries but extensive exposures of horses to mustard vapors will lead to the same type of injury as is seen in man.

(*d*) Consumption of contaminated water or forage will cause ulceration of the lips and mouth and gastroenteritis, accompanied by colic, diarrhea, and bloodstained stools.

(2) *Prophylaxis after contact.*—(*a*) Because the hair coat holds up penetration, prophylactic measures are effective longer after exposure than with man. Immediate prophylaxis is highly successful, but will seldom be possible. Healing time is shortened in proportion to the speed with which decontamination is employed but benefit may be expected up to an hour or more.

(*b*) Scrubbing affected areas with soap and water will remove uncombined agent. Scrubbing of contaminated skin areas with a 5 percent solution of potassium permanganate is an effective field method to neutralize mustard. Bleach paste (1 part calcium hypochlorite to 3 parts water) is also effective, but very irritating to the horse's skin; it should be washed off within 5 minutes. Protective ointment M–4 may be rubbed into the hair coat for decontaminating small areas in emergency, but it is highly irritating and must

be removed shortly after application or a severe dermatitis will develop. The use of solvents (gasoline, kerosene, alcohol, etc.) is not a very satisfactory field procedure to remove mustard, since it merely dilutes the agent and causes it to spread in the hair coat. Eyes affected by liquid mustard should be *freely* irrigated within 5 minutes with a 2 percent solution of sodium bicarbonate, normal saline or water, irrigation to be continued for 10 minutes if possible. If equipment for such irrigation is not available, the water from the trooper's canteen may be used.

(3) *Treatment.*—Decontamination should always precede treatment. The aim of aftertreatment is to prevent secondary infection. Treatment is generally not necessary for slight injury to skin that is not subject to friction of harness or saddlery. Treatment is like that for heat burns of like extent. No specific treatment is yet available for mustard burns. Cod liver oil, tannic acid, or gentian violet may be tried. Amyl salicylate must *not* be used as it produces blistering and vesication of the horse's skin. Pain may be allayed by local anesthetics. Bathing with boric acid solution may help cleanse and soothe the eyes. Installation of 1 percent atropine sulfate daily may be used. Treatment should be directed against secondary infection. Treatment of respiratory and alimentary lesions should follow general symptomatic practices. Fresh air, warmth, and nursing are essential.

c. Lewisite.—(1) *Injury caused by lewisite.*—Lewisite has a more rapid and severe action on the horse's skin than mustard. Burns resemble those caused by mustard except that they are immediately irritant and lead to considerable restlessness. There may be signs of systemic effects and toxic changes in the viscera. Inhalation produces ulceration of the upper respiratory tract and secondary broncho-pneumonia may follow.

(2) *Prophylaxis and aftertreatment.*—Prophylactic measures for the destruction or removal of this agent must be initiated at the first opportunity. Scrubbing the contaminated skin with a 5-percent solution of potassium permanganate or a 3- to 10-percent solution of hydrogen peroxide will reduce the amount of injury and will lessen the danger of arsenical poisoning, even if decontamination is somewhat delayed. Bleach as indicated for mustard is also beneficial. Scrubbing with soap and water serves to remove uncombined agent. Treatment of the eye is similar to that for man (par. 10). Aftertreatment is symptomatic and like that for mustard injury. Mixtures of this agent with mustard should be treated as for lewisite.

d. Ethyldichlorarsine.—Injury to the skin is less marked than with lewisite or mustard. Differential diagnosis may be made by observing symptoms shown by a man accompanying the horses. These consist of sneezing, lacrimation, nausea, and emesis. Such symptoms may not be shown by horses. Treatment is similar to that for lewisite.

41. Lacrimators and irritant smokes.—These agents are intolerable in very low concentrations to man but under ordinary field conditions they have little effect upon horses and mules. Serious irritant effects may result when the liquid lacrimator spray gets into the eyes of animals. Immediate irrigation of the eyes with sodium bicarbonate will limit the irritant effects.

42. Screening smokes.—*a. White phosphorus.*—(1) *Effects.*—Burning particles of white phosphorus produce deep heat burns on contact with the skin. The smoke is nontoxic.

(2) *Treatment.*—Smother the burn immediately with water, mud, or other air-impervious materials. Keep the burn under water until 2 to 10 percent copper sulfate solution can be applied, which excludes air by forming a protective coating on the particles. The particles can then be removed with forceps or hemostats. Further treatment is that for ordinary heat burns.

b. Sulfur trioxide-chlorsulfonic acid solution (FS).—This agent is a fuming, highly corrosive liquid which upon contact with moisture forms hydrochloric and sulfuric acids. It is not believed this smoke in field concentrations will significantly affect the horse's skin. Eye burns may follow exposure to irritating concentrations. A 2 percent sodium bicarbonate solution may be used for eye irrigations.

c. Titanium tetrachloride (FM).—This agent is a liquid which hydrolyzes rapidly in contact with the moisture of air to form titanium hydroxide and hydrochloric acid. The liquid may produce acidlike burns on the skin and in the eyes but it is not as irritant as FS. Treatment is the same as for FS.

d. HC mixture.—This is a solid mixture of several agents. The smoke is composed essentially of zinc chloride and free carbon. Under field conditions it is not irritating to animals. No treatment is needed.

43. Incendiary agents.—Treatment of burns from incendiary agents is that used for any heat burn.

44. Systemic poisons.—*a. General.*—These are agents which produce their effects after absorption into the blood stream. The most important are hydrocyanic acid and arsine. Protection requires an efficient type of horse gas mask.

b. Hydrocyanic acid.—Hydrocyanic acid produces asphyxia by hindering the oxidative processes of the tissues, and depresses and paralyzes the central nervous system, beginning with the medulla. If it does not kill rapidly, it probably will not produce treatable casualties. Animal therapeutic measures in war therefore do not seem practicable.

c. Arsine.—Arsine produces no irritation of the skin but upon inhalation and absorption the red blood cells are hemolyzed. The kidneys may be seriously affected and anuria and uremia may result. Hepatitis is a common complication. A few hours after exposure to high concentrations patchy sweating, increased respiration, anuresis, and an increased temperature may be noted, followed by anemia. Severe hemoglobinuria may appear early. Treatment consists of diuresis, accomplished by allowing the animal free access to water and giving large doses of sodium bicarbonate. Anemia may be treated by usual methods. The horse gas mask gives adequate protection.

45. Incidental gases.—Exposures of horses to incidental gases such as carbon monoxide, nitric fumes, and ammonia are not expected in the field. For reference as to the action of these agents see section IX.

APPENDIX I

FORMULARY

1. Alkali solution (for prophylaxis against lewisite).

	Grams or cubic centimeters
Sodium hydroxide	10.0
Glycerin	30.0
Water, distilled, q. s. ad	100.0

a. The contaminated skin areas should be swabbed alternately and repeatedly with sodium hydroxide solution and with alcohol.

b. This solution is to be used only if hydrogen peroxide is not available.

2. Antipruritic ointment No. 71.

	Grams or cubic centimeters
Butyn sulfate	0.5
Benzyl alcohol	12.0
Menthol	.2
Oil of lavender	.2
Alcohol	5.0
Stearic acid	12.0

a. Dissolve the butyn sulfate and menthol in the alcohol and add the benzyl alcohol and oil of lavender. Place the stearic acid in a porcelain or glass casserole and liquefy by the gentle application of heat. Add the liquid mixture slowly to the melted stearic acid, stirring continuously with a rod or pestle until gradual cooling results in solidification of the mixture. Keep in airtight ointment jars or collapsible tubes.

b. Apply generously with rubbing to itching or painful areas of the skin.

3. Antipruritic ointment No. 88.

	Grams or cubic centimeters
Benzyl alcohol	50.0
Stearic acid	30.0
Glycerin	10.0
Alcohol	8.0
Pontocain	1.0
Menthol	1.0

a. Dissolve the pontocain and menthol in the alcohol and benzyl alcohol and add the glycerin. Place the stearic acid in a casserole and liquefy by the gentle application of heat. Add the warmed liquid mixture slowly to the melted stearic acid, stirring continuously with a rod or pestle until gradual cooling results in solidification of the mixture. Keep in airtight ointment jars or collapsible tubes.

b. Apply generously with rubbing to itching or painful areas of the skin.

4. Cod liver oil ointment.

	Grams or cubic centimeters
Cod liver oil	50.0
Petrolatum	50.0

a. Sterilize the petrolatum in an autoclave, cool, and mix thoroughly with cod liver oil. Sodium bicarbonate should be added to render the ointment alkaline (approximately 1 gram needed). If desired, small amounts of turpentine or tincture of myrrh may be incorporated to mask the odor of cod liver oil.

b. To be used especially with burns where the healing is sluggish.

5. Compound tannic acid powder.

	Grams or cubic centimeters
Potassium chloride	0.42
Calcium chloride	.84
Salicylic acid	1.0
Sodium chloride	10.5
Tannic acid	100.0

a. Grind materials to a powder and mix thoroughly in a mortar. Place in bottle and shake to complete mixing.

b. To make compound tannic acid solution, dissolve all of this powder in 1,000 cubic centimeters of distilled water; for smaller amounts dissolve 1 teaspoonful (3 grams) in 1 ounce (30 cubic centimeters) of distilled water. On standing, the solution will be rendered sterile and stable by the salicylic acid and can be kept in this form.

c. The tannic solution may be applied by sponging or spraying, followed after 15 minutes by 10 percent silver nitrate solution used in the same manner, this sequence being repeated as often as necessary until a firm eschar is formed.

6. Dichloramine-T in triacetin.

	Grams or cubic centimeters
Dichloramine-T	20.0
Triacetin	80.0

After the mustard has been grossly removed from the skin, the areas are dabbed gently and repeatedly with sponges dampened with the solution.

7. Eye solution M–1.

a. Eye solution M–1 to meet specifications of the Medical Department, U. S. Army.

b. For eye contaminated with lewisite or other arsenical vesicants, instill 2 to 4 drops as soon as possible; *do not repeat.*

8. Eye and nose drops—Medical Department item No. 91090.

	Grams or cubic centimeters
Neosynephrin HCl, 1 percent	25.00
Pontocain	0.25
Boric acid, saturated solution	75.00

a. To be used as drops in the eye and nose to relieve pain and congestion.

b. One or two drops in eyes as needed. Two drops in each nostril. Repeat if necessary.

9. Pontocain compound ointment—Medical Department item No. 1K61100.—Apply gently by rubbing on itching or painful areas.

10. Protective ointment—CWS, Medical Department item No. 91187.—For protective and prophylactic action on the skin against vesicants.

a. As a preventive, apply liberally to unprotected parts of the body before moving into an area contaminated with gases or when attack with vesicant gas seems imminent. Remove from skin when tactical situation permits.

b. For prophylaxis, apply a small amount on a piece of packing tissue from protective ointment carton, a piece of gauze, cotton waste, handkerchief, piece of shirt, or similar material and rub vigorously on the affected area for 10 to 20 seconds. The ointment is then wiped off. This procedure of applying, rubbing, and removing the ointment is repeated three or four times.

c. Protective ointment should *not* be used after erythema appears as it will increase irritation.

11. Sodium bicarbonate solution, 2 percent.—*a.* This can be approximated by dissolving 1 teaspoonful of sodium bicarbonate in 1 glass of water.

b. This solution is used as a wash for the eyes, buccal, and nasopharyngeal cavities following contamination by vesicant gases, and as a skin wash following acid and irritant smokes.

12. Sodium sulamyd solution.

	Grams or cubic centimeters
Sodium sulamyd	1.0
Water	30.0

a. Dissolve sodium sulamyd in clean water. Sterile water is not required, since the solution is autosterilizing in solutions stronger than 1 percent.

b. To prevent infection, instill 2 drops in eye every 2 hours for 48 hours, and thereafter 2 drops four times daily until acute symptoms subside.

c. To treat infected eyes, double or triple strength solution (2 to 3 grams per 30 cubic centimeters) may be used, and the frequency of applications increased, as indicated.

13. Sodium sulfite solution, alcoholic (for skin).

	Grams or cubic centimeters
Sodium sulfite (crystals)[1]	4.0
Water, distilled	50.0
Alcohol, q. s. ad	100.0

[1] If anhydrous sodium sulfite is used, the amount required is 2 grams.

a. Dissolve the sodium sulfite in the water and add the alcohol.

b. To be used as a skin wash against chlorpicrin and the lacrimators (high concentrations or splashes).

14. Sodium sulfite solution (for eyes).

	Grams or cubic centimeters
Sodium sulfite	0.4
Water, distilled	25.0
Glycerin	75.0

a. Dissolve the sodium sulfite in the water and add the glycerin.

b. To be used as eyedrops for relief of symptoms from lacrimators.

15. Sulfadiazine ointment, 5 percent—Medical Department item No. 14619 or No. 14620.—*a.* Apply ointment to broken blisters or denuded skin areas following contamination with vesicants, or thermal burns. Then cover area with sterile dressing.

b. Used to prevent infection of denuded skin areas.

16. Triple dye.

Brilliant green	1:400
Gentian violet	1:400
Acriflavine, neutral	1:1000

a. A mixture is made of equal parts of the dyes.

b. This solution is applied to the burned area to form a protective eschar.

APPENDIX II

CHEMICAL AGENT CONTAMINATION OF FOOD, FORAGE, AND GRAIN

1. General.—*a.* Contamination of foodstuffs by chemical warfare agents may occur from contact with vapor, sprays or splashes of liquid, or solid chemicals, following dispersion of the agents by land mines, chemical cylinder clouds, mortar and artillery shells, airplane spray, or possibly by direct manual application by a retreating force. Unprotected food, forage, and grain supplies may be contaminated to such an extent that their consumption will produce gastrointestinal irritation or systemic poisoning. The vesicants and arsenicals are the most dangerous. The bulky foods and the grazing habits of animals present special problems.

b. While field decontamination may be difficult, large stores of foods must not be hastily condemned until available means for decontamination have been considered. Scarcity of supplies may at times make reclamation mandatory. Prompt segregation of the most heavily contaminated portions may prevent or minimize contamination of the bulk of the supplies. With proper packaging and storage precautions gross contaminations of food stores should be largely avoided.

2. Nature of chemical contamination.—The vesicants and chlorpicrin are readily soluble in fats. They will be absorbed by foods of high fat content, and because of wide diffusion throughout the material, it may be impossible to remove them. Coagulation of protein by agents which are acidic or form acids in foods of high protein content may limit diffusion of the agent into the interior. Hydrolysis of acid-forming gases in foods of high water content will allow diffusion of decomposition products throughout the mass, and greatly impair the taste. Foods of low water and fat content will be relatively less receptive to contamination by chemical agents and less difficult to decontaminate.

3. Reclamation of contaminated supplies.—*a. General.*—The most effective and practical measures for purifying food, forage, and grain when contaminated with chemical agents include washing with water or 5 percent sodium bicarbonate solution, trimming of exposed surfaces, adequate aeration, or boiling in water. These measures may be ineffective if the decomposition products are toxic, as in the case of lewisite. In general, food, forage, or grain exposed to low vapor concentrations of chemical agents can be reclaimed by these procedures. It is impracticable to reclaim provisions that have been heavily

contaminated by vapors, droplets, or dusts, especially of the vesicants or arsenicals. Exposed foods on which chemical agents can be seen with the unaided eye should be considered spoiled and their purification impracticable.

b. Lung irritants.—This group of agents offers relatively little danger to food products. With the exception of chlorpicrin, these decompose rapidly upon contact with the water in food products, to form comparatively harmless hydrolytic compounds which may alter the flavor. Therefore, decontamination may be accomplished by complete aeration, supplemented where possible by subsequent washing. Chlorpicrin, however, is insoluble in water but soluble in fat and most organic solvents. It is therefore difficult to remove by washing. Removal from foods of low water and fat content may be accomplished by energetic ventilation with warm air currents. Reclamation of supplies which are of high water or fat content, which have been heavily contaminated with chlorpicrin, will be impracticable under field conditions.

c. Lacrimators and irritant smokes.—(1) It is difficult to see how large stocks of supplies, when protected by coverings or packaging, could be appreciably or consistently contaminated with a sufficient amount of the lacrimators or irritant smokes to cause the destruction of such supplies. However, this could be accomplished by a shell exploding within a storehouse or in a stock pile. These agents are not easily decomposed by hydrolysis and it would be difficult to reclaim foods *heavily* contaminated by them.

(2) Decontamination of dry provisions contaminated by lacrimators could be accomplished by heat in a manner similar to the removal of chlorpicrin.

(3) Foods *heavily* contaminated with irritant smokes should be discarded.

d. Vesicants.—(1) When contaminated with *liquid* mustard, foods of high water or fat content are unfit for human consumption and measures of reclaiming them can be considered impracticable. When foods have been exposed to mustard vapor, they can be reclaimed by the following procedures: washing with soda solutions and rinsing with clear water, intensive cooking, or in the case of dry provisions by extensive aeration at temperatures of 50° to 60° C.

(2) Lewisite and ethyldichlorarsine readily hydrolyze to poisonous arsenical oxides. It is not practicable under field conditions to try to render foods safe for use following their exposure to heavy vapor concentrations or liquid drops of these agents.

e. Screening smokes.—(1) HC, FM, and WP smokes are nontoxic. They may alter the taste of foods by acids produced on contact with moisture, but do not otherwise damage the food. FS smoke is much more acid, but foods exposed to it are safe to use after washing.

(2) Liquid FM (titanium tetrachloride) should be washed from foods with water. Liquid FS (sulfur trioxide-chlorosulfonic acid solution) is highly corrosive and forms strong acids on contact with moisture. It may render foods which cannot be readily washed unfit for use; after trimming, washing, or cooking, if the food does not taste too acid, it is safe to use.

(3) Unburned particles of WP (white phosphorus) are very poisonous and must be completely removed from foods; fats and oils may dissolve poisonous amounts of the white phosphorus and should be discarded.

f. Other agents.—Carbon monoxide, arsine, and hydrocyanic acid will have little effect upon food supplies. HCN is water soluble and where high concentrations are generated foods of high water content may become unfit for consumption.

g. Meat from gassed animals.—Circumstances may make it necessary to use animals for food after they have been exposed to chemical warfare agents. Economics may justify the early slaughter of exposed animals *before the effect of such exposure is shown* rather than to treat them. If such animals are slaughtered in an approved manner in the preliminary stages of a war gas poisoning and the organs exposed to the gas (lungs, and local areas of skin and subcutaneous areas of tissue exposed to vesicants) are discarded, there is no objection to the consumption of the carcass musculature, provided the animal otherwise passes a satisfactory meat inspection. This is also true of animals poisoned by arsenical agents, since the edible tissue will contain amounts of arsenic too small to be considered toxic. Organs such as the liver, brain, heart, kidney, and lungs will contain relatively more arsenic than the carcass musculature, and so these organs should ordinarily be discarded. The remaining meat should be well cooked. Sections of carcass meat under skin areas contaminated with liquid lewisite should be well cooked by boiling and the water poured off.

4. Packaged and stored provisions.—*a.* In determining the disposition of packaged and stored supplies which have been contaminated, consideration must be given to the nature and form of the contaminant as well as to the type of foodstuff and the security afforded by the packaging material. Some of these factors are outlined as follows:

(1) Airtight bottles and sealed tins give complete protection against vapor and liquid.

(2) Wooden barrels, well sealed for the exclusion of air, give complete protection against vapor and moderate amounts of liquid.

(3) Wooden boxes, not sealed for the exclusion of air, give little protection against vapor or liquid.

(4) Waxed paper boxes, well sealed for the exclusion of air, give good protection against vapor and fair protection against liquid.

(5) Paper wrappings give poor protection against vapor and very little against liquid.

(6) Foil and cellophane wrappings, sealed for the exclusion of air, give good protection against vapor and liquid.

(7) Ordinary single layer packaging textiles give practically no protection against vapor and liquid.

(8) Coverings of sod and earth give good protection against vapor and liquid.

(9) Open shelters give protection against liquid sprays and splashes; closed buildings, against both vapor and liquid spray or splashes.

(10) Generally, double layers greatly increase the protective efficiency of packaging materials.

b. When it is necessary to store bulk food supplies which are poorly protected by packaging, measures should be instituted to make the storage space as gasproof as possible, and the most vulnerable foods should be placed in the least exposed positions, keeping in mind the fact that the vapors of chemical warfare agents, heavier than air, tend to accumulate on the ground or in low places.

APPENDIX III

WATER

1. General.—*a.* Water supplies of regions evacuated by the enemy or subjected to previous chemical attack must be considered dangerous until proved otherwise. Such water may contain unchanged chemical warfare agents or their toxic hydrolytic products, or poisons deliberately added by the enemy. There was no known instance of deliberate poisoning of water supplies by the enemy in the first World War, but it is always possible in wells, small ponds, or water holes. The larger the body of water and the greater the rate of flow, the less will be the danger of serious chemical contamination because of the dilution factor.

b. In water contaminated with mustard, most of the agent will be found as a deposit on the bottom. A film of mustard will also be present on the surface, while the intermediate water levels will contain primarily the products of hydrolysis of the mustard, which are nonvesicant. The surface film of mustard will remain only briefly in flowing streams and only for 24 to 48 hours in still water, but the bottom deposit may lay unchanged for months. Lewisite will be stratified in a manner similar to mustard, but its rate of solution will be much higher. The surface films of lewisite will disappear in a few hours while the bottom deposit will be dissolved in from 2 to 3 days. Water should therefore be taken from beneath the surface with absolutely no disturbance of the bottom.

c. Personnel handling contaminated water should have adequate protection, including impermeable gloves, aprons, and gas masks.

2. Criteria of potability.—*a.* Water which is only slightly contaminated with chemical warfare agents may be safely used without treatment (except for usual chlorination) for short periods *not to exceed 1 week*, provided it meets the following criteria:

(1) It has no detectable odor or taste of chemical warfare agents.

(2) The chlorine demand of the water (see par. 3) does not exceed four parts per million.

(3) The water is clear or has only just visible turbidity.

(4) The pH of the water before chlorination is above 5.

b. Water from wells, waterholes, or small ponds in territory formerly occupied by the enemy should not be consumed until tested by a mobile section of an army laboratory and found free from poisons.

c. Water which has a chlorine demand exceeding four parts per million may often be purified in the field in emergency (see pars. 4 and 5) to render it potable enough to use for periods *not exceeding 1 week.*

3. Detection of chemical warfare agents in water.—*a.* No single analytical test has yet been devised which will detect all chemical warfare agents. Taste, odor, pH, and chlorine demand of the water are the best available field tests, but *taste and odor alone must never be relied upon.*

b. The pH of the water may be tested with paper, pH indicator strip (Medical Department item No. 13260), and the following rough check of chlorine demand may be made at the battalion aid station:

(1) Empty the contents of one water sterilizing ampoule (high test calcium hypochlorite) into any suitable small container (e. g., a medicine glass or waxed paper cup) and add 10 cubic centimeters of clean water (may be measured in a 10-cubic-centimeter syringe). Mix by stirring for several minutes.

(2) Fill a canteen with the suspected water and drop into it exactly 3 drops of the hypochlorite solution prepared above. This adds roughly 5 ppm chlorine to the water.

(3) Cap the canteen and mix thoroughly.

(4) After 10 minutes, test the water for residual chlorine by means of the chlorine test set (Medical Department item No. 94295), following the directions in the lid of the set.

(5) If at least 1 ppm chlorine remains after 10 minutes, the water may be used for short periods after chlorination, provided it is clear and free from odor or taste of chemical agent.

c. (1) If less than 1 ppm chlorine remains in the above test, or if doubt exists, the more accurate Leitch test may be used. This test is available in army laboratories, or in the offices of the army, corps, or division medical inspectors. The test is carried out as follows: To 100 cubic centimeters of the water is added 1 cubic centimeter of a standard bleach solution containing 0.5 milligrams of available chlorine per cubic centimeter (dose equivalent to 5 ppm). *Ten minutes* after the addition of the standard bleach solution, test for chlorine with the standard orthotolidine reagent.

(2) If the chlorine remaining is at least 1 ppm, the water is potable providing all other characteristics of the water meet the requirements given in paragraph 2. If the chlorine remaining is less than 1 ppm, the water is nonpotable and must not be used until purified.

4. Purification of large volumes of contaminated water.—*a.* Water must be withdrawn from the intermediate levels with minimum disturbance of the surface and no disturbance of the bottom deposit. If the bottom deposit is disturbed, large amounts of liquid mustard or lewisite may be stirred into the water and purification will then be impossible.

b. The purification of large volumes (2,000 gallons) of contaminated water by an army portable or mobile water purification unit is accomplished by Engineer Corps water supply personnel as follows:

(1) Two thousand gallons of contaminated water are pumped into a large canvas reservoir and treated with 3,000 to 5,000 ppm of activated carbon (200 mesh), 10 grains per gallon of coagulant, and sufficient alkali to give the optimum conditions for coagulation.

(2) After thorough mixing the water is allowed to settle for at least 30 minutes.

(3) After most of the added carbon has settled out, the supernatant water is filtered at about one-fourth the usual rate through the portable or mobile water purification unit.

(4) The filtered water must be tested to see that it meets the proposed characteristics for potable water outlined above.

5. Emergency purification of contaminated water.—When the portable water purification unit is not available, small amounts of water can be purified by using two Lyster bags. Thirty-six gallons of contaminated water are treated in one bag with 2 pounds of activated carbon (200 mesh), 1 ounce of alum, and 1 ounce of sodium silicate. The treated water is thoroughly mixed until a heavy floc has formed, allowed to stand undisturbed for 30 minutes, and then siphoned through a small filter and transferred to the second Lyster bag for chlorination. The filtered water must be tested to see that it meets the proposed characteristics for potable water outlined above.

6. Chlorination of contaminated water.—Since all water contaminated with chemical agents will contain considerable organic matter and will be treated with activated carbon prior to filtration,

it is necessary that chlorination be carried out only *after* filtration. The chlorine feed line from the portable water purification unit must therefore be connected to the effluent pipe from the filter. When the emergency method of purification is used, the water is chlorinated by the usual method in the second Lyster bag after the removal of all activated carbon.

APPENDIX IV

TABULATED DATA ON CHEMICAL AGENTS

1. Lung irritants.

Name / CWS symbol	PHOSGENE (Carbonyl chloride; "palite") CG	CHLORPICRIN (Trichlornitromethane; "vomiting gas") PS	CHLORINE Cl	NITRIC VAPORS (NO, NO_2, N_2O_4) None	AMMONIA None
Method of recognition.	Colorless gas, odor of cut corn, ensilage, or musty hay; renders smoking unpalatable.	Colorless, volatile liquid; vapor has odor of flypaper or licorice.	Greenish-yellow gas; odor like that of bleach; makes smoking unpalatable.	Reddish-brown fumes, with pungent aromatic odor.	Colorless gas, with sharp, penetrating odor.
Tactical uses	Casualty agent, delivered from cylinders, projectors, mortar, artillery shell, and airplane bombs.	Harassing and casualty agent, in grenades, mortar and artillery shell, airplane spray, and bombs.	Casualty agent, dispersed from cylinders and projectors.	No tactical or military use. *Incidental to* combustion of nitro-compounds and explosives.	No tactical or military use. *Incidental to* manufacturing or refrigerating accidents.
Symptoms and effects.	Coughing and lacrimation, pain and sense of constriction of the chest, dyspnoea, later pulmonary edema.	Similar to phosgene, but more irritant and lacrimating. More likely to produce vomiting. Less toxic than phosgene. Pulmonary edema may follow.	Similar to phosgene, but more irritant and less toxic. Coughing more pronounced than with phosgene or chlorpicrin. Pulmonary edema may follow.	Similar to phosgene. Irritation of nose, throat, and lungs, later pulmonary edema.	Prompt, marked irritation of eyes, nose, throat, and lungs; effective concentrations may cause temporary stoppage of respiration. Bronchitis and pneumonia may follow.
Immediate treatment.	Absolute rest and warmth, nonalcoholic hot drinks, venesection in blue stage; oxygen administration. Evacuate in prone position.	Same as for phosgene; in addition, wash splashes on skin with sodium carbonate solution or alcoholic sodium sulfite solution.	Same as for phosgene.	Same as for phosgene.	Artificial respiration, inhalation of weak acid (acetic) vapor.
Protective measures.	Service gas mask; collective protection.	Same as for phosgene.	Same as for phosgene.	Same as for phosgene.	Service gas mask canister *does not* protect against ammonia; special canister necessary.

2. Vesicants.

Name / CWS symbol	MUSTARD (Bisbetachlorethylsulfide; "Yperite" "senfgas") HS	LEWISITE (Betachlorvinyldichlorarsine) M–1	ETHYLDICHLORARSINE ("Dick") ED
Method of recognition	Dark brown to straw-yellow oily liquid, odor of vapor like that of garlic, horseradish, mustard, or onions.	Colorless to brown liquid, odor of vapor like that of geraniums; immediate sneezing and nasal irritation.	Pungent odor; rapid, intense irritation of eyes and nose; sneezing.
Tactical uses	Casualty agent delivered from mortar, howitzer and artillery shell, airplane spray, land mines, and pressure sprinklers.	Casualty agent, projected in same manner as mustard.	Casualty and harassing agent, from artillery and mortar shell, and airplane spray.
Symptoms and effects	*Vapor:* Delayed irritation and inflammation of eyes and conjunctiva; delayed erythema of skin, with or without blistering; bronchitis; pneumonia. *Liquid:* Prompt irritation, inflammation of eyes; corneal lesions may result in blindness; inflammation and erythema of skin with severe vesication.	*Vapor and liquid:* Prompt irritation and inflammation, erythema, marked vesication of the skin; severe eye lesions perhaps followed by blindness; bronchitis, and pneumonia from inhalation of vapor; systemic arsenic poisoning may occur from large burns.	Irritation, erythema, and vesication of skin; inflammation of eyes and conjunctiva; irritation of respiratory tract with marked sneezing.
Prophylaxis and immediate treatment.	*Skin:* If liquid, remove excess with cloth sponge. Dab repeatedly with a sponge moistened with a solution of dichloramine-T in triacetin. Protective ointment may be used as directed (see par. 9*e*). If this is not available, wash with alcohol, kerosene, or carbon tetrachloride, or hot water and soap. Bleach paste may be used but must be removed by washing to prevent injury. Treat burns as ordinary heat burns. *Eyes:* Irrigate with 2 percent sodium bicarbonate solution, normal saline, or water. Use eye and nose drops to control pain.	*Skin:* If liquid, remove excess with cloth sponge. Dab repeatedly with sponge moistened with hydrogen peroxide. Protective ointment may be used as directed (see par. 10*e*). If this is not available, wash with soap and water, then with sodium hydroxide solutions *followed by water.* If large skin areas are involved, the skin should be excised. Multiple incision with cupping may be a valuable procedure. *Eyes:* Use 2 to 4 drops of eye solution M–1 dropped directly on the cornea. *Do not repeat.* If not not available, irrigate with 2 percent sodium bicarbonate solution, normal saline, or water.	General treatment same as for lewisite; excision or cupping not necessary unless lesions are extensive and severe.
Protective measures	Service gas mask; protective clothing; protective ointment; collective protection.		

3. Lacrimators and sternutators.

	LACRIMATORS			STERNUTATORS (Toxic smokes)	
Name	TEAR GAS SOLUTION (Chloracetophenone, chlorpicrin, chloroform)	CHLORACETOPHENONE	BROMBENZYLCYANIDE	DIPHENYLAMINECHLORARSINE (Adamsite)	DIPHENYLCHLORARSINE
CWS symbol	CNS	CN	CA	DM	DA
Method of recognition.	Straw-colored solution with sweetish, flypaper odor.	Colorless crystals, with odor of apple or locust blossoms.	Yellowish-brown crystals or in brown solution; odor pungent and like that of sour fruit.	No odor; recognizable only by onset of symptoms. DM produces canary-yellow smoke haze; DA produces a white smoke.	
Tactical uses	Harassing agent used in mortar shells, grenades, air bombs, and airplane sprays.	Harassing agent used in candles, grenades, mortar and artillery shell, and bombs.	Harassing agent; can be used in artillery shell and airplane spray.	Harassing agent used in candles, destroyer smoke stack, burning type munitions.	Harassing agent used in burning type munitions.
Symptoms and effects.	Immediate lacrimation, photophobia, prickling or itching of the skin.	Similar to CNS, but less action on the skin.	Severe lacrimation and nasal irritation.	Sneezing with burning, aching pains in nose, throat, chest, sinuses, followed by headache, sinus pains, nausea, and often mental depression.	

First aid and immediate treatment.	Adjust gas mask and breathe deeply with eyes open. In more severe cases, wash eyes with a solution of sodium sulfite (for eyes) or with a 2 percent solution of sodium bicarbonate. *Do not rub or bandage eyes.* Persistent pain may be relieved by instilling 2 percent butyn sulfate, or eye and nose drops (item No. 91090). If necessary, skin may be washed with an alcoholic sodium sulfite solution or with a solution of sodium bicarbonate.	Inhale chlorine fumes through nose and mouth from bleach bottle; aspirin for pain. Physical restraint may be necessary to prevent self-injury.
Protective measures.	Service gas mask; collective protection	Service gas mask; collective protection.

4. Systemic poisons.

Name / CWS symbol	HYDROCYANIC ACID (HCN; prussic acid) — None	ARSINE (AsH_3) — None	HYDROGEN SULFIDE (H_2S) — None	CARBON MONOXIDE (CO) — None
Method of recognition	Colorless, volatile liquid; odor of vapor like that of peach kernels, or oil of bitter almonds.	Colorless, inflammable gas, with nauseating, garliclike odor.	Colorless gas, with odor of rotten eggs.	Colorless, odorless gas; recognizable only by onset of symptoms.
Tactical uses	Casualty agent. Used in artillery shell.	Casualty agent. Potential use in cylinders, shells, and bombs, or in form of arsenical powder which would liberate arsine on contact with moisture.	No tactical use. Is *incidental* to chemical manufacturing, analyses, and putrefactive processes.	No tactical use. Is *incidental* to bursting of explosive shell, or various types of combustion, i. e., gun blasts, engine exhausts, etc.
Symptoms and effects	Low concentration of vapor may cause giddiness or headache; effective vapor concentrations or the liquid rapidly produce convulsions, unconsciousness, or death from tissue asphyxia or medullary paralysis.	Shivering, weakness, giddiness, nausea, vomiting, headache, gray color, collapse; hemolysis, anemia, anuria, uremia.	Irritation of eyes, nose, respiratory tract; bronchitis; high concentrations cause unconsciousness and death.	Dizziness, headache, weakness, nausea and vomiting, feeling of constriction in thorax, followed by drowsiness, visual disturbances, stupor, unconsciousness, weakened pulse and respiration, and death.
First aid and immediate treatment.	Inhale amyl nitrite. Give artificial respiration if necessary. Sodium nitrite, sodium thiosulfate, or methylene blue should be given intravenously.	Absolute rest; evacuate in prone position. Give large amounts of fluid, blood transfusions, and try to promote diuresis.	Absolute rest; artificial respiration. Give oxygen-carbon dioxide and blood transfusions.	Artificial respiration, administration of oxygen or oxygen-carbon dioxide; venesection with transfusion of healthy blood may be valuable.
Protective measures	Service gas masks; collective protection			*Service gas mask canister does not protect against carbon monoxides;* special canister is necessary.

5. Incendiaries.

Name CWS symbol	WHITE PHOSPHORUS WP	THERMITE TH	ELECTRON BOMB[1] None
Method of recognition.	Smoke has no odor. Element burns only in presence of oxygen (air), so action can be stopped with water. Will reignite on access of air. Solid has odor of matches.	On ignition forms red, molten mass of metal giving off extremely hot reddish yellow flame, extinguishable with water.	On ignition burns with brilliant white, intensely hot flame, casing of shell being consumed. Water only increases combustion and may cause explosion in closed space.
Tactical uses	Screening and casualty agent. Used in grenades, mortar and artillery shell, airplane bombs.	Incendiary agent for matériel. Used in airplane bombs (and perhaps shell).	Incendiary agent for matériel. Used in airplane bombs.
Symptoms and effects	Severe burns depending on size of particles and length of contact.	Same as with white phosphorus.	More severe penetrating burns than with white phosphorus or thermite, as it continues to burn in tissues in presence of moisture.
First aid and immediate treatment.	Cover burning surfaces with water, or preferably 5 percent copper sulfate solution, and remove phosphorus particles with forceps. Further treatment same as for ordinary burns.	Spray burning areas with water, and remove pieces of material. Further treatment same as for ordinary burns.	Remove burning material. Treatment of injuries that of ordinary burns.
Protective measures	Fireproof clothing or shelters are the only protective measures.		

[1] The electron bomb is a magnesium case filled with fast-burning thermite. The thermite sets fire to the magnesium case which is the effective incendiary material in this bomb. Electron bombs are being widely used in the present conflict.

6. Differential diagnosis of lung irritant casualties.

Agent	PHOSGENE (CG)	CHLORPICRIN (PS)	CHLORINE (Cl)	NITRIC FUMES
Odor	Like cut corn, moldy hay.	Like licorice, sweetish, flypaper.	Pungent.	
Appearance of casualty	Normal, or cyanotic or gray.	Prompt lacrimation and cough, nausea, emesis.	Face flushed; very uncomfortable.	Normal or cyanotic.
Latent period	Long.	Moderate.	Short.	Long.
Cyanosis	Marked.	Not marked early.	Marked.	Marked.
Engorgement of neck veins.	Present except in gray form.	Not present early.	Present.	Present.
Sputa	Abundant, frothy, bloody.	Sparse at first unless exposure was severe. Later may become purulent.	Abundant, frothy, bloody.	Abundant, bloody, frothy.
Cough	Violent.	Violent, paroxysmal.	Violent, paroxysmal.	Violent.
Chest pain	Not marked.	Marked.	Severe.	Not marked.
Auscultation of chest	Moisture throughout.	Moisture at first in bronchi, later throughout.	Moisture throughout.	Moisture throughout.
Secondary broncho-pneumonia.	Uncommon.	Not uncommon after 24 hours.	Uncommon.	Uncommon.
Prognosis	Poor with blue or gray; better if survives 48 hours.	Good unless pulmonary edema or broncho-pneumonia develops.	Good unless pulmonary edema.	Good if no pulmonary edema.

Agent	PHOSGENE (CG)	CHLORPICRIN (PS)	CHLORINE (Cl)	NITRIC FUMES
Characteristic post mortem findings.	Alveolar involvement chiefly pulmonary edema.	Necrosis of bronchial epithelium more pronounced in medium-sized and small bronchi; edema and congestion of the lungs; widespread damage of alveoli walls; edema of mediastinal tissues and pleura; conjunctivitis and skin burns may be present.	Damage to upper bronchi and some alveoli; pulmonary edema.	Pulmonary edema.

Agent	MUSTARD (HS)	LEWISITE (M-1)	ETHYLDICHLORARSINE (ED)
Odor	Garlic.	Geranium.	
Appearance of casualty	May be associated skin burns.	Same as for HS.	Sneezing, lacrimation, skin burns.
Latent period	Long.	Short.	Short.
Cyanosis	Not marked early.	Not marked early.	Not marked.
Engorgement of neck veins	Not present at first unless there is pulmonary edema.	Same as for HS.	Not present early.
Sputa	Sparse unless pulmonary edema; later mucopurulent.	Same as for HS.	Sparse.
Cough	Not marked early unless pulmonary edema.	Same as for HS.	Same as for HS.
Chest pain	Not marked early unless pneumonia.	Not marked early unless pneumonia.	Burning type.
Auscultation of chest	Moisture chiefly in bronchi. Later signs of consolidation.	Same as for HS.	Moisture chiefly in bronchi.
Secondary broncho-pneumonia.	Common.	Common.	Uncommon.
Prognosis	Good if no broncho-pneumonia and no extensive burns.	Same as for HS.	Rarely fatal under field conditions.
Characteristic post mortem findings.	Purulent broncho-pneumonia with ulcerations in upper bronchial tree. Skin burns.	Purulent broncho-pneumonia with ulcerations in upper bronchial tree. Skin burns. Arsenic in skin and viscera.	Toxic changes in viscera; arsenic present.

7. Differential diagnosis of vesicant casualties.

Name	MUSTARD (HS) (Bisbetachlorethylsulfide)	LEWISITE (M-1) (Chlorvinyldichlorarsine)	ETHYLDICHLORARSINE (ED)
Odor	Garlic.	Geranium.	Biting.
Onset	Slow.	Rapid.	Rapid.
Pain at onset	Slight or none.	Severe.	Slight.
Erythema around blister	Marked.	Slight.	Slight.
Early color of blister	Clear.	Opaque.	Opaque.
Degree of blistering	Severe.	Very severe.	Moderate.
Later secondary infection of blisters	Common.	Uncommon.	Uncommon.
Associated systemic poisoning	Uncommon (toxemia).	Common (arsenical).	Fairly common (arsenical).
Pigmentation after healing	Common.	Uncommon.	Uncommon.
Prognosis	May be fatal if broncho-pneumonia occurs.	May be fatal from arsenical poisoning.	Rarely fatal under field conditions.

APPENDIX V

MISCELLANEOUS DATA FOR MEDICAL OFFICERS

1. Useful rules on treatment of chemical casualties.—*a. What to do.*—(1) Learn gas discipline yourself.

(2) Protect yourself from contamination.

(3) Give treatment as rapidly as possible.

(4) Evacuate your chemical casualties as rapidly as possible.

(5) Make every effort to know the exact etiologic agent or agents.

(6) Examine the casualty for nongas wounds.

b. What not to do.—(1) Do not allow phosgene cases which show any symptoms to be up and about.

(2) Do not give artificial respiration to acute phosgene casualties.

(3) Do not give morphine to phosgene cases.

(4) Do not use cocaine in mustardized eyes.

(5) Do not forget that there may be latent periods with many of the chemical agents.

(6) Do not use contaminated gloves on a nonchemical casualty.

(7) Do not fail to look at the eyes of all casualties.

c. Treatment cautions.—(1) The primary step in immediate procedure is to remove the casualty from the contaminated environment; if this is not possible, he should be properly masked or placed in a collective protection shelter.

(2) Clothing which has been splashed with a liquid agent should be removed immediately.

(3) Affected eyes should never be rubbed or bandaged but should be shielded from light.

2. Questions to be asked patient in order to establish diagnosis.—*a.* When were you exposed?

b. Where were you and what were you doing?

c. Did you apply any first aid?

d. Do you know what agent was used?

e. What did the agent smell like?

f. Was it used as a gas or spray?

g. How long was it before you put on your mask?

h. When did you remove your mask?

i. What ill effects did you first feel?

j. How do you feel now?

k. What treatment have you had?

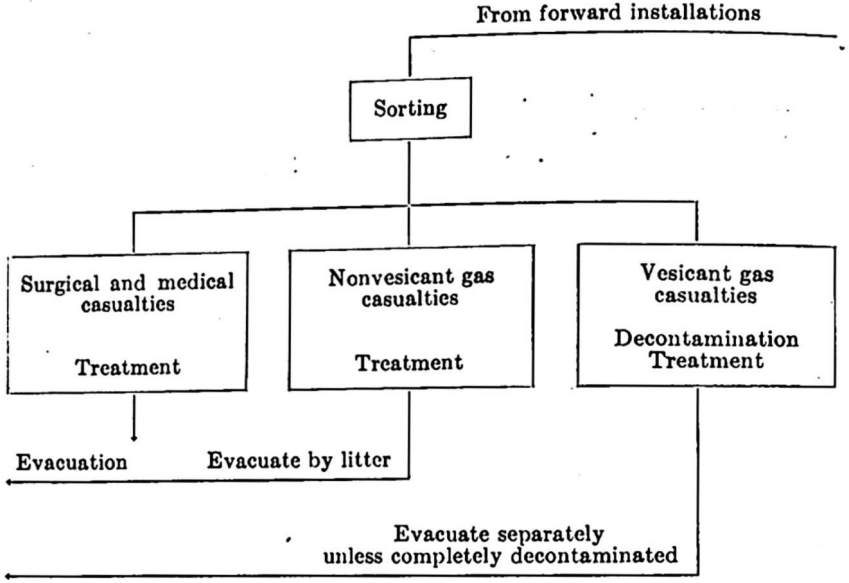
l. Have you any other wounds?

m. Have you been sick lately?

n. Did you walk or ride here?

o. How does a cigarette taste to you?

3. Evacuation chart for gas casualties.—The following chart shows sorting and evacuation of casualties and necessary separation of vesicant casualties in flow to rear.



4. Identification of agents by odor.—*a.* Do not inhale deeply; sniff.

b. Sniff only once. Repeated sniffing dulls sense of smell.

c. First sniff, then think. The memory of odors can be trained by practice.

d. Every perception of odor must be named. Learn odors by the memory of the thing sniffed rather than by name of something else.

e. After each test, breathe out strongly through the nose several times. Do not sniff a new sample until the old perception of odor has vanished.

f. Do not smoke while sniffing. Smoking dulls sense of smell.

g. Do not forget that sometimes a heavy concentration of an agent may be odorless.

h. Select for gas sentry a man with a trained sense of smell.

5. Medical estimate of situation—weather and terrain.—*a. Classification.*[1]

[1] A majority of factors determines classification.

	Favorable	Average	Unfavorable
Sky	Heavily overcast.	Partly overcast.	Clear.
Time of day	Night or early morning.	Midmorning, late afternoon.	11 AM to 4 PM.
Terrain	Level field or water.	Moderately rolling farm lands.	Broken or wooded.
Ground temperature.	Colder than air.	Air and ground nearly same temperature.	Much hotter than air.
Winds	Steady, 0 to 4 mph for gas clouds and for gas fired by projectiles; steady, 5 to 8 mph for smoke.	Slightly shifting, 4 to 9 mph for gas; slightly shifting, 8 to 12 mph for smoke.	Variable, over 9 mph for gas; over 12 mph for smoke.

b. Persistency of mustard gas versus ability to produce casualties.—This table shows the danger periods to be observed when traversing or occupying contaminated terrain under average weather conditions. Service dress (not impregnated) with leggings is assumed; the periods are shorter if protective clothing is worn. Allowance must be made for HS thickened for higher viscosity. These estimates are for open country; add 50 to 200 percent to the danger period when in woods of varying density. It is *not safe* to traverse or occupy a mustard contaminated area until the period of days or hours shown in the table have elapsed after contamination, under *average weather conditions.* If doubt exists, gas detectors (see FM 21–40) should be employed.

Number	Degree of contamination square yards/ gallons	Traversing [1]				Occupation [1]	
		Long grass (6 inches and over)	Medium grass (1 to 6 inches)	Short grass (under 1 inch)	Hard ground	Grass any length	Hard ground
1	25	2 to 4	1	(6) to (18)	(1) to (6)	7 to 9	1 to 2
2	150	1 to 2	6 to 18	(3) to (9)	Nil	3 to 4	(6) to (18)
3	720	(6) to (18)	(1) to (6)	Nil	Nil	1	(6) to (18)
4	Airplane spray from low altitudes (less for higher altitudes).	(2) to (8)	(2) to (3)	(1) to (2)	(½) to (1)	Probably same as 3 above.	

[1] Figures in parentheses are for hours, remainder are for days.

6. Field test of hydrogen peroxide.—*a.* Hydrogen peroxide deteriorates with age. Its strength should be checked occasionally, especially before moving into an area where gas warfare is likely.

b. Apparatus (available at any aid station or hospital).

Container: Paper or enamelware cup, or 2-ounce graduate.
10-cubic-centimeter Syringe, Luer.
2-cubic-centimeter Syringe, Luer.
25-gage hypodermic needle.
Adhesive tape, 3- by 1-inch strip.
Bottle (from Medical Department chest No. 2).

c. Reagents.—(1) Copper solution:

Copper sulfate---------- 4 grams (⅛ oz)
Aromatic spirits of ammonia----- 90 cubic centimeters (3 ozs)

Mix in bottle and shake frequently. Use after 2 hours. Save for future use.

(2) Water, clear (not chlorinated).

d. Procedure.—(1) Use *clean* apparatus.

(2) Place *exactly* 18 cubic centimeters of water in a paper or enamelware cup, or graduate. Measure carefully, using the 10-cubic-centimeter syringe.

(3) Draw *exactly* 2 cubic centimeters of the hydrogen peroxide solution into a 2-cubic-centimeter syringe and expel it into the 18 cubic centimeters of water. Measure carefully. Mix well.

(4) Draw *exactly* 3 cubic centimeters of the diluted sample into the 10-cubic-centimeter syringe and dry the tip and barrel of the syringe with gauze or cotton. Measure carefully.

(5) Place the tip of the 10-cubic-centimeter syringe in the center of the sticky side of the strip of adhesive tape, fold the ends upward, and attach them securely to the syringe barrel. Press the excess tape tightly around the tip. (Use care not to allow air to enter, or fluid to escape from the syringe.)

(6) Rinse the 2-cubic-centimeter syringe with water, and draw into it about 2.5 cubic centimeters of the copper solution. Attach the 25-gage needle and insert the needle through the adhesive tape into the hole of the 10-cubic-centimeter syringe tip as far as possible so that the hub of the needle is in firm contact with the tape. Expel the copper solution into the 10-cubic-centimeter syringe.

(7) Hold both syringes in the coupled position and shake gently in a horizontal plane for 2 minutes.

(8) Invert, holding the plunger of the 10-cubic-centimeter syringe below, and read the volume of gas present in the 10-cubic-centimeter

syringe (space above the liquid). Check the 10-cubic-centimeter syringe to see that the plunger is not sticking but is freely movable.

(9) Repeat steps (7) and (8) above until a constant reading is obtained (completion of the reaction).

(10) The number of cubic centimeters of gas gives the percentage of hydrogen peroxide directly; for example, 5 cubic centimeters of gas equal 5 percent H_2O_2. This is an approximation only, accurate to ±25 percent.

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The Adjutant General.

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