TREATMENT OF CASUALTIES

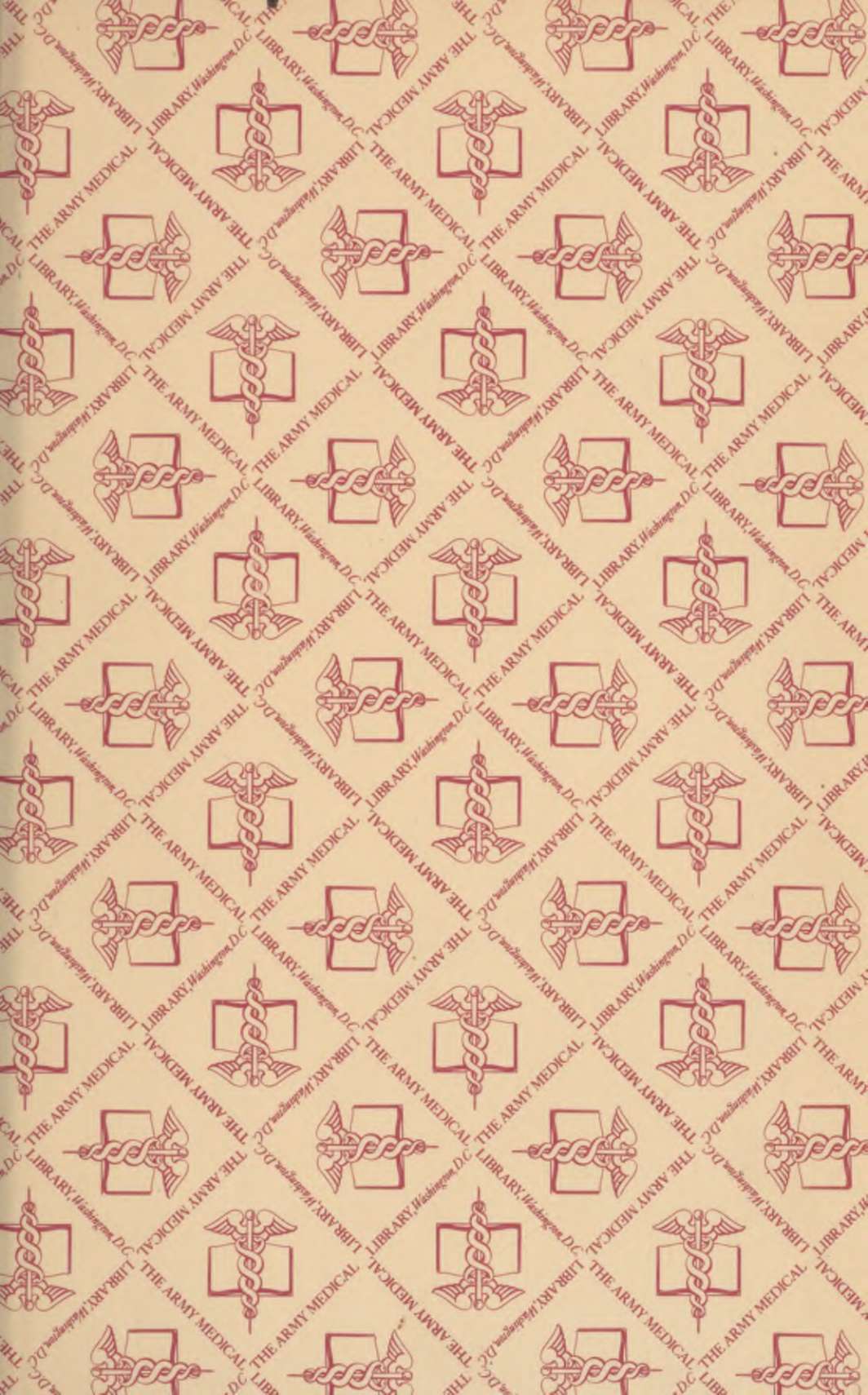
FROM

CHEMICAL WARFARE AGENTS

NAVMED 220

A MANUAL
FOR THE INFORMATION AND GUIDANCE
OF MEDICAL OFFICERS
UNITED STATES NAVY

20 JULY 1944


THE ARMY MEDICAL LIBRARY, Washington, D.C.

RESTRICTED

MANUAL ON

TREATMENT OF CASUALTIES

FROM

CHEMICAL WARFARE AGENTS

NAVMED 220

Issued By

THE BUREAU OF MEDICINE AND SURGERY

NAVY DEPARTMENT

1944

United States Government Printing Office
Washington: 1944

PREFACE

This Manual on the Treatment of Casualties from Chemical Warfare Agents is published for the information and guidance of medical officers.

Its purpose is to make available in concise form the most recent and generally accepted data concerning self-aid, first-aid, and definitive treatment of casualties from Chemical Warfare Agents. Certain additional topics with respect to gas defense falling under the cognizance of the medical officer, have also been included.

This material is largely based upon the latest revision of Technical Manual TM 8-285, Treatment of Casualties from Chemical Agents, War Department. Representatives of the Medical Corps of the Navy and of the Committee on the Treatment of Gas Casualties of the National Research Council collaborated with representatives of the Medical Division of the Chemical Warfare Service, War Department in the preparation of this revision. Acknowledgment is made herewith to the Surgeon General, United States Army, for authority to duplicate certain chapters.

Ross T McIntire
Surgeon General, United States Navy

TABLE OF CONTENTS

SECTION I

GENERAL

1. INTRODUCTION

A. Chemical warfare agents are used to produce casualties, to make areas both ashore and afloat impassable or untenable, to render food, water and material unusable, to provide concealment and to start fires.

B. The scope of chemical warfare is broad. It aims at groups rather than individuals. Gas may penetrate turrets, compartments, emplacements, dugouts and trenches. Projected from the airplane, chemical agents may produce casualties and contamination in topside battle stations, or within ships even though far out to sea, as well as on shore stations, beaches or far back into rear areas.

C. In contemplating casualties due to gas attack cognizance must be given to specific problems pertaining to naval operations in contrast to shore operations. Especially should it be stressed that contaminated areas on land may be avoided, whereas at sea, once a ship is contaminated, the personnel must not only continue to fight in the contaminated area, but will be forced to eat, sleep, rest and live in it until decontaminated.

D. The medical officer must be familiar with the tactics of chemical attack and the methods of defense to lessen or neutralize its effect. He must realize that the most effective gas defense for personnel demands fearless action, the best possible use of protective equipment and, when exposed, prompt self-aid.

E. The medical officer afloat must be acquainted with the *damage control organization* of the ship. He must formulate his plans accordingly and in conformity with the necessary compromise between the function of the ship as a combat unit and the effective handling of casualties when they occur. Stations for the decontamination of wounded gas casualties must be so placed as to be available quickly without contaminating otherwise clean passageways and compartments.

F. The medical officer attached to shore activities must appreciate the problems specific to such activities. He must devise plans for the care of gassed cases with additional injury whether they be in forward areas or on shore stations within range of gas attack. Undue delay in decontamination must be avoided and gas-contaminated personnel must be denied admission to medical installations not specifically designated to handle such cases.

G. The purpose of this manual is to acquaint medical personnel with the treatment of casualties produced by chemical agents.

2. CLASSIFICATION OF AGENTS

Chemical warfare agents are classified according to their physiological action, persistency, and tactical use.

A. Classification by Physiological Action.—(1) *Lung irritants* (choking gases) primarily irritate and damage the respiratory tract. Example: Phosgene.

(2) *Vesicants* (blister gases) injure the eyes, produce reddening and blistering of the skin, and when inhaled damage the respiratory tract. Example: mustard.

(3) *Lacrimators* (tear gases) act primarily on the eyes, causing tears and intense, though temporary, pain. Example: chloracetophenone.

(4) *Irritant smokes or sternutators* (vomiting gases) irritate the nose, throat and eyes. They may produce temporary prostration. Example: diphenylaminechlorarsine (adamsite).

(5) *Systemic poisons* (blood and nerve poisons) stop essential physiological processes. Example: hydrocyanic acid.

B. Classification by Persistency.—The ability of an agent to maintain an effective concentration under field conditions is called its persistency.

(1) *Persistent agents* maintain effective concentrations longer than 10 minutes, and then may last for days or weeks. They are used to neutralize or force evacuation of certain areas. Example: mustard.

(2) *Nonpersistent agents* maintain effective concentrations less than 10 minutes. They do not render ground untenable after the cloud has passed. Example: phosgene.

C. Classification by Tactical Use. (1) *Casualty agents* injure personnel. Example: mustard and phosgene.

(2) *Harassing agents* force the wearing of masks and thus impede operations. Example: irritant smoke.

(3) *Screening agents* produce obscuring smoke to prevent observation. Example: white phosphorus.

(4) *Incendiaries* ignite materiel and produce burns on personnel. Example: thermite.

3. FUNDAMENTALS OF SELF-AID AND TREATMENT

A. *Prompt Self-Aid* is the most important factor in reducing the number of gas casualties. It is concerned with the removal and neutralization of the chemical agent before serious injury occurs. Unless incapacitated, each man will care for himself at the earliest possible moment.

B. *Definitive Treatment* is designed to promote healing after injury has occurred and should be differentiated from Self-Aid. This is the function of the Medical Department.

SECTION II

LUNG IRRITANTS

4. GENERAL

A. The primary lung irritants are phosgene, diphosgene, chlorpicrin, chlorine and nitrous fumes. In general, the gases which are the most irritating, such as chlorine and chlorpicrin, are most likely to injure the trachea and bronchi. Those which are less irritating, such as phosgene and nitrous fumes, produce their major effect on the lungs and cause pulmonary edema. In addition to the above-designated lung irritants, vesicants and certain systemic poisons also damage the respiratory tract. (See sections III and VIII.)

B. Personnel exposed to a lung-irritant gas need not be withdrawn during combat unless signs of pulmonary distress are apparent. The medical officer should so advise the responsible commanding officer.

C. The service mask and collective protector offer adequate protection. On detection, hold the breath instantly, apply the mask and exhale as completely as possible. Speed is absolutely essential.

5. PHOSGENE (CG) AND DIPHOSGENE (DP)

Phosgene and Diphosgene are essentially similar in pathology, symptoms and treatment.

A. *Pathology.*—Phosgene has no effect on the skin. In the upper respiratory tract and the eyes it may produce a mild inflammatory reaction. Its main sites of action are the bronchioles and alveoli. Congestion, edema and mild cellular infiltration of the bronchiolar or alveolar wall, with alternating patches of emphysema, are present soon after exposure. The permeability of the capillaries is increased, and plasma-like fluid escapes into the alveoli. This accumulation of fluid reduces the space vital for respiratory exchange, fills many of the bronchioles, and produces pulmonary consolidation. Areas of lung not so consolidated become emphysematous. As plasma is lost into the lungs, hemoconcentration and anoxemia result. Small hemorrhages, due to the anoxia, are frequent in the lungs and elsewhere, especially in the central nervous system. Death may result finally from oxygen want. If recovery takes place, the fluid in the lungs is absorbed or expectorated. Patchy areas of fibrosis represent the

healed lung lesion. This focal scarring follows the injury by the gas and usually is not a result of a bacterial bronchopneumonia. Occasionally, however, a bacterial pneumonia may be superimposed.

B. *Symptoms.*—Immediately after exposure there is likely to be coughing, choking, a feeling of tightness in the chest, and lacrimation. The presence or absence of these symptoms is of little value in immediate prognosis as some patients with severe cough fail to develop serious lung injury, while others with no signs of respiratory tract irritation go on to fatal pulmonary edema. There may be slowing of the pulse initially, followed usually by an increase in rate. This transient bradycardia is presumptive evidence of phosgene poisoning. A period follows during which abnormal chest signs are absent and the patient may be symptom-free. This interval commonly lasts 2 to 24 hours, but occasionally is shorter. It is terminated by the signs and symptoms of pulmonary edema. These begin with rapid, shallow breathing, painful cough, and *cyanosis* (blue stage). Nausea and vomiting may appear. As the edema progresses, discomfort, apprehension and dyspnea increase, and much frothy sputum is raised. Rales and rhonchi are audible over the chest. The patient may develop a shock-like state with leaden, clammy skin, low blood-pressure and a feeble heart (gray stage).

C. *Diagnosis.*—Irritation of the nose and throat by phosgene may be mistaken for an upper respiratory tract infection. Difficulty in breathing and complaint of tightness in the chest may suggest an acute asthmatic attack. The pulmonary edema is like that produced by many other war gases and may be confused with the edema associated with heart failure. Diagnosis can be established with certainty only from a definite history of exposure to phosgene, the odor suggesting musty or burned hay, silage or green corn.

D. *Treatment.*—(1) *Rest.*—Pending the appearance of definite symptoms, men may continue their duties. When symptoms appear, if there is no respiratory distress with moderate exertion, casualties may be evacuated by walking. Essential equipment may be carried. Unnecessary exertion is to be avoided.

(2) *Warmth.*—Phosgene casualties should be kept only comfortably warm.

(3) *Oxygen therapy.*—Anoxia should be treated with oxygen. The need for oxygen is indicated by cough, dyspnea, cyanosis and restlessness. Oxygen should be administered in as high a concentration as possible, in any case high enough to eliminate cyanosis. Oxygen decreases anoxia and quiets the patients. It is best administered by a mask which allows regulation of the proportions of oxygen and air. Lower and less well-controlled concentrations of oxygen are obtainable in tents and with nasal catheters. Carbon dioxide-oxygen mixtures are not indicated in phosgene poisoning.

(4) *Venesection.*—There is at present no definite evidence that venesection is beneficial at any time; it is certainly harmful during the shock-like state.

(5) *Sedation.*—If oxygen fails to quiet the patient, morphine may be used subcutaneously in a dose of .01 to .015 grams (grains 1/6 to ¼). The physician must weigh the value of its sedative effect against its depression of respiration. Codeine may be more useful than morphine if cough is the prominent symptom. Sedative doses of barbiturates are ineffective and larger doses may be harmful.

(6) *Chemotherapy.*—Sulfonamides should not be given during the latent period. Thereafter they should be administered for the prevention of pulmonary infection as soon as the edema begins to subside, as evidenced by an improvement in the patient's general condition. Two grams (grains 30) of sulfadiazine should be given initially, followed by 1 gram (grains 15) every six hours for five to seven days. The urine should be kept alkaline during sulfonamide therapy by the administration of 2 grams (grains 30) of sodium bicarbonate every 4 hours. Sufficient fluids should be given to maintain a daily urinary output of at least 1 liter (about 1 quart).

(7) *Expectorants.*—Expectorants should not be used in the treatment of pulmonary edema. They may be of value in relieving cough when irritation is limited to the upper respiratory tract.

(8) *Other measures.*—Atropine does not diminish edema or improve breathing; its acceleratory action on the heart is undesirable. Plasma is of no value in the treatment of phosgene poisoning. Infusions pass readily into the lungs and increase the edema. Concentrated plasma is even more harmful. Surgery, except emergency measures to save life, is contraindicated in the active stage of edema. If anesthesia is required, local infiltration or nerve block is the method of choice. Cardiac and respiratory stimulants, such as adrenalin, ephedrine, benzedrine, coramine, and metrazol do more harm than good. Alcohol is contraindicated.

E. *Convalescent care.*—Absolute rest must be continued until the acute symptoms have disappeared. As recovery progresses, exercise should be resumed gradually. Sitting in bed should be permitted first, then for brief intervals in a chair. Bathroom privileges should follow and then short periods of alternate walking and resting. Later the convalescent should walk increasing distances.

F. *Prognosis.*—Prognosis should be guarded because of the insidious nature of the poisoning. Most deaths occur within the first 48 hours. The few which occur later are due largely to bronchopneumonia. Casualties from phosgene which survive more than 48 hours usually recover without sequelae. Rarely chronic bronchitis and bronchiectasis result. The incidence of tuberculosis is not greater in men with a history of phosgene poisoning than in the general population.

6. CHLORPICRIN (PS)

A. *Pathology.*—(1) Chlorpicrin vapor produces conjunctivitis and may, after severe exposure, cause corneal ulceration.

(2) The epithelium of the respiratory tract is injured by chlorpicrin. In the trachea and large bronchi the damage may be only slight and temporary, but in the small bronchi there is more necrosis of the epithelium than is produced by either phosgene or chlorine. In the alveoli chlorpicrin produces less injury than phosgene, but more than chlorine.

(3) The vapor of chlorpicrin irritates the skin, and the liquid can produce deep burns.

B. *Symptoms.*—Irritation of the eyes is the first symptom noted, as chlorpicrin is a strong lacrimator. This is frequently followed by pain in the chest, cough, nausea and vomiting. Severe exposure causes pulmonary edema, like that produced by phosgene, and generalized muscular weakness, with feeble heart action. Repeated small exposures increase susceptibility to asthmatic attacks from traces of this gas.

C. *Diagnosis.*—Diagnosis can be established by a history of exposure, a characteristic fly paper odor on clothing and the symptoms described above.

D. *Treatment.*—Irritation of the eyes and nose can be relieved by irrigation with water, followed by the instillation of butyn ophthalmic ointment or a few drops of solution, anesthetic. Inhalation of steam relieves the tracheobronchial irritation. Codeine helps to allay the cough. If pulmonary edema develops, it is treated like that caused by phosgene. (See par. 5 D, page 4.)

E. *Prognosis.*—Most deaths occur in the first 24 hours and if later, are due usually to bronchopneumonia. Casualties surviving this period generally recover without sequelae.

7. CHLORINE (CL)

A. Chlorine is very irritating to the respiratory tract. It produces damage which may result in necrosis of the mucous membrane of the trachea, bronchi and lungs. Pulmonary edema occurs, and is similar to that caused by phosgene. After exposure, the initial symptoms are burning in the throat, violent coughing, and a feeling of suffocation. Pulmonary edema follows sometimes within 20 minutes. The history and the intense irritation of the nose and throat are aids to early diagnosis. The treatment of chlorine poisoning is the same as that outlined for chlorpicrin. (See par. 6 D, page 6.)

8. NITRIC (NITROUS) FUMES

A. *Properties.*—Nitric fumes consist chiefly of mixtures of the oxides of nitrogen. They are orange-yellow to red-brown in color, soluble in water, and react with water and oxygen to form nitrous and nitric acids.

B. *Occurrence of poisoning.*—The danger of nitrous fume poisoning is great if high explosives such as smokeless powder or cordite are burned or detonated under conditions of deficient ventilation. This may occur in gun pits and armored vehicles, ship magazines and turrets, as well as in mining and tunneling operations. Nitrogen dioxide may be used as a war gas.

C. *Pathology.*—Nitrous fumes, like phosgene, so damage the bronchioles and alveoli of the lung that pulmonary edema with progressive anoxemia and hemoconcentration develops. Inflammatory changes of the upper respiratory tract also are produced but are moderate. Bacterial bronchopneumonia or peribronchial fibrosis may be sequelae. In the brain, hyperemia and multiple small hemorrhages are common in fatal cases. Continued exposure to nitrous fumes may lead to chronic inflammation of the mucous membranes of the eyes and upper respiratory tract.

D. *Symptoms.*—When inhaled, nitrous fumes may cause little or no discomfort. There may be coughing or choking, possibly followed by headache, nausea, and vomiting. In some patients central nervous system symptoms predominate. After a latent period of variable length, the signs and symptoms associated with increasing pulmonary edema and anoxemia may appear.

E. *Diagnosis.*—The diagnosis is made from the history, the symptoms described and sometimes from the pungent odor or the yellow discoloration of the exposed mucous membranes.

F. *Treatment.*—Treatment of casualties with symptoms of pulmonary irritation is the same as that outlined for phosgene poisoning. (See par. 5 D, page 4.) The few cases with symptoms referable to the central nervous system either die quickly or on removal to fresh air recover spontaneously.

G. *Prognosis.*—Fatal cases usually die within 48 hours. Bronchopneumonia and varying degrees of pulmonary fibrosis and emphysema often follow recovery from the acute stage.

SECTION III

VESICANTS

9. GENERAL

A. The vesicants act primarily on the eyes and skin. In addition, they damage the respiratory tract when inhaled and when absorbed, they cause systemic poisoning. The nitrogen mustards and the arsenical vesicants are the most dangerous in this last respect.

B. Vesicants poison food and water, and render other materials dangerous to handle.

C. Casualties contaminated with vesicants endanger unprotected attendants. Those in contact with such patients should wear gas masks, impermeable aprons and gloves, and other protective clothing if the area is contaminated. Exposed areas of the skin should be covered with protective ointment.

D. Special precautions must be taken in receiving contaminated casualties to prevent injury of others. These casualties should be undressed in the open to prevent vapor accumulation indoors. They should be kept separate from uncontaminated patients until decontamination is complete. Contaminated litters, blankets and equipment should be left outdoors. It is necessary to decontaminate equipment and ambulances after transporting such casualties. (See section XI, page 53 and section XV, page 69.)

E. Identification of the agent is essential in order to apply specific treatment.

F. The gas mask protects only the face, eyes and respiratory tract. The eye shield protects the eyes from contamination by liquid, but not from vapor. Permeable protective clothing protects the wearer from field concentrations of vapor and droplets of liquid vesicant for a limited period. Large drops of blister gas exhaust the impregnite in the clothing at the point where the liquid wets the fabric and some of the agents will then penetrate to the body of the wearer. Ointment Protective S-461 or S-330 prevents mustard gas from reaching the skin covered by the Ointment.

G. *After exposure without adequate protection, immediate self-aid is essential.*—(1) *Self-Aid* is the individual responsibility of all hands in all branches of the Navy and Marine Corps and must be accomplished immediately after contamination if battle conditions permit. Only casualties who are physically unable to decontaminate themselves are cared for by medical personnel.

(2) If exposed to vapor, the gas mask must be put on at once.

(3) If splashed by liquid vesicant, Self-Aid is as follows:

a. Decontaminate at once. Do not expect or wait for help from others.

b. Speed is essential. The imperative need of prompt action cannot be overstressed. Correct decontamination of the eyes and skin during the first minute is always successful. After two minutes in the eye and three minutes on the perspiring skin or five minutes on the cool dry skin, no method of decontamination will prevent serious injury.

c. Decontamination should be performed, however, no matter how late, as long as liquid mustard is still present. On the other hand, decontamination is of no value after vapor exposure.

d. Vapor inhaled from splashes on the skin or clothing will damage the trachea, bronchi and lungs. This means every effort should be made to avoid breathing the fumes.

e. All decontamination must be completed as rapidly as possible, in fact within the first five minutes if injury is to be avoided.

10. MUSTARD (H)

A. *Properties.*—Mustard is an oily liquid slightly soluble in water, more in fats and oils, and freely in gasoline, kerosene, acetone, carbon tetrachloride, and alcohol. These solvents do not destroy mustard. It is slowly absorbed by rubber gloves and rubber clothing, and so may contaminate the inner surfaces of these articles. Its odor is like garlic or horseradish. Mustard disappears slowly through evaporation and hydrolysis in moist ground. It can be destroyed rapidly by decontaminating chemicals and by boiling. The persistence of hazard from the liquid agent or its vapor depends upon the degree of contamination, the character of the contaminated material, the climatic conditions, and whether a vessel is underway or at anchor. Examples of persistence are given in the following table for average summer weather on open grassy ground:

Degree of Contamination Pounds of H per square 100 by 100 yd.	Can be traversed after	Can be occupied after
1,000 lb.	6–18 hr.	4–5 days.
250 lb.	1–6 hr.	1–2 days.
25 lb.	Immediately	1 day.

The table assumes the wearing of the service uniform (not impregnated) and no anti-gas precautions. The above estimates are for average open ground and would be multiplied by factors of two or four for wooded areas. In winter

the persistence is two to five times as long as in summer. All values of persistence times are estimates and should be checked by gas detection devices such as paper, crayon and paint detectors.

B. *Eyes.*—(1) *Pathology, symptoms and prognosis.*—a. The eye is more vulnerable to mustard than either the respiratory tract or the skin. Eye lesions follow an exposure of 2 hours to a concentration barely perceptible by odor. (0.001 mg. per liter.) This exposure does not affect the respiratory tract or skin. (Plate No. 7.)

b. A latent period of 2 to 36 hours follows mild exposure, after which there is lacrimation and sensation of grit in the eyes. The conjunctivae and lids become red and edematous. Heavy exposure irritates the eye after a latent period of minutes to hours, and produces more severe lesions. Mustard burns of the eye may be divided into the following groups:

a. Mild conjunctivitis: (75 percent of all Mustard eye cases in World War I). Recovery, 1–2 weeks.

b. Severe conjunctivitis: (15 percent of cases). Blepharospasm, and edema of lids and conjunctivae; orange-peel roughening of the cornea. Recovery: 2-6 weeks.

c. Mild corneal involvement: (10 percent of cases). Areas of corneal erosion staining green with 2 percent of fluorescein. Superficial corneal scarring and vascularization. Iritis with a tendency to temporary relapses. Convalescence requires 2–3 months. This group requiring Base Hospital care.

d. Severe corneal involvement: (0.1 percent of cases). Ischemic necrosis of conjunctivae. Dense corneal opacification with deep ulceration and vascularization. Convalescence requiring several months. Predisposition to late relapses.

(2) *Decontamination of the eyes.*—Liquid mustard in the eye demands immediate irrigation at the *earliest possible moment* since irrigation is markedly effective in the first few seconds and worthless after two minutes. The eye must be flushed with water from the canteen or other uncontaminated source. The head is thrown back, the injured eye held open with the fingers and water poured slowly into it. The eye should be rolled about during the washing, which should be continued at least 30 seconds and not over two minutes. Irrigation must be completed before the gas mask is put on in spite of exposure to field concentrations of vapor.

(3) *Decontamination of eyelashes and lids.*—The lids, lashes and skin areas close to the eyes are best decontaminated by washing with soap and water. Ointment protective is irritating to the eyes, and therefore should not be used. If water is not available, liquid vesicants may be removed from the lids by dabbing carefully with a cloth or other absorbent.

(4) *Treatment of mustard conjunctivitis.*—a. Mild lesions require little treatment. Although they seldom become infected, 2 drops of 3 percent sodium

sulamyd solution, where available, should be instilled every 4 to 8 hours. In addition, Butyn Ophthalmic Ointment or Solution Anesthetic may be instilled for added comfort. Local anesthetics should not be used unless necessary and then not oftener than every 6 hours. If the lids tend to stick together during sleep, sterile petrolatum should be applied to the lid margins.

b. Mustard conjunctivitis with edema of the lids severe enough to obstruct vision is alarming to the patient. The lids should be gently forced open to assure the casualty that he is not blind. Pain may be allayed by Butyn Ophtalmic Ointment or drops of Solution Anesthetic. To prevent infection, a sulfonamide ophthalmic ointment[1] or a few drops of 3 percent to 10 percent solution of sodium sulamyd, where available, may be instilled every 4 hours, after the first 24 hours. Wherever possible, sulfonamide drugs in solution are preferable to ointment if the drops can be put in every 1 to 2 hours. The eyes must not be bandaged nor the lids allowed to stick. The accumulation of secretions in the conjunctival sac or any pressure on the eye at this stage predisposes to corneal ulceration. Irrigations must be held to the minimum necessary to dislodge secretions, since excess fluid and trauma loosen the injured corneal epithelium. Isotonic or slightly hypertonic sterile solutions must be used, never hypotonic solutions; 1 percent saline is satisfactory. When the lids can be opened sufficiently for an ophthalmic examination, the cornea should be stained with fluorescein, one drop of 2 percent solution in saline into the lower conjunctival sac. The eye then should be rinsed with a few drops of sterile saline and examined for yellowish-green staining of the cornea. Staining indicates a loss of corneal epithelium. If the cornea stains, or if iritis or photophobia is present, atropine should be administered in 1 percent solution. The patient is then transferred to the care of the ophthalmologist. Sealing of the lids may be prevented by the application of petrolatum to the lid margins. Dark glasses or an eye shade should be worn for photophobia, but discarded as soon as possible to prevent developing of neurasthenia.

(5) *Treatment of infected mustard burns of the eye.*—a. Secondary infection is serious. Secretions must be removed gently by a minimum of irrigation with 1 percent saline. The eye should then be filled with a sulfonamide ophthalmic ointment[1] every 4 hours or a 10 percent solution of sodium sulamyd, where available, every 2 hours. Irrigation should be employed only to remove the accumulated exudate. Local anesthesia should not be used unless necessary, and then not oftener than every 6 hours. It is very important to prevent sticking of the lids and the sealing in of purulent secretions. Cases developing corneal ulcer or other complications should be referred to the opthalmologist.

[1] Sulfonamide Ophthalmic Ointment: 5 per cent Sodium Sulfadiazine in 50 percent each of Lanolin and Petrolatum.

C. *Skin.*—(1) *Pathology.*—a. The severity of the lesions and the rapidity with which they develop are greatly influenced by weather conditions as well as by the degree of the exposure. Hot, humid weather, as in the tropics, strikingly increases the action of mustard. Even under temperate conditions, the warm, moist skin of the perineum, external genitalia, axillae, antecubital fossae and neck are particularly susceptible (Plate No. 2). Cold weather and snow delay the action of mustard.

b. After a latent (Plate No. 1) period of variable length, an erythema gradually appears, resembling sunburn. Vesication may follow. Usually multiple pinpoint lesions form and coalesce into a single large vesicle (Plate No. 3). The typical blister is very superficial, translucent and surrounded by erythema. The blister fluid is clear, straw-yellow and does not coagulate early. It is non-vesicant.

c. The amount of dermal edema is variable (Plate No. 2). In severe burns it may be considerable, and limit motion of a limb. Large drops of liquid may produce a ring of vesicles surrounding a gray-white area of skin which, though necrotic, does not vesicate. If a blister is not ruptured, it begins to be resorbed in about a week. The roof forms a crust, beneath which re-epidermization takes place. The vesicles frequently break, however, and infection may occur.

d. Mustard burns usually are followed by a persistent brown pigmentation, except at the site of actual vesication, where there may be a temporary depigmentation (Plate No. 4 and Plate No. 5).

e. Repeated burns may lead to hypersentitivity of the skin to mustard.

(2) *Symptoms and prognosis.*—a. Exposure of the skin is followed by a symptomless latent period of hours or days which varies in length with the degree of contamination. In temperate weather this period usually lasts 6 to 12 hours, and in tropical weather 1 to 3 hours. As lesions appear, the skin develops generalized itching, which may last 4 to 8 days or longer. Blisters usually appear within 18 to 36 hours. The uncomplicated mustard lesion heals without scarring, usually in 3 to 6 weeks.

(3) *Diagnosis of skin lesions due to mustard.*—a. Nearly identical skin lesions are produced by mustard and the nitrogen mustards. Mustard burns tend to resemble those due to lewisite and other arsenical vesicants. Differentiation of mustard lesions from those produced by lewisite is based upon:

a. History of exposure to the gas.

b. Absence of pain or discomfort at time of contamination (lewisite causes immediate pain).

c. Latent period before the development of symptoms (none with lewisite).

d. Wide zone of erythema surrounding blisters (not prominent in the case of lewisite).

PLATE NO. 1

Early Mustard Erythema

The casualty clothed in a defective impregnated protective suit was exposed to Mustard vapor concentration of 17 mg/cu. meter for 60 minutes. One hour after exposure the skin itched and burned. The picture shows the intense generalized mustard erythema. Note its absence about the ankles and feet which were protected by 2 pairs of socks and a pair of overshoes. The case demonstrates the insidious way in which mustard gas injures its victim. Since the action is delayed the gas may continue to inflict injury for hours before the victim recognizes its presence.

PLATE NO. 2

Mustard Burn of Genital Organs

Same casualty as presented in plate No. 1. It illustrates the extreme vulnerability of the genitals to burns by blister gases. Other moist regions are equally sensitive. Note the raw and swollen scrotum and penis and contrast with the thighs which are only erythematous. Burns of the genital organs are painful and interfere seriously with wearing of clothes and with walking.

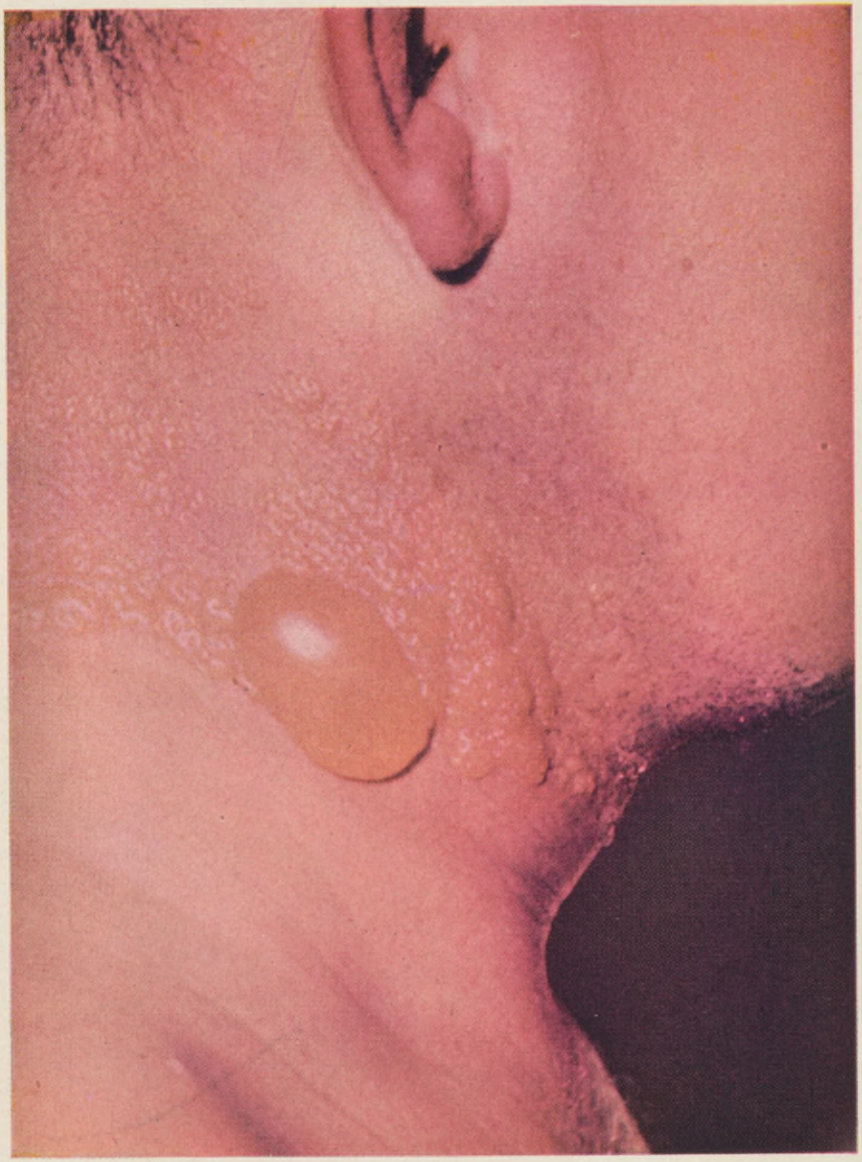


PLATE NO. 3

The Blisters of a Mustard Burn

This picture presents a severe mustard burn of the neck after exposure to mustard vapor concentration of 20 mg/cu. meter for 30 minutes. Blistering began 24 hours later and the picture was taken 4 days after exposure. The mustard blister is usually a clear tense bleb with slanting sides. Note the pinpoint vesicles about the large blister.

PLATE NO. 4

Severe Mustard Vapor Burn

The casualty clothed in a defective charcoal coated protective suit was exposed on two successive days to Mustard vapor concentration of 20 mg/cu. meter for 60 minutes. The suit was worn for 56 hours thereafter and then removed because of developing erythema of the buttocks, thighs and genital organs. Subsequently the erythema of the buttocks became very intense. Edema and blisters appeared. The picture, taken eleven days after the second exposure to the vapor, shows the violaceous erythema of the buttocks. Note the scattered irregular areas of superficial ulceration where the skin has denuded. The blisters that develop in these burned areas are almost painless, but the raw surfaces left after the blisters burst are acutely sensitive.

PLATE NO. 5

Mustard Vapor Burn in Brown Pigmented Stage

Same casualty as presented in plate No. 4 but 9 days later, or 20 days after the second exposure to the vapor. The case now presents the brown pigmentation which occurs in mustard burns. This gradually deepening pigmentation usually appears in areas that were first inflamed and red, but it may arise without such preceding erythema. It may begin to appear at any time from the fifth day onward and it persists for several weeks until the stained cuticle desquamates. There is no deep pigmentation and the sites of actual blistering usually are temporarily depigmented.

It should be remembered that vesicular lesions much like mild mustard burns may be produced in sensitive individuals by a variety of substances, notably plant poisons such as poison ivy or poison oak.

(4) *Decontamination of the skin.*—a. The contaminated skin should be blotted quickly with the absorbent paper furnished with the protective ointment or with a dry cloth. (Later destroy the used absorbent material.)

b. Ointment Protective S–461 or S–330[2] should then be squeezed onto the spot on the skin and thoroughly rubbed into the affected areas with the fingers for about 15 seconds. Excess ointment should then be wiped off. On large splashes, the ointment should be applied and removed once more.

c. If reddening of the skin has appeared, cleanse the area with soap and water. Ointment Protective S-461 or S-330 is irritating to the reddened skin and should be used only when liquid mustard is still present and soap and water are not available for thorough washing. Solvents for removal should not be used if soap and water are available.

d. Should the supply of Ointment Protective run short, the following alternatives may be employed:

a. Bleach paste: Prepared by mixing 1 part of bleach and 2 parts of water. Because of its irritant properties, it must be washed off the skin within three minutes.

b. Solvents: Any nonirritant organic solvent may be used in an emergency to dissolve and dilute the liquid mustard. Since solvents do not neutralize the vesicant, the mustard solution formed must be completely and rapidly removed from the skin by flooding with a large excess of the solvent. Alternatively, the area may be sponged repeatedly with cotton or gauze dampened with solvent with care to avoid the spread of mustard from contaminated skin. Gasoline, kerosene, alcohol and carbon tetrachloride (from automobile fire extinguishers) are most commonly available. *Caution:* Precautions against fire and explosion must be observed when employing inflammable solvents. Leaded gasoline and carbon tetrachloride, when absorbed by the body, are poisonous.

c. The decontaminated skin areas should be thoroughly washed with soap and water as soon as practicable after decontamination.

d. Wounded personnel, with liquid mustard contamination of the skin will seldom be received at battle dressing stations on ships or at shore medical installations in time to prevent subsequent blistering. Nevertheless, if erythema has not appeared, known or likely areas of contamination should be decontaminated as outlined in the preceding paragraph.

(5) *Decontamination of hair.*—a. The contaminated hair may be decontaminated with bleach paste or clipped off. The scalp should then be washed with soap and water. Ointment Protective may be used but is difficult to apply and to remove.

---

[2] An individual issue of Ointment Protective is made to all men in combat zones.

(6) *Treatment of mustard erythema.*—a. Mustard erythema in mild cases requires little or no treatment. If annoying itching is present, considerable relief can be obtained by covering the area with anesthetic ointment or with calamine lotion.[3] Severe erythema is often accompanied by edema, stiffness and pain. Effective subjective relief and subsidence of edema may be obtained in these cases by application of a light dressing moistened with saline or with amyl salicylate[4], where available. The dressing is remoistened every 12 to 24 hours for about four days. Painful erythema of the genitalia may be treated with calamine lotion and a suspensory bandage applied. Alternatively, petrolatum, a light protective dressing and a suspensory may be used.

(7) *Treatment of the mustard blister.*—a. Large blisters, if tense or painful, should be drained by puncture at the lower margin, after sponging the area with alcohol. It is not necessary to express clots; they will be absorbed and not delay healing. Blisters are often partially refilled with fluid 24 hours after drainage when a second puncture may be desirable to prevent traumatic rupture and a loss of blister top. Usually the blister may be covered with a dressing which can be moistened once or twice daily with saline or with amyl salicylate[4], where available, if there is pain or itching. Thereafter, a dry or a sterile petrolatum dressing may be used. Frequent dressings are not desirable.

b. If the dressing sticks to the wound, care will be necessary to avoid pulling off the blister top. It is good practice to trim the edges of the adherent gauze, leave it in place, and put a fresh dressing over it. If necessary to examine the wound or treat infection, the dressing can be soaked off.

c. Small blisters may be covered simply with a light dry dressing, moistened once daily for 3 or 4 days with saline or with amyl salicylate[4] if the burn is painful or itches. The dressing can be removed ordinarily in 2 or 3 weeks, when the area will be covered by a thin, pliable crust.

(8) *Treatment of denuded areas.*—a. Blistered areas which have become denuded may be coated with 5 percent Ointment sulfathiazole (See par. 10 C(9), page 19).

b. Alternatively, sterile petrolatum may be used, as for thermal burns. (See section X, page 49.)

c. Strong antiseptics and escharotics of all kinds are contraindicated.

d. Sterile technic should be employed, if possible including face masks for attendants as for thermal burns. Frequent change of dressings is to be avoided.

e. Occasional extensive granulating surfaces may require skin grafting. Multiple pinch grafts have proved successful.

---

[3] Calamine lotion, NF., with 0.5 percent each of phenol and menthol.

---

[4] *Caution*: The strong odor of amyl salicylate may put the soldier at a disadvantage in close jungle fighting as the odor may assist the enemy in stalking him, especially at night. Amyl salicylate should not be used in the axillae, groin, perineum or about the genitalia.

(9) *Treatment of infected mustard burns.*—a. Contamination of mustard burns with saprophytic bacteria is common, but not serious. If there is no inflammatory reaction, the treatment is the same as for uncontaminated burns. (See par. 10C (6) & (7), page 18.)

b. Infected burns with an inflammatory reaction should be considered infected wounds. They may be treated with sulfathiazole ointment. The latter should be limited to 100 grams of 5 percent ointment and to not more than 5 percent of the body surface, since there is danger of excessive absorption of the sulfonamide. Infection is best controlled by oral administration of a sulfonamide. Sulfadiazine or sulfanilamide may be given, 4 grams (grains 60) initially and 1 gram (grains 15) every 4 hours thereafter. Sufficient fluids should be given to maintain output of urine over 1500 c.c. (1½ quarts) daily. Two grams (grains 30) of sodium bicarbonate may be given every 4 hours to keep the urine alkaline.

c. Strong local antiseptics are contraindicated.

D. *Respiratory Tract.*—(1) *Pathology.*—a. Inhalation of mustard vapor causes irritation of the mucous membranes of the respiratory tract. Inflammatory changes may include necrosis with pseudomembrane formation and slough. A cast of the tracheobronchial tree may be formed.

b. The pulmonary parenchyma, injured by mustard vapor, shows patchy emphysema, congestion and atelectasis. These changes are insufficient to cause anoxia, but they may be complicated by bronchopneumonia which is responsible for almost all the deaths following mustard. The mortality from mustard in the American Expeditionary Force in World War I, slightly more than 2 percent, resulted almost entirely from inhalation of vapor.

(2) *Symptoms and prognosis.*—a. Respiratory tract lesions, like skin injuries, develop slowly and do not reach maximal severity for several days. Symptoms begin with hoarseness, which may progress to aphonia. A cough appears early and becomes productive. Fever, dyspnea, and moist rales may develop. The incidence of bronchopneumonia is high. Convalescence is slow, and cough may persist a month or longer. Milder symptoms, like hoarseness, last only a week or two.

(3) *Treatment of injury of respiratory tract due to mustard.*—a. Mild respiratory tract injury with hoarseness and sore throat only, usually requires no treatment. Cough may be relieved by codeine and pharyngitis with alkaline gargles. Relief from nasal inflammation may be obtained with nose drops of anesthetic solution. Since severe respiratory tract injuries predispose to bronchopneumonia, the prophylactic oral administration of sulfadiazine or sulfanilamide, 2 grams (grains 30) initially and 1 gram (grains 15) every 6 hours thereafter, is indicated. (See par. 5D(6), page 5.) Laryngitis and tracheitis should be treated by steam inhalations. Morphine or the barbiturates can be

used to quiet the patient. Secondary bronchopneumonia should be treated like any other bronchopneumonia.

E. *Systemic and Gastrointestinal.*—(1) *Symptoms.*—a. Severe exposure of the skin to mustard may cause transient nausea and vomiting. The systemic reaction from large mustard burns is like that from thermal burns of comparable size.

b. Ingestion of food or water contaminated by liquid mustard produces pain, diarrhea and prostration. Mustard vapor does not significantly contaminate food or water.

(2) *Treatment.*—a. Atropine may prove useful in reducing the gastrointestinal activity. Injury due to the ingestion of liquid mustard in food or water may require morphine and atropine for the relief of pain, and shock therapy for collapse. *Bismuth subcarbonate* (or *subnitrate*) can be used for diarrhea.

(3) *Prognosis.*—a. A few deaths are recorded from the systemic effects of mustard absorbed through the skin in extensive burns. These casualties showed pronounced leukopenia, which may be regarded as a bad prognostic sign.

b. Severe injury from ingestion of mustard is rare.

11. NITROGEN MUSTARDS (HN)

A. *General.* The nitrogen mustards are oily, colorless or pale-yellow liquids, sparingly soluble in water but freely soluble in organic solvents. Some possess a faint fishy odor, while others are odorless. Their volatility varies with the particular compound. All are persistent, though not equally so. They are more readily hydrolyzed than mustard, but less so than lewisite. All their hydrolytic products, except the final ones, are toxic.

B. *Eyes.*—(1) *Symptoms and pathology.*—Nitrogen mustards irritate the eyes before the skin or respiratory tract. The eye irritation caused by the nitrogen mustards appears in a shorter time than that from mustard but not as early as that from lewisite. Mild or moderate exposure causes mild smarting and lacrimation within 15 minutes. Thereafter symptoms may wax and wane until they become persistent about 2½ hours later and reach their maximum in 8 to 10 hours. After more severe exposure, symptoms may begin immediately and progress for 24 hours or longer. Mild exposure produces erythema and edema of the palpebral and bulbar conjunctivae and superficial steamy haziness of the cornea. Irritation, lacrimation, deep eye pain, miosis and photophobia are usually present. After more severe exposure the symptoms described above are followed by spotty hemorrhagic discolorations of the iris. The corneal epithelium begins to show a roughened, lusterless surface with areas of punctate staining demonstrable by the instillation of fluorescein. Severe exposure may cause the corneal epithelium to exfoliate. Slit lamp examination will reveal clouding and edema of the corneal substance extending deep below Bowman's membrane. Local necrosis of the cornea may rupture the globe.

(2) *Decontamination and treatment.*—These are the same as for mustard. (See par. 10 B (2), page 11.) In general, the symptoms and the lesions are more severe, requiring intensive and early treatment with atropine.

(3) *Prognosis.*—The prognosis in contamination with any liquid nitrogen mustard is serious, unless the agent is removed by irrigation within a minute or two. Mild injury progresses to complete recovery in about 2 weeks. Severe injury heals more slowly requiring 9 to 12 weeks or longer. The cornea heals by vascularization, and the iris with discoloration and atrophy. Scarring may be expected. The degree of recovery is remarkable, although relapses may occur, as from mustard injuries.

C. *Skin.*—(1) *Symptoms and pathology.*—The skin is more resistant than other tissues to the vapor of the nitrogen mustards and is less affected by them than by mustard. In mild exposures there may be no skin lesions. After severe exposures erythema appears earlier than is the case in mustard contamination. Later, blisters may appear in the erythematous areas. Liquid nitrogen mustards are also vesicant. The blisters produced are more superficial and more rapidly formed, but are otherwise similar to those caused by mustard (Plate No. 6).

(2) *Decontamination and treatment.*—The contaminated areas should be washed with large quantities of soap and water or water alone. If soap and water are not available, decontamination procedures are the same as for mustard. (See par. 10 C (4), page 17.) It should be remembered however that ointment protective merely dilutes the nitrogen mustards and does not destroy them. It is necessary, therefore, to wash off the film of ointment with water or soap and water as soon as possible. The possibility of systemic poisoning from absorbed nitrogen mustards through the skin is much greater than with liquid mustard. Decontamination should be carried out as late as 2 to 3 hours after exposure, in an attempt to neutralize the nitrogen mustard not bound as yet by the skin, even at expense of increasing somewhat the severity of the local reaction. Later treatment of skin lesions is like that for mustard burns. (See par. 10 C (6), (7), (8) and (9), pages 18 and 19.)

(3) *Prognosis.*—Most blistered areas will heal in 2 to 4 weeks if infection is prevented. Occasionally, deeper burns require a longer time.

D. *Respiratory Tract.*—(1) *Pathology.*—The lesions caused by nitrogen mustards are similar to those caused by mustard. They decrease in severity down the respiratory tract from the point of entry. In the nose, larynx and trachea, there may be marked swelling, erythema, and necrosis of the mucosa, followed by sloughing, hemorrhage and fibrino-purulent exudation. The larynx is especially vulnerable. Edema and necrosis may lead to respiratory obstruction. In sever cases the damage may extend to the bronchioles and alveoli. Although pulmonary edema usually is not massive, secondary pulmonary infection is common.

PLATE NO. 6

Nitrogen Mustard Burn

A Nitrogen Mustard burn of the fingers was accidentally incurred by a research worker in handling metal rods which were used to inflect experimental burns. He wore surgical rubber gloves and was not aware that Nitrogen Mustard had penetrated them until he noticed a burning sensation 10 hours after handling the rods. This is the appearance of the burn the following morning. A large blister fills the interdigital space.

(2) *Symptoms.*—The symptoms are much the same as those due to mustard, namely, delay in appearance, irritation of the nose and throat, hoarseness progressing to aphonia, a persistent cough, evidence of lung edema. Bronchopneumonia may appear after the first 2 to 4 hours.

(3) *Treatment.*—The treatment of casualties with respiratory tract involvement is the same as for mustard. (See par. 10 D (3), page 19.)

(4) *Prognosis.*—Mild tracheitis is likely to result in a cough which persists for several weeks. The prognosis is grave if there is severe respiratory tract involvement. Most late deaths are due to pneumonia.

E. *Gastrointestinal tract.*—(1) Following oral introduction or systemic absorption, the nitrogen mustards cause injury to the intestinal tract. Lesions are most marked in the small intestine and consists of inflammatory and degenerative changes in the mucosa. In animals, severe diarrhea, which may be hemorrhagic, occurs. In man, the ingestion or parenteral administration of 2 to 6 mgm. causes nausea and vomiting.

F. *Systemic effects.*—(1) *Pathology.*—The most specific effects of the nitrogen mustards are on hematopoietic and lymphoid tissue. These follow absorption from intact skin, respiratory or gastrointestinal tract. In bone marrow the degenerative changes can be detected within 12 hours and may progress to severe aplasia. The thymus, spleen and lymph nodes involute rapidly with necrosis and phagocytosis of their lymphocytes. This injury is demonstrable in the blood through a transient leukocytosis of a few hours' duration followed by severe lymphopenia, granulocytopenia, thrombocytopenia and a moderate anemia. The blood picture may show little change for 5 to 10 days after exposure, at which time the white count may fall below 500 cells/mm3. The various nitrogen mustards differ in their abilities to produce these changes.

(2) *Treatment.*—The blood should be studied carefully and transfusions of whole blood given for thrombocytopenia or anemia. Vomiting or severe diarrhea may call for the replacement of fluid in addition to symptomatic treatment with sedatives, atropine and opiates. If these symptoms are prolonged, every attempt should be made to maintain an adequate nutritional status by intravenous infusion of glucose, amino acids and plasma, and the parenteral administration of vitamins.

(3) *Prognosis.*—Leukocyte counts below 2,000 and great loss in weight probably point to a fatal outcome.

(4) *Diagnosis.*—Diagnosis is based upon a history of exposure, a faint fishy odor on the skin and clothing, and signs and symptoms characteristic of mustard exposure but which appear more rapidly than with mustard.

PLATE NO. 7, EXPLANATION

Burns of the Eye, With Blister Gases

It is not possible to photograph many human eyes burned severely by blister gas. However severe lesions can be produced experimentally in animals to demonstrate many characteristics of the severe blister gas lesions of the human eye. The rabbit eye though less sensitive than the human eye is nearly comparable.

Photo No. 1: A perfectly normal rabbit's eye. Note the complete absence of any redness or injection of the conjuctiva, the sparkling clear cornea and the smooth bright iris.

Photo No. 2: A rabbit's eye six hours after exposure to a saturated mustard vapor at 23 degrees centigrade for only one minute. The nictitating membrane and the palpebral conjunctiva are mildly swollen and injected. The light reflex on the cornea is slightly blurred. Compare with photo No. 5.

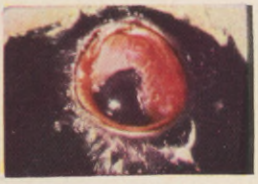
Photo No. 3: Twenty-four hours after injury the conjunctiva is strikingly swollen and injected and there are many small hemorrhages scattered through the reddened areas. There is a diffuse haziness of the cornea. Thick mucopurulent secretion can be seen clinging to the margin of the upper lid and on the matted hair below the eye. The pupil was moderately contracted due to an associated iritis. The cornea showed areas of punctate staining when 2 percent fluorescein was applied. Compare with Photo No. 6.

Photo No. 4: Twelve days after injury the edema of the conjunctiva has subsided. The nictitating membrane is still injected and swollen. The corneal damage has progressed as evidenced by distortion and the development of a large bulla. The usefulness of this eye has been destroyed and it will probably rupture in a day or two. Compare with Photo No. 7.

Photo No. 5: A rabbit's eye only one hour after exposure to a saturated lewisite vapor at 23 degrees centigrade for 30 seconds. An extreme degree of conjunctival edema has developed, obscuring the cornea. The rapid onset of eye injury due to lewisite is striking contrast to the delayed slow development following exposure to the vapors of mustard or the nitrogen mustards. Compare with Photo No. 2.

Photo No. 6: Two days after exposure the conjunctival edema has partially subsided. A large amount of mucopurulent discharge fills the conjunctival sac. The cornea showed a well delineated area completely denuded of epithelium. The iris was hyperemic and thickened and its normal pattern was further blurred by corneal haziness and exudate in the anterior chamber. Compare with Photo No. 3.

Photo No. 7: Eleven days after exposure the injection and edema has subsided. There is considerable mucopurulent discharge present. The cornea is now opaque because of the dead white necrosis of the bulbar conjunctiva. It was impossible to see the iris and the anterior chamber. This eye will perforate in a few days and be completely destroyed.



12. LEWISITE (L)

A. *General.*—(1) Lewisite is an oily, colorless to light amber liquid with a faint odor of geraniums. It is more volatile and less persistent than mustard, making it more effective in cold weather. Lewisite is readily soluble in gasoline, kerosene and alcohol. Although poorly soluble in water, it is rapidly hydrolyzed in contact with moisture. Lewisite oxide, one of the hydrolysis products, is vesicant and toxic and may contaminate ground for long periods. Lewisite, like mustard, penetrates fabrics and rubber, making it dangerous to wear clothing or rubber gloves previously contaminated.

(2) Lewisite, like mustard, injures the eyes, skin and respiratory tract, and may produce systemic effects. Liquid lewisite in contrast to liquid mustard causes stinging pain in 10 to 30 seconds, which increases in severity. However, the risk of burns from field concentrations of vapor is small. No decontamination or treatment is necessary following exposure to vapor unless pain is experienced. Then the procedures to be followed are those to be described under liquid lewisite. (See par. 12 B (2), (3) and (4), page 25; par. 12 C (4) to (11), page 27.)

B. *Eyes.*—(1) *Symptoms, pathology and prognosis.*—Liquid lewisite causes severe damage to the eye. On contact, pain and blepharospasm appear instantly. Edema of the conjunctiva and lids follows rapidly and closes the eye in an hour (Plate No. 7). Inflammation of the iris usually is evident by this time. After a few hours the edema of the lids begins to subside, while haziness of the cornea develops and iritis increases. The corneal injury, which varies with the severity of the exposure, may heal without residue, may develop pannus formation, or progress to massive necrosis. The iritis may subside without permanent impairment of vision if the exposure was mild, or after heavy exposure, hypopyon may ensue, terminating in necrosis, depigmentation of the iris and synechiae formation. Liquid lewisite instantaneously produces a gray searing of the cornea like an acid burn at the point of contact. Necrosis and sloughing of both bulbar and palpebral conjunctivae may follow very heavy exposure. All injured eyes are susceptible to secondary infection. Mild lewisite conjunctivitis in man heals in a few days without specific treatment. Severe exposure may cause permanent injury or blindness.

(2) *Decontamination of the eyes.*—Eyes contaminated with liquid lewisite required immediate treatment with Ointment BAL. If BAL is used the first minute following contamination, the eye usually recovers in a few days. When used 10 minutes after contamination, the lesion requires several weeks to heal and ordinarily leaves permanent damage. Ointment BAL exerts little influence after 30 minutes. Ointment BAL is available to all men. It is issued in a ½ oz. tube and is to be carried in the gas mask carrier.

(3) *Procedure of Decontamination with Ointment BAL.*—a. Open the tube of BAL ointment.

b. If the eye can be opened by traction on the lower lid with the fingers, squeeze the ointment directly into the injured eye and massage the lids gently.

c. If the eye cannot be opened, apply the ointment to the lids and rub in as much as possible between them.

d. As soon as the pain lessens and the lids can be pulled apart, squeeze additional Ointment BAL into the eyes.

e. Rub a small quantity on the lashes, lids and skin around the eyes.

(4) *Caution.*—a. BAL ointment should not be put into the eye unless there is acute pain. BAL causes sharp stinging pain and blepharospasm in the normal eye. The discomfort lasts about 30 minutes, followed by irritation and redness for several hours. BAL has the opposite effect in eyes contaminated with lewisite, giving marked and rapid relief from pain. When the identity of the contaminating agent is in doubt, it is advisable to use BAL for any acutely painful war gas contamination of the eye.

b. Hydrogen peroxide solutions must *not* be used in the eye; they are worthless for the treatment of lewisite injury and are damaging to the cornea.

(5) *Treatment of lewisite conjunctivitis.*—The treatment is like that for mustard. (See par. 10 B (4) and (5), pages 11 and 12.)

C. *Skin.*—(1) *Symptoms.*—Stinging is felt in 10 to 30 seconds after contact with liquid lewisite. This increases in severity as the lewisite penetrates, and in a few minutes becomes a deep aching pain. After five minutes' contact, a gray area of burned epithelium is apparent much like an acid burn. Erythema and edema of the skin appear in about 30 minutes. Erythema is like that caused by mustard but is more painful. Itching and irritation persist only about 24 hours.

(2) *Pathology.*—Liquid lewisite acts more rapidly and produces more severe lesions of the skin than does mustard. Lewisite vapor, however, is distinctly less dangerous than mustard vapor because vapor concentrations in the field are difficult to maintain. Contamination of the skin with liquid lewisite is followed in a short time by erythema. Vesication follows and tends to cover the entire area of erythema, so that the red peripheral halo associated with the mustard lesion is seldom seen. The lewisite blister, often indistinguishable from the mustard blister, is steep-sided with a thick roof and contains slightly opaque yellow fluid. Microscopically, the roof exhibits more complete necrosis than does that of the mustard blister, a greater infiltration of cells within the vesicle, and an injury extending much deeper into the corium. The vesicle fluid contains a trace of arsenic, but is non-toxic and non-vesicant. Blisters are often well developed in 12 hours and are painful at first, in contrast to the relatively painless mustard blister. After 48 to 72 hours the pain lessens. Deep burns from lewisite rarely occur in man, because the pain on contact gives warning in time for decontamination. Such burns probably would occur only in the case of an unconscious victim. Lewisite can penetrate the skin, subcutaneous

tissue, and muscle, causing enormous edema and gelatinous necrosis of the affected part. This is followed by failure of circulation, gangrene and slough.

(3) *Prognosis.*—Lewisite erythema heals somewhat more rapidly than mustard erythema, and with less pigmentation. Small lewisite blisters heal in about the same time as those due to mustard. The larger lewisite lesions involve deep injuries which heal slowly and require skin grafts.

(4) *Decontamination of skin—vapor.*—The risk of skin burns from field concentrations of lewisite vapor is small and decontamination of the skin for such exposure should seldom be required. When drops of liquid lewisite contaminate the clothing, concentrated vapor from these drops penetrates the cloth and damages the underlying skin. Such clothing must be removed promptly. Decontamination of the skin may be accomplished if specific measures are taken within a few minutes after contact.

(5) *Decontamination of the skin—liquid.*—a. The removal of liquid lewisite from the skin is the individual responsibility, that is, a matter of self-aid for all personnel in all branches.

b. If the skin is wet with lewisite, the excess liquid is quickly removed by blotting with absorbent material.

c. For each blot a clean portion of the absorbent should be used and then discarded. Care should be taken in discarding the used absorbent to prevent spread of lewisite to personnel or materiel.

d. Ointment BAL[5] is then immediately applied to area contaminated. BAL is a specific antidote for lewisite and other arsenicals. It should be spread on the skin in a thin film, rubbed in with the fingers and allowed to remain at least 5 minutes. Thereafter the ointment may be washed off when conditions permit.

e. If Ointment BAL is not available, wash immediately with soap and water.

f. Organic solvents are effective in preventing blisters only when used in the first few seconds.

g. Ointment BAL sometimes causes temporary stinging and itching urticarial wheals on the skin. The lesions usually last only an hour or so and should not cause alarm. Mild dermatitis, persisting a few days, may follow a single application. Dermatitis is fairly frequent if repeated applications are made to the same skin area. This prevents the use of the Ointment BAL as a protective film in contrast to the use of anti-mustard ointments.

(6) Wounded men, contaminated with liquid lewisite, will seldom be received at battle dressing stations on ships or medical installations ashore in time to prevent blistering. However, their burns may be lessened and significant systemic protection obtained if the decontamination procedures outlined under (5) are carried out promptly.

---

[5] An individual issue of Ointment BAL is made to all men in combat zones.

(7) *Decontamination of hair.*—Contaminated hair may be decontaminated with Ointment BAL and then washed with soap and water. As an alternative, the hair may be clipped off followed by washing of the scalp with soap and water.

(8) *Treatment of lewisite erythema.*—The treatment of lewisite erythema is the same as that for mustard erythema, except that treatment seldom is required for longer than 24 hours. (See par. 10 C (6), page 18.) BAL ointment may be tried in the early stages.

(9) *Treatment of the lewisite blister.*—Lewisite and mustard blisters are treated alike. (See par. 10 C (7), page 18.)

(10) *Treatment of denuded areas and infected lewisite burns.*—The treatment of these lesions is the same as that for similar lesions due to mustard. (See par. 10 C (8) and (9), pages 18 and 19.)

(11) *Treatment of deep lewisite burns.*—Large burns may be accompanied by serious systemic poisoning and shock demanding general measures as well as local treatment. (See par. 12 E (3), page 29.) Morphine and splinting of the affected parts may be necessary for the relief of pain. When the burned tissue becomes gangrenous, it may be allowed to slough, or it may be excised. (See section X, page 49.)

D. *Respiratory tract.*—(1) *Symptoms.*—Lewisite vapor is highly irritating to the respiratory tract and quickly induces sneezing and coughing. This property and the strong smell of geraniums have so effectively warned of its presence, that no severe respiratory injuries have been reported. Inhaled lewisite vapor produces lesions of the respiratory mucosa essentially similar to those produced by mustard. Edema of the lung often is more marked, and is frequently accompanied by pleural fluid.

(2) *Treatment of respiratory tract injury due to lewisite.*—Since there have been no human respiratory tract injuries from lewisite, treatment is recommended solely from the results of animal experimentation. In general, the treatment is a combination of that for the systemic effects of lewisite (See par. 12 E (3), page 29) plus that for mustard respiratory tract injuries. (See par. 10 D (3), page 19.)

(3) *Prognosis.*—The prognosis in respiratory tract injury from lewisite is unknown but probably is similar to that for an equivalent mustard injury with the added danger of systemic arsenical poisoning.

E. *Systemic.*—(1) *Pathology and symptoms.*—Liquid lewisite on the skin, as well as inhaled vapor, is absorbed and may cause systemic poisoning. A manifestation of this is a change in permeability which permits loss of sufficient fluid from the blood stream to cause hemoconcentration, shock and death. In non-fatal cases, hemolysis of erythrocytes has occurred with a resultant hemolytic anemia. Although lewisite is oxidized within the body, it may still be

toxic. Its excretion into bile by the liver produces focal necrosis of that organ, necrosis of the mucosa of the biliary passages with peribiliary hemorrhages and some injury to the intestinal mucosa. Acute systemic poisoning from large burns, in animals, causes pulmonary edema, diarrhea, restlessness, weakness, subnormal temperature and low blood pressure.

(2) *Prognosis.*—Burns severe enough to cause shock and systemic poisoning are dangerous to life. Even though the patient survives the acute effects, the prognosis must be guarded for several weeks.

(3) *Treatment.*—There has been no experience in treating systemic lewisite poisoning in man, but the following measures may be of value:

a. As soon as possible, apply the entire contents of one tube of BAL ointment to the contaminated skin, spread widely, and rub in well to obtain the maximum absorption. Leave the preparation on the skin. Repeat at 12 hourly intervals for 48 hours and daily thereafter for 4 days.

b. If signs of shock appear, administer the usual treatment, including plasma.

c. Give fluids freely and intravenously if necessary.

d. Give a high carbohydrate, high protein diet, employing intravenous glucose if the patient cannot retain food by mouth.

e. Give supplementary vitamins in full dosage.

13. ETHYLDICHLORARSINE (ED)

A. *Properties.*—Ethyldichlorarsine is a colorless or brown liquid which is more volatile than lewisite and possesses a faint fruit odor.

B. *Pathology.*—The lesions are the same as those caused by lewisite. (See par. 12 B, C, D and E, pages 25 to 29.)

C. *Symptoms.*—Low concentrations of vapor produce no symptoms for the first minute. Stinging pain in the nose and a burning sensation in the throat, nausea and vomiting then begin. Even though the gas mask is put on at once, symptoms may increase for several minutes. High concentrations are instantly so irritating to the eyes and respiratory tract that they compel wearing of the gas mask. A stinging and burning sensation is felt on the skin within a minute or two. In very hot weather this may progress to redness in ten minutes, and to shallow blistering in a few hours. Pain persists only about 24 hours, and the blisters crust over in a few days and heal rapidly. Liquid ethyldichlorarsine, like lewisite, is immediately painful on the skin and causes severe blistering. It produces eye injuries similar to, but less severe, than those due to lewisite.

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

(1) History of exposure.

(2) Fruity odor of skin and clothing.

(3) Intense sternutatory irritant, and early vesicant effect.

E. *Decontamination.*—Decontaminating procedures are identical with those for lewisite. (See par. 12 B (2) and (3), page 25; par. 12 C (4), (5) and (6), page 27.)

F. *Treatment.*—Treatment of mild respiratory tract irritation is the same as that for DM. (See par. 18 D, page 36.) After decontamination, eye and skin lesions are treated as those due to mustard. (See par. 10 B (4) and (5), pages 11 and 12; par. 10 C (6), (7), (8) and (9), pages 18 and 19.) Ointment BAL may be used in the early stages of skin erythema due to ethyldichlorarsine, or after severe exposure to prevent or treat systemic or respiratory tract injury.

G. *Prognosis.*—Respiratory tract irritation from low vapor concentrations subsides within an hour. Skin burns, in general, heal more rapidly than similar mustard burns. Liquid ethyldichlorarsine contamination in the eye causes serious injury, possibly blindness, unless Ointment BAL is promptly administered. (See par. 12 B (2) and (3), pages 25 and 26.)

14. PHENYLDICHLORARSINE (PD)

A. *Properties.*—This agent, a clear viscid liquid, is less volatile than lewisite or ethyldichlorarsine. It is readily hydrolyzed in water.

B. *Action.*—Phenyldichlorarsine when inhaled is a strong sternutator and lung-irritant. Eye injury produced is similar to that caused by lewisite. (See par. 12 B (1), page 25.) On the skin the vapor or liquid is only slightly less vesicant than mustard or lewisite. If absorbed, phenyldichlorarsine may produce systemic poisoning.

C. *Pathology.*—The lesions and the systemic effects produced by phenyldichlorarsine are essentially those of lewisite.

D. *Symptoms.*—Irritation of the eyes, nose and throat is prominent. Symptoms referable to the skin and lungs are like those produced by lewisite. (See par. 12 C (1), page 26; par. 12 D (1), page 28.)

E. *Treatment.*—Treatment in general is the same as that described for lewisite. (See par. 12 B, page 25; par. 12 C, page 27; par. 12 D, page 28; par. 12 E, page 29.)

15. MIXED BLISTER GASES

A. *General.*—Arsenical vesicants, such as lewisite (L) or phenyldichlorarsine (PD) mixed with mustards may be encountered as Chemical Warfare Agents. Such mixtures do not produce more severe lesions than either agent alone, but they tend to confuse and make diagnosis difficult.

B. *Decontamination.*—(1) *Eyes.*—If the exposure causes severe eye pain and blepharospasm, it should be assumed that an arsenical blister gas is present, and the first-aid measures for lewisite applied at once. (See par. 12 B

(2), page 25.) If the contamination is painless, immediate irrigation with water from the canteen or other uncontaminated source is employed. (See par. 10 B (2), page 11.)

(2) *Skin.*—If stinging and burning are felt immediately, it will be assumed that an arsenical is present. Any excess of the liquid mixture is blotted from the skin at once. Ointment protective S-461 or S-330 is then applied as described under mustard. (See par. 10 C (4), page 17.) The ointment is thoroughly removed and Ointment BAL is rubbed on as for lewisite. (See par. 12 C (5), page 27.) This should be removed immediately and applied again.

C. *Treatment.*—(1) *Eyes.*—Definitive treatment of eye injuries due to a mixture is like that for mustard injury of the eye. (See par. 10 B (4) and (5), pages 11 and 12.)

(2) *Skin.*—Definitive treatment of skin lesions produced by mixtures is like that described for lewisite burns. (See par. 12 C (8), (9), (10) and (11), page 28.)

SECTION IV

LACRIMATORS

16. CHLORACETOPHENONE (CN), CHLORACETOPHENONE SOLUTION (CNS), CHLORACETOPHENONE TRAINING SOLUTION (CNB) AND BROMBENZYL CYANIDE (BBC)

A. *Symptoms.*—General symptoms produced by the lacrimators include lacrimation, photophobia, and blepharospasm, some irritation of the nose and of the freshly shaven face. In hot weather moist skin will be irritated or even burned with blister formation. In addition, chloracetophenone solutions CNS and CNB may cause some mild papulovesicular dermatitis, especially in warm weather, and occasional vomiting. Lacrimator casualties ordinarily do not require medical attention.

B. *Treatment.*—(1) *First-Aid.*—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 burns of a strong acid. The instillation into the eyes of a solution of sodium sulfite (¼ percent in saline), if available, dissolves and neutralizes the irritating agent. Eye pain may be treated by instilling Ointment Butyn Ophthalmic or eye drops of Solution Anesthetic. Local anesthetic should not be used unless necessary and then not oftener than once every 6 hours. The further treatment is symptomatic as for any other burns of the eye.

b. *Skin.*—For skin burns caused by the lacrimators a 4 percent solution of sodium sulfite in 50 percent alcohol is advised. This must not be used in the eyes. The further treatment is the same as for other burns. (See par. 38, page 49.)

SECTION V

VOMITING GASES (NOSE GASES, IRRITANT SMOKES, STERNUTATORS)

17. DIPHENYLAMINECHLORARSINE (DM, ADAMSITE), DIPHENYLCHLORARSINE (DA), AND DIPHENYLCYANARSINE (DC)

A. *General.*—These agents are crystalline solids which are dispersed by heat as fine particulate smokes. DM smoke is canary yellow near the point of emission while those of DA and DC are white; all are colorless when diluted with air. Low concentrations are effective and suggest the odor of burning fireworks.

B. These agents produce strong pepper-like irritation in the respiratory tract, most pronounced in the trachea and large bronchi. The onset of symptoms may be delayed for several minutes, especially with DM, and effective exposure therefore may occur before the presence of the smoke is suspected. If the gas mask is then put on, symptoms will increase for several minutes, in spite of adequate protection. The casualty may believe his mask ineffective, remove it, and be further exposed. This is disastrous if the smoke is immediately followed by a lethal gas.

C. **The gas mask offers adequate protection against these agents.**

18. DIPHENYLAMINECHLORARSINE (DM) (ADAMSITE)

A. *Pathology.*—DM produces local inflammation of the nose and nasal accessory sinuses, throat and eyes.

B. *Symptoms.*—These consist of pain and a sense of fullness in the nose and sinuses accompanied by a severe headache, 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, and coughing is uncontrollable. The nasal secretion is greatly increased, and quantities of ropy saliva flow from the mouth. Nausea and vomiting are prominent. Mental depression may be so marked that the individual will need to be restrained to prevent self-injury.

C. *Diagnosis.*—This is made from the history of exposure, and the relatively rapid spontaneous improvement which occurs despite the original unfavorable appearance and condition of the individual.

D. *Treatment.*—The mask must be worn in spite of nausea and salivation, but it may be lifted from the face during actual vomiting. Frequent inhalations of chloroform administered early, give relief; aspirin may be given to relieve the headache and general discomfort. Few cases should reach the medical service for treatment since recovery is prompt. Personnel should carry out their battle mission in spite of sternutators.

E. *Prognosis.*—Ordinarily all symptoms disappear in approximately 1 or 2 hours. No permanent injury occurs even in severely affected individuals.

19. DIPHENYLCHLORARSINE (DA) AND DIPHENYLCYANARSINE (DC)

A. The pathology, symptoms, diagnosis, treatment and prognosis are similar to those of diphenylaminechlorarsine (DM). (See par. 18, page 35.)

SECTION VI

SCREENING SMOKES

20. GENERAL

The most important of these agents are HC mixture (HC), sulfur trioxide-chlorsulfonic acid (FS), and titanium tetrachloride (FM). These smokes are not toxic in the usual tactical concentrations, but may be dangerous in the heavy concentrations formed at the immediate site of dispersion, or within closed spaces where accidental discharge might occur.

21. WHITE PHOSPHORUS (WP) (See par. 28, page 39.)

22. TITANIUM TETRACHLORIDE (FM)

A. *Pathology.*—The liquid produces acid burns.

B. *Symptoms.*—Smoke generated by liquid FM is unpleasant to breathe as it irritates the nose and throat, but it is not dangerous in field concentrations. Exposure of the eyes to spray will cause conjunctivitis with lacrimation and photophobia. Skin burns like those from acids are produced by contact with the liquid.

C. *Treatment.*—The burned eyes or skin should be thoroughly washed with water and then treated like any other burn. (See par. 38, page 49.)

D. *Prognosis.*—Good.

23. SULFUR TRIOXIDE-CHLORSULFONIC ACID SOLUTION (FS)

A. *Pathology.*—Acid burns are produced by contact with the liquid.

B. *Symptoms.*—These are usually limited to a prickling sensation on the skin, but exposure to heavy concentrations may result in severe irritation of the eyes, skin, and respiratory tract.

C. *Treatment.*—The eye is irrigated with water at once. Fluorescein will reveal corneal ulceration. For pain Ointment Butyn Ophthalmic or eye drops of Solution Anesthetic may be instilled. The eye is then covered with a light pad. Skin burns should be washed with water and then with sodium bicarbonate solution. Later treatment should be that employed for other burns. (See par. 38, page 49.)

D. *Prognosis.*—The prognosis depends on the degree of corneal ulceration.

24. HC MIXTURE (HC)

A. *Toxicity.*—Field concentrations of this smoke are harmless, but dangerous to fatal levels may be encountered in confined, poorly ventilated spaces or near the point of smoke production.

B. *Pathology.*—HC smoke, if inhaled in sufficiently high concentration, damages the respiratory tract by the action of the contained zinc chloride. Following severe exposure a chemical pneumonia with pulmonary edema may develop, as in phosgene poisoning.

C. *Symptoms.*—When HC is breathed in high concentrations, there is a feeling of suffocation and some irritation of the nose and throat with coughing and choking. Later, signs and symptoms of pulmonary edema may appear.

D. *Treatment.*—Treatment is like that for phosgene poisoning. (See par. 5 D, page 4.)

E. *Prognosis.*—The prognosis depends on the severity of exposure and the extent of pulmonary damage.

SECTION VII

INCENDIARY AGENTS

25. GENERAL

The principal agents of this group are thermite (TH), magnesium and its alloys, white phosphorus (WP) and combustible oils. All generate tremendous heat and can inflict severe burns. Chemical fire extinguishers containing carbon tetrachloride (pyrene) or liberating carbon dioxide should not be used in confined spaces to extinguish thermite and magnesium incendiary bombs. When carbon tetrachloride comes in contact with flame or a highly heated metal, a mixture of phosgene, chlorine, carbon monoxide and hydrochloric acid is liberated. The service gas mask does not offer protection against carbon monoxide.

26. THERMITE (TH)

Thermite incendiaries burn at a temperature of about 4330° F. and scatter molten iron. Frequently, explosive charges are added and make control hazardous. The particles of iron that lodge in the skin usually produce multiple small but deep burns. The particles should be cooled immediately with water and removed. Thereafter, the treatment is that used for other thermal burns. (See par. 38, page 49.)

27. MAGNESIUM AND ITS ALLOYS

Magnesium burns at a temperature of about 3630° F. with a scattering effect similar to that of thermite. Deep burns are caused by its particles, which, unless removed promptly, result in slow healing. Removal is usually possible under local anesthesia. When explosive charges have been added to the magnesium bomb, the fragments may be embedded deep in the tissues, causing localized gas formation and tissue necrosis.

28. WHITE PHOSPHORUS (WP)

Extensive burns may be produced by incandescent particles of white phosphorus. The burns are usually multiple, deep and variable in size. The smoke is non-toxic. White phosphorus continues to burn unless deprived of oxygen. The burned areas should be immersed immediately in water or covered with a dressing soaked with water, urine or any non-irritant aqueous solution.

Immersion should be continued until a 5 percent solution of copper sulfate is applied as a wet dressing. Copper sulfate forms a non-inflammable coating of copper phosphide on the phosphorus particles. All particles should be removed under water, unless the copper sulfate solution has been applied. They may be located by their phosphorescence in the dark. Burning particles are recognizable by their evolution of smoke. It is well to debride the burn promptly, if the patient's condition will permit, in order to remove unnoticed bits of phosphorus. Following the removal of the particles, the lesions are treated as thermal burns. (See par. 38, page 49.) Salves with an oily base should not be used during the first few hours since phosphorus is soluble in oil and might be absorbed with resultant systemic poisoning. Otherwise the risk of systemic effects from embedded particles is small. Copper sulfate is innocuous even in large burns.

29. OIL INCENDIARIES

Burns may be produced by flamethrowers and by oil incendiary bombs which may also contain phosphorus and sodium. Lung damage from heat and irritating gases may be a complication added to the injuries from incendiaries, especially in confined spaces. Pulmonary embolism by particles of coagulated plasma—formed by the intense heat in peripheral veins—has been reported. Morphine should be given guardedly to patients with pulmonary complications. The treatment of burns caused by oil incendiaries is like that for other heat burns. (See par. 38, page 49.)

SECTION VIII

SYSTEMIC POISONS

30. GENERAL

Systemic poisons produce their effects after absorption into the body and cause little or no local injury. Hydrocyanic acid, cyanogen chloride and arsine are included in this group.

31. HYDROCYANIC ACID (AC)

A. *Physical properties.*—Hydrocyanic acid is a colorless, highly volatile liquid which boils at 26° C. Its vapor is extremely non-persistent, and has the odor of bitter almond. Aqueous solutions are weakly acid.

B. *Pathology.*—Hydrocyanic acid acts by combination with an enzyme essential for oxidative processes of the tissues. The central nervous system, particularly the respiratory center, is especially susceptible to this interference, and respiratory failure is the usual cause of death. In high concentrations of hydrocyanic acid (10 mg. per liter or more) the amount inhaled in a few breaths may be sufficient to cause immediate death without anatomical changes. After exposure to lower concentrations, death may be delayed for hours to days. Small areas of hemorrhage and softening, the more pronounced the longer the course, may be found in the brain in fatal cases.

C. *Symptoms.*—The symptoms depend upon the concentration of the gas and the duration of the exposure. In high concentrations there is increased depth of respiration within a few seconds; violent convulsions after 20 to 30 seconds; cessation of regular respiration in 1 minute; occasional shallow gasps; and finally, cessation of heart action several minutes after initial exposure. Following moderate exposures, vertigo, nausea and headache appear very early and are followed by coma and convulsions. These may persist for hours or days and be followed by death or recovery. If the patient recovers, after prolonged symptoms there may be evidence of damage to the central nervous system such as irrationality, altered reflexes, and unsteady gait, which may persist for months or longer. Mild exposure may produce headache, vertigo and nausea, but recovery is complete.

D. *Diagnosis.*—The diagnosis may be made from the history, the odor and the rapid onset of symptoms.

E. *Treatment.*—Under combat conditions, treatment may be difficult. When hydrocyanic acid is detected, the gas mask must be adjusted instantly and

the breath held as far as is possible while so doing. If one is capable of doing this quickly, the hydrocyanic acid already absorbed usually will be detoxified. If incapacitated, emergency treatment must be given instantly by the nearest individual. The gas mask must be applied and an ampoule of amyl nitrite crushed and inserted quickly under the facepiece. The patient should inhale the amyl nitrite for 4 to 5 minutes when another ampoule may be given. If the patient is conscious, he will be faint and dyspneic from this therapy, and may attempt to remove his mask. Artificial respiration is given if breathing has ceased. Where available, sodium nitrite and sodium thiosulfate should be administered intravenously. Sodium nitrite (10 c.c. doses of 1 percent solution) should be injected slowly to a total of 50 cubic centimeters. If necessary, epinephrine should be employed to counteract excessive fall of blood pressure. Between the nitrite injections 20 cubic centimeters of 5 percent sodium thiosulfate should be given intravenously and continued, if necessary, to a total of 500 cubic centimeters. Should the patient become greatly cyanosed as a result of methemoglobin formation, blood transfusions may be given. In general, treatment should be continued as long as there is the slightest sign of cardiac activity.

32. CYANOGEN CHLORIDE (CC)

A. *Properties.*—Cyanogen chloride is a colorless liquid which boils at 15° C. yielding a volatile irritant vapor. Although only slightly soluble in water, it dissolves readily in organic solvents. Very low concentrations (0.0025 mg. per liter) are sufficient to produce lacrimation. Its lethal concentration for 10 minutes' exposure is 0.40 mg. per liter.

B. *Pathology.*—The acute toxicity of cyanogen chloride is similar to that of hydrocyanic acid. The respiratory center is at first stimulated and then rapidly paralyzed. Cyanogen chloride, like chlorine, also attacks the respiratory tract resulting in mild inflammatory changes in the bronchioles, and congestion and edema of the lungs. The edema may form more rapidly than in phosgene poisoning. Rarely, bacterial bronchopneumonia may complicate the original chemical injury.

C. *Symptoms.*—The signs and symptoms combine those produced by hydrocyanic acid and chlorine. Following exposure there is immediately intense irritation of the nose, throat and eyes with coughing, choking, tightness in the chest and lacrimation. Simultaneously the exposed person becomes dizzy and increasingly dyspneic. Respiration fails rapidly followed by unconsciousness and death within a few minutes. Convulsions, retching, and involuntary urination and defecation may occur. If these effects, due to the CN ion, are not fatal, the signs and symptoms of pulmonary edema may develop. There may be persistent cough with much frothy sputum, rales in the chest, severe dyspnea

and marked cyanosis. As in phosgene or chlorine poisoning, a shock-like state may develop.

D. *Prevention.*—The gas mask protects for a limited period. On detection, instantly hold the breath, apply mask and exhale.

E. *Treatment.*—The treatment is that outlined for both hydrocyanic acid and for chlorine poisoning. (See par. 31 E page 41; par. 7, page 6.) The preliminary signs and symptoms determine therapy. Artificial respiration must be given in cyanogen chloride poisoning if breathing has ceased.

F. *Prognosis.*—If death does not follow promptly from the action of the CN ion, the effects of chlorine on the respiratory tract must be considered. (See par. 7, page 6.)

33. ARSINE (SA)

A. *Properties.*—Arsine is a colorless, odorless gas, but when impure, it may have a garlic-like odor in high concentrations.

B. *Pathology.*—The gas is absorbed from the respiratory tract into the blood and gives rise to intravascular hemolysis. This results in anemia, hemoglobinemia and hemoglobinuria. Through the action of circulating arsine and its oxidation products, there is serious disturbance of the tissue metabolism of kidney and liver. The kidneys show marked tubular change and numerous hemoglobin-albumin casts. Anatomical changes in the liver are less constant, but hepatitis and focal necrosis may be present. Jaundice is due to hemolysis or to liver damage or both. Death results from renal or hepatic failure, anemia, or a combination of these.

C. *Treatment.*—Therapy consists of bed rest, whole blood transfusions, oxygen, mild diuretics and parenteral glucose. Specific therapy for arsine poisoning is still in an experimental stage.

SECTION IX

INCIDENTAL GASES

34. GENERAL

A. This group includes carbon monoxide, ammonia, and hydrogen sulfide. These may be encountered in dangerous concentrations in confined or poorly ventilated spaces.

B. *Protection against incidental gases.*—The service mask and collective protectors are not efficient against carbon monoxide, ammonia or hydrogen sulfide. A special type of canister is required for such protection.

35. CARBON MONOXIDE

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

B. *Occurrence in military operations.*—Carbon monoxide is formed by gun blasts, bursting shells, internal combustion engine exhaust, and by fires in confined spaces in ships. Dangerous concentrations are apt to occur in confined spaces such as poorly ventilated engine rooms, gun turrets or emplacements, hangar decks of aircraft carriers, tank landing craft, garages and in mining operations.

C. *Pathology.*—Asphyxiation is produced by the inactivation of hemoglobin through combination with carbon monoxide. The resultant anoxia produces nervous system pathology. Post mortem examinations reveal little beyond the characteristic cherry-red color of the blood and hemorrhages in the brain. The dissociation of carbon monoxide from hemoglobin may be hastened by oxygen with or without added carbon dioxide.

D. *Symptoms.*—Carbon monoxide is very insidious in its action and poisoning may occur without appreciable initial signs. Usually, however, symptoms progress from throbbing headache, vertigo, yawning and poor visual acuity to the development of cherry-red appearance of the skin and mucous membranes, weakness and coma, subnormal temperature, feeble pulse and perhaps death.

E. *Diagnosis.*—The diagnosis is made from the circumstances of exposure and the appearance of cherry-red cyanosis.

F. *Protection.*—Adequate ventilation should be provided for all inclosed spaces where carbon monoxide may be produced. The safety of the air in the space may be tested by means of a standard carbon monoxide indicator.

G. *Treatment.*—Remove to pure air, give 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 chance for recovery. The majority of mildly exposed individuals recover with early treatment. Tachycardia and dyspnea may continue for months, and there may be central nervous system disturbances ranging from simple neuritis to mental deterioration.

36. AMMONIA

A. *Physical properties.*—Ammonia is a colorless gas which is soluble in water and has a pungent, characteristic odor.

B. *Occurrence in military operations.*—This gas has not been used in warfare but may be encountered in bombings involving refrigeration plants, in industrial accidents and in holds of ships as a product of decomposing material.

C. *Pathology.*—Exposure to high concentrations of ammonia produces prompt and violent irritation of the eyes and respiratory tract. There may be spasm and edema of the glottis or even necrosis of the laryngeal mucous membranes. Pulmonary edema may develop as in phosgene poisoning and may be complicated by bronchopneumonia.

D. *Symptoms.*—Exposure to high concentrations produces violent, burning pain in the eyes and nose, lacrimation and sneezing, pain in the chest, cough, spasm of the glottis, and pulmonary edema. Often there is temporary reflex cessation of respiration, which with the spasm and edema may cause asphyxia. Concentrations of 0.1 per cent are intolerable to man. Liquid ammonia is vesicant.

E. *Treatment.*—First-aid treatment consists of prompt removal to pure air, and artificial respiration. Inhalation of the fumes of weak acetic acid or vinegar may be of some benefit. Later measures are directed toward the prevention of pulmonary edema and the treatment of bronchitis and pneumonia. (See par. 5 D, page 4.)

F. *Prognosis.*—The mortality is high following severe exposure; with lower concentrations, recovery is usually rapid although bronchitis may persist.

37. HYDROGEN SULFIDE

A. This colorless gas in low concentration has the odor of rotten eggs. In high concentrations it may dull the sense of smell and be difficult to recognize. Hydrogen sulfide, a systemic poison, is nearly as toxic as hydrocyanic acid. It is produced during the decomposition of sulfur-containing compounds in sewers, waste coal bins or stacks, holds of ships and waterfront excavations.

B. *Pathology.*—Hydrogen sulfide produces inflammation of the eyes, nose and throat, and in high concentrations paralyzes the respiratory center or causes pulmonary edema.

C. *Symptoms.*—At first there is irritation of the eyes, nose and throat. Panting respirations and loss of consciousness follow quickly. Convulsions often occur as respiration ceases. If the exposure is not sufficiently high to be rapidly fatal, pulmonary edema may develop.

D. *Treatment.*—As heart action continues after respiration has ceased, immediate first-aid may be life-saving. This consists of: (1) removal of the patient from the contaminated atmosphere at once or adjusting his mask immediately, (2) artificial respiration, and (3) inhalations, if possible, of oxygen-carbon dioxide mixtures, or oxygen alone. The treatment of pulmonary edema developing later is the same as that caused by phosgene. (See par. 5 D, page 4.)

E. *Prognosis.*—Mortality from severe exposure is high. When there are symptoms of lung damage, the prognosis is like that in phosgene poisoning. (See par. 5 F, page 5.)

SECTION X

38. *THE TREATMENT OF THERMAL BURNS*

A. *Primary Objectives of Treatment.*—(1) To protect the burned area, which is an open wound, from further contamination.

(2) To prevent and combat shock as promptly as possible by plasma or albumin transfusion.

(3) To relieve pain.

(4) To minimize fluid loss.

(5) To maintain optimum healing conditions by adequate protein and vitamin intake.

(6) To prevent contracture and excessive scarring by proper splinting and early skin grafting.

B. *First-Aid Treatment.*—(1) *Asepsis.*—A burn is a sterile wound; therefore, all infection will be introduced from the outside. In the primary treatment of burns, it is essential that the burned area be protected from contact with bacteria. Contamination of the burned surfaces by organisms from the attendant, especially from his nose and throat, is responsible for most of the more serious infections which subsequently develop. Therefore, to minimize contamination from this source, the medical officer and assistants should be masked, if practicable; otherwise, mouths must be kept closed as far as possible.

(2) *Morphine.*—Pain should be relieved by adequate doses of morphine. Pain resulting from an extensive burn can ordinarily be relieved by a dose of ½ grain (0.030 grams) of morphine. In the presence of circulatory failure, there may be a delay in absorption of morphine administered subcutaneously, the full effect not being manifest before normal circulatory dynamics are restored. Therefore, caution must be exercised to control the dosage intervals, avoiding a cumulative effect which may result in severe morphine intoxication. In the presence of pronounced anoxia, large doses of morphine are dangerous, and under such circumstances the dose should not exceed ¼ grain (0.015 grams). Syrettes of morphine, ½ grain, are available in the first-aid pouch.

(3) *Chemotherapy.*—Administer 4 grams (60 grains) of sulfadiazine by mouth. This is contained in the first-aid pouch.

(4) *Prophylaxis against tetanus and gas bacillus.*—a. *Infection.* All personnel with burns of the second and third degree shall be given an emergency injection of 0.5 (½) c.c. of tetanus toxoid injected intramuscularly, providing

they have received initial immunization. The prophylactic dose of gas bacillus antitoxin may be given at the discretion of the medical officer.

(5) *Shock therapy.*—Administer plasma promptly, if available, or the equivalent number of units of human serum albumin, as this is an important element in the treatment of shock. When albumin or plasma are not immediately available, water should be given by mouth.

(6) *Burned area.*—Do not use tannic acid or other escharotics in treatment. Remove rings from fingers of burned hands. Irrespective of its location, cover the burned surface with a liberal amount of sterile petrolatum. The burn should then be covered with one or two layers of sterile fine mesh gauze (44 mesh gauze bandage is satisfactory). Place over this a smooth thick layer of sterile gauze dressing (large or small first-aid dressings are especially suitable for this purpose). Finally, a gauze or muslin bandage should be firmly applied over the dressing. When an extremity is involved, a splint is advised as a final step in the dressing.

C. *Definitive Treatment When Patient Arrives Where Hospital Facilities Exist.*—(1) Combat shock by adequate and prompt plasma or human serum albumin administration. In the presence of extensive burns, quantities of plasma up to 12 units may be required in the first twenty-four hours. Plasma must be given rapidly to the patient in critical condition, if possible, not being allowed to flow drop by drop. Syringe injection may be used. After hemoconcentration has been corrected by plasma and fluids, transfusion of fresh whole blood, if available, should be given to combat the rapidly developing severe anemia which follows extensive burns; when anemia exists, whole blood transfusion is particularly indicated as a preliminary to skin grafting.

(2) Parenteral fluid replacement other than that attained by means of plasma or whole blood transfusions should be accomplished by means of 5 per cent glucose in sterile distilled water. The intravenous administration of sodium chloride solution should be reserved for those burn cases in which mineral depletion occurs, such as that resulting from persistent vomiting.

(3) Minimize pain by adequate doses of morphine.

(4) Treat the burned area as an open wound, using standard operating room technic with patient and attendants fully masked and gowned.

a. *Cleansing.*—In cases in which the burned surface appears clean, no further preparation should be done. It should be reserved for gross soiling. If the burned area is heavily covered with fuel oil, the excess may be removed by gently swabbing the area with a suitable detergent, sterile lard or liquid petrolatum. Cleanse separately and carefully the surrounding skin with white soap and water. Cleansing must be done with a minimum of trauma. Do not use brushes in the cleansing of the burn, and avoid applying tincture of green soap.

b. *Debridement.*—Loose shreds of epidermis should be carefully removed with sterile forceps and scissors, and saved for bacteriologic study if feasible. Small blisters should not be disturbed, but larger ones may be punctured without the removal of the epidermis. Evidence of irreparable damage to deeper layers of skin may not be apparent for several days, and excision in such cases should not be done until it is certain that the tissue is dead. The resulting wound should be handled as any other open surgical wound, primary grafting of the skin being carried out as soon as conditions permit. Inhalation anesthesia should be avoided if possible, but intravenous anesthesia may be utilized for painful surgical procedures or dressings. Local anesthesia is contraindicated.

c. *Dressing of the burned area.*—Tannic acid and all other escharotics will not be employed in the treatment of burns. Cover the burned area with sterile petrolatum. Strips of a fine mesh sterile gauze (44 mesh gauze bandage is satisfactory) should be applied. Over this should be added a smooth, thick layer of sterile dressing; this may consist of gauze, absorbent cotton, cotton waste, or cellulose. The dressings should be held in place by an evenly and firmly applied bandage; stockinette or some form of elastic bandage is more effective than the ordinary roller bandage. Firm pressure is especially important in the case of burns of the hands and face. All dressings should extend well beyond the burned area, and in cases involving the extremities, the dressing should start near the tip of the digits, separating them one from another. Uninvolved tips are left exposed to check for circulation. The principle of infrequent dressings in the treatment of burns is especially desirable. For this reason, unless complications develop, the dressing should not be disturbed for from ten days to two weeks. Immobilization of the part by splinting should be effected when possible.

(5) *Chemotherapy.*—In all cases with moderate to severe burns, prophylactic chemotherapy should be continued. Sulfadiazine, subsequent to the initial first-aid dose, should be given only under the direction of the medical officer. While sulfadiazine is the drug of choice, sulfathiazole or sulfanilamide may be substituted. It is emphasized that although sulfonamide therapy may prevent infection, caution must be exercised in administering such treatment in burn cases. The extensive fluid loss so common in these cases and possible kidney damage increase the danger of renal complications from sulfonamide therapy. Maintenance doses of sulfadiazine should be given in 0.5 grams (7½ grains) doses every four hours until such time as an adequate kidney function, a daily urinary output of at least 1500 c.c. (1½ quarts) can be demonstrated, under which circumstances the dosage may be increased to 1 gram (15 grains) every four hours. It is recommended that 2 grams (30 grains) of sodium bicarbonate be administered every four hours to keep the urine alkaline. In the event of persistent infection despite sulfonamide therapy and in the event of sensitivity or of kidney intolerance, discontinue the drug.

Penicillin should then be administered in dosages of 15,000 to 20,000 units intramuscularly every three hours or by continuous intravenous drip in a concentration of 20 units per cubic centimeter of normal saline or 5 per cent glucose.

(6) *Skin grafting.*—One of the most important factors in preventing contractures and in obtaining an optimum functional and good cosmetic result in burns is early epithelization. For this reason skin grafting of granulating surfaces should always be done as soon as practicable. At the end of 10 days or sooner, areas of part thickness loss, that is, second degree burns, should be largely healed. Areas of whole thickness loss, that is, third degree burns, are prepared for grafting by excision of the dead tissue. If suppuration is present, wet dressings are advisable and the local use of compresses wet with penicillin solution, concentration of 250 units per cubic centimeter of normal saline, may be helpful in combating the local infection. Skin grafting at the earliest opportunity is mandatory if the whole thickness of the skin was destroyed. Transfusion of fresh whole blood is required to combat the rapidly developing severe anemia complicating severe burns. When such anemia occurs, whole blood transfusion is particularly indicated as a preliminary to skin grafting. In addition, the depleted serum protein must be restored prior to such surgery and maintained thereafter for effective results. This is accomplished by the judicious use of whole blood, plasma and adequate oral intake of protein. Where available, amino acid preparations are valuable protein sources which may be administered orally or parenterally to correct the grave protein deficiency in these cases.

SECTION XI

39. *THE CARE OF CONTAMINATED CLOTHING AND EQUIPMENT AT MEDICAL INSTALLATIONS*

A. *Introduction.*—(1) In the event of gas warfare, due care must be exercised at medical installations to prevent injury to patients and medical attendants from clothing, blankets, or other equipment, which has become contaminated with blister gases. Proper steps must also be taken to obtain timely replacement of items made unusable by contamination, and to insure the salvage and decontamination of such equipment. For detailed instructions refer to Manual F.T.P. 222, "Chemical Warfare Defense Instructions" United States Fleet.

B. *Removal of Contaminated Clothing and Equipment.*—(1) Clothing and equipment contaminated with a blister gas should be removed from the casualty at the earliest practicable moment, with due regard for the general condition of the patient.

C. *Disposition of Contaminated Clothing and Blankets.*—(1) An area out of doors should be designated as a clothing dump, and contaminated blankets and clothing (except impermeable aprons and rubber gloves) should be transferred to this dump as conditions permit. At shore establishments the dump should be at a safe distance from the medical installation, preferably at least 100 yards, down-wind.

(2) The dump should be clearly marked "Danger, Gas."

(3) Gas casualties should not be admitted to a hospital, sick bay, dressing station or other enclosed spaces unless clothing or blankets known to be contaminated with blister gas have been removed and the patient decontaminated. To do so may result in severe skin burns by contact with the blister gas and in burns of the eyes and respiratory tract from vapors which accumulate in confined spaces. Provision should be made for well ventilated posts where decontamination can be accomplished without breaking the gas-tight integrity of the ship or subjecting the shore installation to contamination.

D. *Notification of Chemical Warfare Officer.*—(1) The Medical Officer should notify the Chemical Warfare Officer advising him of the existence of the dump of contaminated clothing and blankets, its exact location, and approximate size.

E. *The Apron, Protective Impermeable.*—(1) The apron, protective, impermeable is intended for use by personnel of the Medical Department while treating and handling blister gas contaminated casualties. The apron is always

worn in conjunction with complete permeable protective clothing, and impermeable protective rubber gloves. The gas mask is also necessary as a part of the complete protective outfit.

(2) Litter bearers moving into dangerously contaminated areas should don the complete outfit described above before entering such areas. Aid station attendants and others should don the complete outfit prior to handling or treating contaminated patients, and the apron should not be removed until the danger of contamination has been removed. If treatment of patients is hampered by the use of the impermeable gloves, such gloves may be removed with comparative safety after removal of all of the patient's heavily contaminated clothing, and the treatment continued wearing protective cotton gloves. Contaminated aprons may be worn with safety for many hours in conjunction with permeable protective clothing. However, aprons should be decontaminated after each day of wear, as prolonged contact with the liquid blister gases may have a deleterious effect on the coated fabric. The complete outfit should also be worn while decontaminating litters, ambulances and other equipment which may have been contaminated in transporting casualties.

(3) In removing the apron care should be exercised so that contaminated surfaces of the apron are not permitted to come into contact with the clothing of the wearer or other individuals. Decontamination procedure should be applied as soon as practicable to contaminated articles of clothing and equipment.

SECTION XII

40. *DISINFECTION OF GAS MASKS*

A. Whenever masks are stored, exchanged or used by more than one individual for training purposes, or when the wearer has been suffering from a cold or sore throat, they should be thoroughly disinfected.

B. The Navy has available on its supply table approved disinfectants for this purpose under BuMed stock No. 1-851 and No. S1-4790. They are effective germicides and fungicides. Their main advantages are that they do not damage the gas mask and they allow wearing of the mask within 30 minutes. Directions for their use are as follows:

(1) Dilutions shall be made as specified on the container.

(2) In disinfecting the mask keep the facepiece lower than the hose and cannister to prevent the disinfectant from running into them. Hold the facepiece in the hand, saturate a small piece of clean rag with the disinfectant, and sponge the entire surface of the facepiece, including the outer and inner sides of the deflector. In this operation do not turn the facepiece inside out. Then apply the disinfectant similarly to the outside of the outlet valve.

(3) Squeeze a few drops of the disinfectant from the rag into the exit passage to the outlet valve. Press the sides of the outlet valve with the thumb and finger to let the disinfectant run out. Do not shake off the excess.

(4) Also disinfect the inner surface of the diaphragm attachment on special type masks. Excessive wetting of the internal parts of these attachments must be avoided by keeping them above the general level of the area being treated.

(5) Allow all disinfected parts to remain moist for about 15 minutes and then wipe out the inside of the facepiece with a clean dry rag. The mask should dry thoroughly in the air (usually 30 minutes) before it is returned to the carrier.

C. If approved disinfectants are not available, ordinary soap and water may be used, providing the mask is thoroughly dried before stowage.

D. There are objections to the use of formaldehyde, cresol, lysol, Dakin's Solution, hydrogen peroxide, copper sulfate, alcohol and other disinfectants. Either they destroy the mask, have a low antiseptic value, persist for a long time necessitating many hours for airing and ventilation, or they irritate the skin and breathing passages.

SECTION XIII

41. *CHEMICAL AGENT CONTAMINATION OF FOOD*

A. *General.*—(1) The Medical Officer is charged with the responsibility to pass upon the edibility of food under conditions of known or suspected contamination with chemical warfare agents.

(2) Contamination of foodstuffs by chemical warfare agents may occur from contact with vapor, sprays or splashes of liquid, or solid chemicals. Unprotected food supplies may be so contaminated that their consumption produce gastrointestinal irritation or systemic poisoning. The vesicants and arsenicals are the most dangerous.

(3) While 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 necessary. Prompt segregation of the heavily contaminated portions may prevent or minimize contamination of the remainder. Generally, foods not especially packed in protective packages constitute the major difficulty. The present method of packing foods used by the Bureau of Supplies and Accounts for overseas minimizes the dangers of contamination. With such packaging in most cases only decontamination of the outer packing is required.

B. *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 diffusion throughout the material, it may be impossible to remove them. Coagulation of protein by agents which are acidic or acid formers in high protein foods may limit diffusion of the agent. Hydrolysis of acid-forming gases in foods of high water content causes decomposition products which render the food unpalatable. Foods of low water and fat content will be relatively less easily contaminated by chemical agents and less difficult to decontaminate.

C. *Reclamation of Contaminated Supplies.*—(1) *General.*—The most effective and practical measures for purifying food when contaminated with chemical agents include washing with water or 2-5 per cent sodium bicarbonate solution, trimming of exposed surfaces, serrating adequately, and boiling in water. These measures may be ineffective, if the decomposition products are toxic, as in the case of lewisite. In general, food 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

liquid droplets of vesicant agents. Unpackaged foods on which chemical agents can be seen with the unaided eye should be considered spoiled and their purification impracticable.

(2) *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 foods, to form comparatively harmless compounds which may alter the flavor. Decontamination can be accomplished by washing, supplemented, where possible, by aeration. Chlorpicrin is slightly soluble in water, and is soluble in fat and most organic solvents. Its removal from foods of low water and fat content can be accomplished by aeration.

(3) *Lacrimators and irritant smokes.*—a. Large stocks of supplies, when protected by covers or packages, probably cannot be contaminated with a sufficient quantity of the lacrimators or irritant smokes to warrant their destruction. However, these agents are not easily decomposed by hydrolysis and it would be difficult to reclaim foods *heavily* contaminated by them.

b. Dry provisions contaminated by lacrimators can be decontaminated by aeration.

(4) *Vesicants.*—a. When contaminated with *liquid* mustard or a liquid nitrogen mustard, foods of high water or fat content are unfit for consumption and reclamation is not practical. When foods have been exposed to vesicant vapor, they can be reclaimed by washing with soda solutions and rinsing with clear water, intensive cooking, or in the case of dry provisions, by 24-48 hours aeration. Lean meat can be reclaimed by boiling in water for one-half hour or more, or in the case of the nitrogen mustards, with a 2 per cent solution of baking soda. The water must be discarded after boiling.

b. Lewisite, ethyldichlorarsine and phenyldichlorarsine readily hydrolyze to poisonous arsenical oxides. Foods contaminated with these agents cannot be reclaimed.

(5) *Screening smokes.*—a. HC, FM, FS and WP smokes are non-toxic. They may alter the taste of foods by acids produced on contact with moisture, but do no damage otherwise.

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

c. Unburned particles of white phosphorus are poisonous and must be removed from foods. Fats and oils may dissolve poisonous amounts of the agent and should be discarded.

(6) *Other agents.*—Carbon monoxide, arsine, and hydrocyanic acid will have little effect upon food supplies. Hydrocyanic acid is water soluble and foods with high water content may become unfit for consumption after exposure to high concentrations of that agent.

(7) *Meat from gassed animals.*—It may be necessary to use animals for food after they have been exposed to liquid splashes of chemical warfare agents. Economy may justify the early slaughter of exposed animals *before the effect of such exposure is shown.* If such animals are slaughtered in an approved manner in the preliminary stages of poisoning and all tissues exposed to the gas (lungs, and other local areas) are discarded, there is no objection to the consumption of the meat, provided the animal passes an otherwise satisfactory meat inspection. This is true even of animals poisoned by arsenical agents, since the edible tissue will contain amounts of arsenic too small to be toxic. Organs such as the liver, brain, heart, kidney, and lungs will contain relatively more arsenic than the musculature, and should be discarded. The meat should be well cooked.

D. *Packaged and Stored Provisions.*—(1) In determining the disposition of packaged and stored supplies which have been contaminated, consideration must be given to the nature 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:

a. Airtight bottles and sealed tins give complete protection against vapor and liquid.

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

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

d. Waxed paper boxes, well sealed for the exclusion of air, give good protection against vapor and fair protection against liquids.

e. Paper wrappings give poor protection against vapor and very little against liquid.

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

g. Ordinary textiles in a single layer packaging give practically no protection against vapor and liquid.

h. Coverings of sod and earth give good protection against vapor and liquid.

i. Open shelters give protection against liquid sprays and splashes; closed buildings, against both vapors and liquids.

j. Generally, double layers greatly increase the protective efficiency of packaging materials.

E. 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. The most vulnerable foods should be placed in the least exposed positions, keeping in mind the fact that the vapors of chemical warfare agents are heavier than air and tend to accumulate in low places. In the field, tarpaulins covering food supplies give fairly good protection against vapor and liquid agents. Food supplies which have become contaminated should be handled only by those trained in decontamination methods and equipped with protective clothing and gas masks.

SECTION XIV

42. *THE DETECTION OF WATER CONTAMINATED WITH CHEMICAL WARFARE AGENTS*

A. *General.*—(1) The medical officer is charged with the responsibility to pass upon the potability of water. It therefore follows that the testing of water for the presence of chemical warfare agents falls under his cognizance.

(2) Contamination of water supplies with chemical warfare agents has been encountered rarely, but in those instances the percentage of casualties was high.

(3) Methods for detecting chemical agents make it possible to determine safe and unsafe water. The decontamination of contaminated water is difficult and should be resorted to only in extreme emergency. Decontamination is not a function of the Medical Department but is under the cognizance of the group responsible for the procurement and treatment of water supplies.

(4) The important chemical warfare agents most likely to cause casualties when introduced into water are the vesicants and the systemic poisons, i.e., cyanogen chloride and hydrogen cyanide. It is considered improbable that toxic concentrations of heavy metals and alkaloids will be encountered.

B. *Toxic Limits of Chemical Warfare Agents in Water.*—(1) The toxic limit for lewisite is 20 ppm. (20 mg/1) (10 ppm. (10 mg/1) as As_2O_3), provided the water is chlorinated by the standard procedure for bacterial purification and is used for not more than one week in order to avoid cumulative effects. Nitrogen mustards in concentrations of 10 ppm. (10 mg/1) have produced vomiting in man but have not caused actual casualties. In higher concentrations they are extremely toxic. Mustard dissolves slowly in water but may be found floating in tiny globules, as a film on the surface or collected in pools on the bottom. Small droplets when fed with water to rats have produced perforating ulcers in the intestinal tract. The toxic limit for cyanogen chloride and hydrogen cyanide are 10 ppm. (10 mg/1).

C. *Reactions With Water.*—(1) The three vesicants, lewisite, mustard, and nitrogen mustards, all react with water to form hydrochloric acid and the hydrolysis product corresponding to the agent. Lewisite reacts with water practically instantaneously, forming the hydrolysis product "lewisite oxide" which is toxic and somewhat vesicant. Mustard reacts with water to form the non-toxic thiodiglycol. A solution containing 100 ppm. (100 m/1)

mustard becomes non-toxic at the end of one hour. Some types of mustard contain a highly odorous compound which renders the water non-palatable even after hydrolysis. Nitrogen mustards hydrolyze slowly to a non-toxic product. A solution containing 100 ppm. may remain toxic for 4 to 6 days. Cyanogen chloride, hydrogen cyanide, and heavy metal salts dissolve in water but do not react extensively with it.

D. *Detection of Chemical Warfare Agents in Water.*—(1) The water testing, screening kit approved by the Bureau of Medicine and Surgery affords simple and rapid tests of raw water to detect dangerous contaminations by chemical warfare agents.

(2) The kit contains equipment for testing 15 samples of water. The tests employ dry reagents which are furnished as tablets or pellets of proper size. Except for warming with the hand in some of the tests, no heat is required.

(3) The kit also contains a booklet which gives specific directions for each test. Non-technical language is used and the reagents are referred to by the letters on the vials. These directions must be followed exactly. Briefly the tests involve the following chemical processes:

a. Arsenicals are converted to arsines through the action of hydrogen, produced by the action of sodium acid sulfate on zinc. The arsine reacts with a sensitized paper to produce a stain. This is sensitive to 5 ppm.

b. The pH of the water is determined by means of nitrazine test papers. These papers test over a pH range from 4.5 to 7.5.

c. Mustard is detected by means of the DB-3 reagent in pellet form; 5 ppm. (5 mg/1) of nitrogen mustard can be detected. Cyanogen chloride produces a yellow color with this reagent.

d. The chlorine demand or chlorine uptake is determined by means of halazone tablets and an O-tolidine testing assembly. This test includes the presence of a number of less important agents not specifically tested for.

e. If no evidence of contamination is found, odor and taste can be tried with safety.

E. *Directions for Use of Kit, Water Testing, Screening.*—(1) *Purpose.*—a. The water testing kit is employed to screen out sources of water so contaminated with chemical agents that they cannot be rendered potable by customary field treatment methods, such as chlorination in the Lyster bag. Individuals performing the tests must have normal color vision.

b. Negative tests indicate water suitable for chlorination and may thereafter be used.

c. If any of the tests are positive, the water should not be used until a more complete analysis can be made.

d. The main purpose of the kit is to detect contamination by chemical agents in raw water. It is not designed for use in the control of chlorine

treated water. Chemical reactions during water treatment invalidate the interpretations.

F. *Procedures for Tests.*—(1) *General.*—a. Read directions thoroughly.

b. Obtain water sample in canteen cup without excessive disturbance of water source.

c. Start the arsenic test. While the arsenic test is developing, carry out the other tests.

(2) *Arsenic test.*—a. Pour suspected water into the bottle (P) to mark on bottle.

b. Place 2 tablets from vial A into the bottle. Shake to dissolve.

c. Take a test strip from vial B by the top end. Carefully insert into the tube (H) bending the strip near the top so that it will remain in the upright tube. Touch only the top end of the strip. Keep dry.

d. When the tablets (A) have disintegrated, add 5 tablets from Vial C to the contents of the bottle P.

e. Promptly fit the test paper assembly into the bottle.

f. If cold, warm the bottle in your hands. Let react for 20 minutes.

g. Remove the strip and note the length of the yellow to brown stain. A stain 1/4 inch or more indicates a positive test. A stain less than 1/4 inch indicates a negative test.

(3) *pH Test.*—Dip a strip of the nitrazine paper into the water until it becomes wet. Remove and compare resulting color with color chart on case lid. pH less than six (6) indicates possible contamination.

(4) *Mustard Test* (Including Nitrogen Mustard and Cyanogen Chloride).—a. Rinse test tube with suspected water.

b. Carefully fill test tube to 1/2 inch depth with suspected water.

c. Add one tablet from vial D.

d. Shake for 3 minutes, to break up the tablet. Allow to stand for 5 minutes.

e. During cold weather, warm tube in hand or inside pocket for additional 5 minutes.

NOTE: Yellow color after d or e is positive test for Cyanogen Chloride.

f. Break one tablet from vial E in half and add *both halves* to water being tested.

g. Shake until broken up. While shaking, watch for the development of any color.

h. Observe for 1/2 minute against white background.

i. Even a slight blue or red color (mainly in curd) indicates a positive test for mustard or nitrogen mustard.

j. A yellow color indicates CNCI. In heavy contamination the yellow color appears before step (f).

k. White or light gray color indicates a negative test for mustards

(5) *Chlorine Demand Test.*—a. Fill a canteen with water to within an inch of the top.

b. Add three (3) tablets from vial F, screw cap on and shake to dissolve. (2-5 min.)

c. Five (5) minutes after tablets have dissolved transfer treated water from canteen to plastic tube with yellow band, of vial X testing set, filling the plastic tube to bottom of yellow band.

d. Add one tablet from vial X, shake and note color when dissolved.

e. A positive test is indicated by no color or color lighter than yellow band in plastic tube.

f. A negative test is indicated by an orange color or color as deep as the yellow band.

(6) *Taste and Odor.*—(a) If test F(2), arsenic; F(4), mustard; F(5), chlorine demand; are negative, and pH is six or above, carefully smell and taste a small sample of the suspected water.

a. A positive test is indicated by:

i. a lacrimating or chlorinous odor.

ii. a biting and/or peppery chlorinous taste.

iii. any taste or odor of a known war gas.

b. Absence of all tastes or odors will indicate a negative result but not necessarily a safe water. A negative test is also indicated by the presence of only those odors and/or tastes normally characteristic of natural water.

(7) *Interpretations*:

Test	CONTAMINATED WATER[1]	NONCONTAMINATED WATER[2]
Arsenic test, (F2)	Positive	Negative.
pH test, (F3)	pH below 6	pH above 6.
Mustard test, (F4)	Positive	Negative.
Chlorine Demand, (F5)	Positive	Negative.
Taste and Odor, (F6)	Positive	Negative.

[1] Water will be considered contaminated if one or more of the tests gives results as indicated in this column.

[2] Water will be considered suitable, after bacterial disinfection by usual methods, for one week if all the tests give results indicated in this column.

G. *Sensitivity and Limitations of the Tests.*—(1) If the tests are carefully performed, the threat of serious casualties from using water contaminated with chemical warfare agents will be avoided.

(2) The arsenic test will show whether any arsenic is present or not. The lengths of stain on the strips of test paper, produced by 5, 10 and 15 ppm. of arsenic or arsenic in the form of organic arsenicals are sufficiently different to manifest approximately how much arsenic is present. Inorganic arsenite or

arsenate produce very long, dark stains at the above concentrations. The test for arsenic allows some latitude in the interpretation of the results. If the stain on the test is not longer than one-fourth inch, the arsenic content is not more than 10 ppm. as organic arsenic. This water may be used for a period not to exceed one week because of possible cumulative effects, provided all the other tests are negative and the water is thoroughly chlorinated. If the stain is longer than ¼ inch, the water shall not be used.

(3) The pH test is a general screening test. A pH below 6.5 should be regarded with suspicion unless the character of the water source seems to indicate a naturally low pH. Contamination of the water by mustard, the nitrogen mustards or the arsenicals would lower the pH as all these chemical agents release hydrochloric acid in water solution. A pH above 8.5 probably means contamination with some basic material as potassium cyanide.

(4) The test for mustards will detect mustard or the nitrogen mustards in 5 ppm. Thiodiglycol will not react. Ethyl iodoacetate and Chloroacetophenone will also react, but these can be easily detected by their odor. Cyanogen chloride gives a yellow color with the mustard test and can be detected as low as 10 ppm. No blue color develops when the RB tablet is added. If the test for mustard and the nitrogen mustards is positive, the water should be rejected for all purposes. Water may pass the test for nitrogen mustards and still give symptoms if consumed in large quantities. Therefore the water should not be used without special purification if even the faintest blue color develops. When the result of the test is questionable, the amount of water permitted per man at the first drinking should be limited to one-half pint; if no symptoms of nausea or vomiting develop during the succeeding two hours, the water may be used freely thereafter.

(5) The O-tolidine reaction used to detect chlorine residuals in the chlorine demand test is sensitive to 0.1 ppm. of chlorine. A chlorine residual does not mean a safe water. It has been shown that water contaminated with mustard or thiodiglycol may show a chlorine residual and actually still have a chlorine demand. An excess of 4 to 5 ppm. of chlorine above what is needed for the actual chlorine demand is necessary in order to have complete reaction between the chlorinating agent and the mustard or thiodiglycol. If this condition is not met, the water will show a chlorine residual as determined by the O-tolidine reaction when it still has a chlorine demand. Other colors may be obtained when using the O-tolidine reaction. If the color is blue or green, it means there is too much O-tolidine for the amount of chlorine present. A red or orange color means that too great an amount of chlorine has been added. A high chlorine demand means contamination with mustard, thiodiglycol, arsenicals or pollution by organic waste material. If the arsenic test is negative, the chlorine demand is a measure of contamination by mustard.

However, the water may also be contaminated with the nitrogen mustards. These compounds do not react in the chlorine demand test.

(6) The tests provided by this kit are not quantitative, and therefore will serve as a guide for the purification of water supplies only within the limitation specified.

H. *Action Required if the Water Is Found Contaminated by Chemical Warfare Agents.*—(1) Whenever positive tests are obtained with the water testing kit, the water will be considered contaminated and the following action taken:

a. The Commanding Officer will establish the necessary safeguards to prevent men from drinking the contaminated water.

b. An alternative source of uncontaminated water should be sought and, if found, should be employed.

c. If a source of uncontaminated water cannot be found, consideration should be given to moving to a different location, or to importing purified water.

d. In any event, the contaminated water should not be used by men until it is purified and then only after every effort has been made to obtain an uncontaminated supply.

e. Contamination discovered in otherwise suitable water should be reported as promptly as possible to the Commanding Officer so that the matter can be brought to the attention of the officer responsible for purification.

I. *Scale for Issue of Water-Testing Kits.*—As the kit is expendable, the individual items of its contents are not supplied for refilling. When the contents have become exhausted, the complete kit can be replaced through the usual channels of medical supply.

J. *Use of Suspected Water.*—(1) Water which is only slightly contaminated can be used for periods not to exceed 1 week after chlorination for bacterial pollution.

(2) When suspected water is used, great care should be taken not to stir up material from the bottom as it may contain chemical agents when the water above does not.

K. *Procedure in Case of Heavy Contamination.*—When water is too heavily contaminated to pass the Screen Kit test, every effort should be made to secure another source or to have pure water supplied. If pure water is not available, treat the contaminated water as outlined briefly below. Only trained personnel should undertake such procedures.

L. *Purification of Contaminated Water.*—(1) Water must be withdrawn from the intermediate levels with minimum disturbance of the surface and no disturbance of the bottom.

(2) *Treatment of large volumes.*

a. The contaminated water is pumped into a canvass reservoir and a quantitative analysis made by the responsible officer.

b. It is then treated with activated carbon (200 mesh) in the following doses:

i. For lewisite, 30 ppm. (30 mg/1.) carbon for each ppm. (mg/1.) lewisite.

ii. For mustard, 30 ppm. (30 mg/1.) carbon for each ppm. (mg/1.) mustard.

iii. For nitrogen mustard, 60 ppm. (60 mg/1.) carbon for each ppm. (mg/1.) nitrogen mustard.

c. The carbon and water are mixed for 20 minutes to insure complete absorption of the agent by the carbon.

d. 175 ppm. (175 mg/1.) of coagulant is added to the carbon-dosed water, together with sufficient alkali to give optimal coagulation.

e. After thorough, gentle mixing, the water is allowed to coagulate and clarify by sedimentation for 30 minutes.

f. The supernatant water is filtered through the portable water purification unit, at normal rate 8 + 10 gpm., or preferably more slowly.

g. The filtered water must be tested quantitatively to see that it meets the following requirements:

i. Mustards—not more than 2 ppm. (2 mg/1.).

ii. Lewisite (arsenicals) not more than 20 ppm. 20 mg/1.).

iii. pH above 5.

iv. Chlorine demand, less than 5.

v. No chemical odor or taste.

(3) *Treatment in Lyster Bags.*

a. When the portable water purification unit is not available, small volumes can be purified by using two Lyster bags.

b. If testing equipment is available to identify the contaminating agents and determine their concentrations, add activated carbon in the dosages given in par. L (2), to the water in one Lyster bag. If the identities and concentrations of contaminants are unknown, add 2 lbs. activated carbon.

c. Stir for 20 minutes.

d. Add 1 ounce of alum and sufficient alkali to give optimal coagulation. These chemicals should be dissolved separately in small volumes of water prior to their addition to the Lyster bag.

e. After thorough, gentle mixing, allow to coagulate and clarify by sedimentation for 30 minutes.

f. Siphon the supernatant water to another Lyster bag (preferably through a filter).

g. After testing to insure that the requirements of par. L (2) g, page 67, are met, the water in the second Lyster bag must be chlorinated.

M. *Chlorination of Contaminated Water.*—Chlorine reacts with some of the chemical agents making it difficult to remove them by the activated carbon and alum treatment. Therefore, chlorination should be carried out only after filtration through the portable purification unit, and the chlorine feed-line must be connected to the effluent pipe from the filter. In the case of treatment in the Lyster bag, chlorine is added in the *second* Lyster bag. When contamination is suspected, no chlorinating compounds should be added until the water has been clarified.

SECTION XV

43. *MANAGEMENT AND TRANSPORT OF CHEMICAL WARFARE CASUALTIES IN NAVAL AND MARINE FORCES*

A. *General.*—(1) Casualties unable to apply self-aid are cared for by the medical services. A casualty is defined as one who is no longer able to carry out his military duties as a result of injury.

(2) Non-casualties who are contaminated are charged with the responsibility of self-aid at the earliest possible moment consistent with battle conditions.

(3) The management and transport of contaminated gas casualties whether wounded or otherwise will be governed primarily by military considerations.

(4) To facilitate the management and transport of gas casualties, the medical officer whether afloat or ashore shall develop a practicable and safe plan applicable to the command to which he is attached. This plan shall be incorporated in the gas defense bill of that unit.

(5) Certain improvisations may be necessary to activate such a plan. The basic principles of management and transport must be clearly understood and applied in order to make it effective.

(6) The most difficult problems of management and transport concern casualties contaminated with blister gas.

B. *Principles of Management and Transport.*—(1) Avoid spread of contamination:

a. If gas warfare agents have been used, it must be assumed that all casualties are contaminated until proved otherwise.

b. Personnel shall take all reasonable precautions to protect themselves adequately while handling contaminated casualties. If blister gas is encountered they must wear the mask, protective ointment, protective suits, protective gloves, rubber overshoes and an impervious apron. In an emergency the individual protective cover issued to advanced base personnel may be used instead of the impervious apron. These items, except the mask and protective cover, are contained in the gas casualty treatment case, unit No. 10, Med. Supply Catalog Item 14–055.

c. Personnel handling contaminated casualties shall avoid spreading contamination to other personnel and to facilities not specifically designated for the reception of gas casualties.

d. Contaminated personnel, casualties, clothing and equipment must be pre-

vented from gaining access to totally enclosed spaces either afloat or ashore. Interior contamination of the ship or of enclosed structures ashore must be avoided.

e. Contaminated clothing and equipment shall be placed in tightly covered containers marked for the purpose, or in designated dumps sufficiently far moved from the scene of activities, for decontamination or disposal as determined by the chemical warfare officer.

(2) First Aid:

a. The problem will arise frequently as to which condition requires priority of first aid, the surgical condition or the gas hazard.

b. In all instances such as severe hemorrhage or shock, the surgical condition takes priority of action.

c. If the surgical condition permits delay, the casualty shall be decontaminated on the spot, protected from further exposure and, if consistent with battle conditions, transported to the nearest aid station designated to receive gas casualties.

C. *Transport of Gas Casualties.*—(1) Stretcher bearers adequately trained and equipped to handle gas contaminated casualties should be detailed to transport such cases.

(2) The gas hazards attending the management and transport of contaminated casualties in operations ashore may be enhanced by the distances involved and by the character of the terrain, foliage and weather. Afloat, the hazards tend to be increased by the limited topside space available for decontamination, the provisions for gas integrity of the ship, and the small openings and passageways which limit transport to dressing stations.

(3) Ashore, the hazards of transporting gas contaminated casualties by stretcher shall be minimized by using two stretcher covers, if available as follows:

a. Stretcher Cover No. 1.

a. This cover shall be the impervious cover issued to advanced base naval and Marine Corps personnel. Medical officers of advanced bases shall arrange to draw the necessary supply of this item from the stock to be maintained by the Bureau of Ships in these areas. If not available from this source it may be obtained from the casualty encountered or other personnel as in the case of the Marine Corps. Medical officers attached to Marine Corps units shall utilize the impervious protective cover carried in the gas mask carrier of the casualty transported, or from other personnel, as the Marine Corps does not maintain a reserve stock for use as stretcher covers. In an emergency, the poncho carried by Marine Corps personnel in combat areas may be utilized.

b. For use on the stretcher the cover will be split up each side or up one side and across the top.

c. The use of a clean impervious cover with each casualty permits the alternate transport of a wounded, but clean casualty, by the same stretcher, since it prevents contamination from the stretcher to the casualty and vice versa.

b. Stretcher Cover No. 2.

a. This cover is an ordinary unimpregnated blanket routinely issued to stretcher bearers.

c. If two stretcher covers, No. 1 and No. 2 are used the following procedure should be carried out:

a. Stretcher Cover No. 2 is laid over No. 1 and both are folded over so as to bring the side edges to the center. They are to be folded again and the ends turned in to fit the stretcher, when in the carrying position.

b. The prepared stretcher is placed beside the casualty; first aid is administered; the covers are unfolded; the casualty is laid on No. 2 cover; the sides are folded over the casualty and transport begun.

d. Transport by ambulance or other enclosed vehicle of the contaminated gas casualty cannot be undertaken except with grave risk of contaminating its interior. Casualties must be decontaminated before such transport.

e. Upon depositing the casualty at the aid station the stretcher covers are to remain with the casualty. Clean covers (if available), previously folded, are to be laid into the stretcher for the transport of another casualty.

(4) Afloat, the problems of transport do not warrant the use of the impervious protective cover. This item is not issued to naval vessels. It is advised that an ordinary blanket be substituted, even though it is pervious to vesicant liquid or vapor. This is preferred to leaving the casualty completely exposed. The blanket must be subsequently handled as a contaminated item.

(5) For all activities, it must be emphasized, that if the stretcher is not equipped to limit undue hazards, it becomes contaminated and must be handled as such.

D. *Aid Stations for Gas Contaminated Casualties*.—(1) Aid stations shall be improvised with free ventilation, upwind from the gassed area and protected as much as possible against drops of liquid gas from overhead structures or foliage. In no event shall it be an enclosed space.

(2) The station shall be located in a gas-free area, if possible. If a contaminated area must be selected, proper decontamination shall be carried out. Afloat, this is accomplished by using the non-corrosive decontaminating agent RH–195 issued by the Bureau of Ships. Ashore, chloride of lime (also known as bleach) is satisfactory. Bleach may be spread over the area either as a powder or mixed with water.

(3) The aid station shall be clearly posted for easy identification and shall be marked off into an unclean and a clean area, the latter being on the windward side.

a. The unclean area:

a. The unclean area should be equipped with tightly covered G. I. cans or similar receptacles for reception of contaminated clothing and equipment, a reserve stock of protective ointment S–461 or S–330 and BAL Ointment, an adequate supply of water and soap for cleansing, standard first aid equipment for the care of wounded casualties and a foot box containing RH–195 powder or bleach powder through which all personnel must walk in going from the unclean to the clean area in order to decontaminate foot gear. It is advisable also to improvise stands (sawhorse or the like) for supporting the stretcher and casualty above the terrain or deck.

b. The contaminated casualty deposited in the unclean area shall receive first aid. All contaminated clothing, equipment, covers, blankets and valuables, except the gas mask, if worn, shall be placed in specified G. I. cans for disposal by the chemical warfare officer. The casualty is to be further cleansed by the removal of all gross liquid agents and by the application of antigas ointment and other decontaminating procedures as outlined in Manual NavMed, 220 "The Treatment of Casualties from Chemical Warfare Agents." The casualty is then ready for transfer to the clean area in a clean stretcher and/or clean covers and blankets.

b. The clean area:

a. The clean area shall be reserved for decontaminated casualties. Before entering this area, the gas mask shall be removed if the atmosphere is gas-free. Additional first-aid measures may then be carried out, after which the casualty is ready for transport to a battle dressing station or to a shore medical facility for further specific treatment.

SECTION XVI

NAVY MEDICAL SUPPLY DEPOT ITEMS FOR SELF-AID AND DEFINITIVE TREATMENT OF CHEMICAL WARFARE CASUALTIES

Stock No.	Item	Unit	Quantity
	S2-1058 Kit, First Aid (Gas Casualties): (contents)		
1-140	AMYL NITRITE, 5 minim pearl	12 in box	1
1-	COPPER SULFATE SOLUTION, 10% with BLUNT DRESSING FORCEPS.	pkg	1
S1-3355	OINTMENT, ANESTHETIC	1-oz tube	1
S1-3361	OINTMENT, BAL	½-oz tube	1
S1-3365	OINTMENT, BUTYN OPHTHALMIC, 2%	1-dr tube	2
S1-3375	OINTMENT, PROTECTIVE, S-461	3-oz tube	2
S2-845	COTTON PADS, 1- by 2-in	50 in pkg	1
	14-055 Field Medical No. 10 CASE, Treatment Chemical Casualties		
	Packing: Four hard fiber suitcases, 26- by 13- by 9- in. Weight: Case No. 1, 43 lb; case No. 2, 25 lb; case No. 3, 40 lb; case No. 4, 30 lb. Total cubic measurements: 7.6 cu ft.		
	Case No. 1		
1-140	AMYL NITRITE, 5 minim pearl	12 in box	8
1-245	CHLOROFORM (for anesthesia)	¼-lb bot	2
1-285	CUPRIC SULFATE	2-oz bot	4
1-495	MORPHINE TARTRATE, 0.032-gm, 1½ cc tube with sterile needle	syrette	5
1-725	SOAP, hard (Castile)	1-lb pkg	1
1-745	SODIUM, BICARBONATE	1-lb ctn	1
1-995	CODEINE SULFATE, 0.0162-gm	100 bot	1
2-135	BATH, eye	one	6
2-350	COTTON, absorbent, compressed	1-oz pkg	6
2-435	GAUZE, plain, compressed	1-oz pkg	25
3-766	SHEARS, bandage, angular, 5½-in (Lyster)	one	1

Stock No.	Item	Unit	Quantity
3-865	SUITCASE, hard fiber, 24- by 12- by 8-in	one	1
4-110	BOTTLE, 8-fl-oz	doz	1/12
4-745	MEDICINE DROPPER	doz	½
6-235	SPOON, table	one	1
13-025	BASIN, hand, rubber, collapsible	one	1
13-185	STIRRER, wood, ½- by 12-in	one	1
13-210	TIN, ½-gal capacity	one	1
14-280	CASE, canvas, carrying	one	1
14-500	SPOON, tea	one	1
S1-3355	OINTMENT, ANESTHETIC	1-oz tube	5
S1-3361	OINTMENT, BAL	tube	50
S1-3362	OINTMENT, BORIC ACID	4-oz tube	10
S1-3365	OINTMENT, BUTYN, ophthalmic 2%	1-dr	12
S1-3375	OINTMENT, PROTECTIVE, S-461	3-oz tube	50
S1-3785	SOLUTION, ANESTHETIC	1-oz bot	1
S7-300	TREATMENT OF CASUALTIES FROM CHEMICAL AGENTS	one	1
	Case No. 2		
1-140	AMYL NITRITE, 5 minim pearl	12 in box	7
1-245	CHLOROFORM (for anesthesia)	¼-lb bot	2
1-285	CUPRIC SULFATE	2-oz bot	4
1-495	MORPHINE TARTRATE, 0.032-gm, 1½-cc tube with sterile needle	syrette	5
1-725	SOAP HARD (Castile)	1-lb pkg	1
1-745	SODIUM BICARBONATE	1-lb ctn	1
1-980	ACID, ACETYLSALICYLIC, 0.324-gm	1,000 bot	1
1-995	CODEINE SULFATE, 0.0162-gm	100 bot	1
2-135	BATH, eye	one	6
2-350	COTTON, absorbent, compressed	1-oz pkg	6
2-435	GAUZE, plain, compressed	1-oz pkg	25
3-766	SHEARS, bandage, angular, 5½ in	one	1
3-865	SUITCASE, hard fiber, 24- by 12- by 8-in	one	1
4-730	MEASURE, glass, graduated, 500-cc	one	1
4-745	MEDICINE DROPPER	doz	½
13-025	BASIN, hand, rubber, collapsible	one	1
13-185	STIRRER, wood, ½- by 12-in	one	1
13-210	TIN, ½-gal capacity	one	1
14-280	CASE, Canvas, carrying	one	1
14-500	SPOON, tea	one	1
S1-3355	OINTMENT, ANESTHETIC	1-oz tube	5
S1-3361	OINTMENT, BAL	tube	50
S1-3362	OINTMENT, BORIC ACID	4-oz tube	10
S1-3365	OINTMENT, BUTYN, ophthalmic 2%	1-dr tube	12
S1-3375	OINTMENT, PROTECTIVE, S-461	3-oz tube	50
S1-3565	POWDER, BLEACHING, HIGH TEST HYPO	3¾-lb cont	1
S1-3785	SOLUTION, ANESTHETIC	1-oz bot	1

Stock No.	Item	Unit	Quantity
	Case No. 3		
3-865	SUITCASE, hard fiber, 24- by 12- by 8-in.	one	1
13-025	BASIN, hand, rubber collapsible	one	2
13-105	GLOVES, acid, rubber	pair	8
14-280	CASE, canvas, carrying	one	1
S13-010	APRON, impermeable, surgeon's	one	2
S13-500	OVERSHOES, rubber	pair	8
	Case No. 4		
3-865	SUITCASE, hard fiber, 24- by 12- by 8-in.	one	1
14-280	CASE, canvas, carrying	one	1
S13-700	SUIT, gas-resistant, 2-piece	one	8

ADDITIONAL ITEMS NOT IN UNIT

Stock No.	Item	Unit
1-150	ATROPINE SULPHATE	15-gr vial.
1-170	BISMUTH SUBCARBONATE	1-lb ctn.
1-175	BISMUTH SUBNITRATE	¼-lb bot.
S1-2601	FLUORESCEIN SODIUM	10-gm bot.
S1-1130	PENICILLIN SODIUM, CRYSTALLINE 100,000 Oxford Units	Ampule.
S1-3530	PLASMA Normal Human Dried	250 cc.
S1-3531	PLASMA Normal Human Dried	500 cc.
S1-4315	SODIUM BICARBONATE 0.648 gm	100 bot.
S1-4316	SODIUM BICARBONATE 0.648 gm	1,000 bot.
S1-3808	SULFADIAZINE 1 gm Tables	24 pkg.
S1-4341	SULFANILAMIDE 0.324 gm Tablets	100 bot.
S1-3790	SOLUTION DEXTROSE (glucose) 5 percent normal	1,000 cc.
S1-3795	SOLUTION Normal SALINE	1,000 cc.
S1-2092	TETANUS TOXIDE, Alum Precipitated	10-cc vial.
S1-4790	ZEPHIRAN CHLORIDE aqueous (concentrate)	4-oz bot.

SECTION XVII

SYLLABUS OF INSTRUCTION AND TRAINING IN CHEMICAL WARFARE DEFENSE FOR ALL MEDICAL PERSONNEL

(10-Hour Course)

A. *Basic Gas Defense Instruction and Training.*—(1) 5-hour, 10-hour, or 24-hour course depending upon the local command. The Chemical Warfare Officer of each unit or sub-unit is responsible for this training which includes all naval personnel (Ref. Section 12, CNO Manual FTP. 222, "Chemical Warfare Defense").

B. *Medical Gas Defense Instruction and Training.*—(1) General.

FIRST HOUR

a. Introduction to problem.
b. War gases; physiological classification of:
    i. Blister gases.
    ii. Choking gases.
    iii. Blood and nerve poisons.
    iv. Vomiting gases.
    v. Tear gases.
c. Screening smokes.
d. Incendiaries.

(2) Effects of chemical warfare agents on the body; self aid, first aid, and treatment relating to the eyes, the skin, the respiratory tract and systemically.

SECOND HOUR—BLISTER GASES

a. Mustard gas (H).
b. Nitrogen mustard gas (HN).

THIRD HOUR—BLISTER GASES, CONTINUED

a. Lewisite (L), Ethyldichlorarsine (ED), Phenyldichlorarsine (PD).
b. Mixed blister gases (H & L, HN & L, etc.).

FOURTH HOUR—CHOKING GASES

a. Phosgene (CG), Diphosgene (DP), Chlorpicrin (PS), Chlorine (CL), Nitric Fumes.

FIFTH HOUR—BLOOD AND NERVE-POISONS AND TEAR GASES

a. Hydrocyanic Acid (AC), Cyanogen Chloride (CC), Arsine (SA).
b. Chloracetophenone (CN), Chloracetophenone Solution (CNS), Chloracetophenone Training Solution (CNB), Brombenzylcyanide (BBC).

SIXTH HOUR—VOMITING GASES AND SCREENING SMOKES

a. Adamsite (DM), Diphenylchlorarsine (DA), Diphenylcyanarsine (DC).

b. Hexachlorethane Mixture (HC), Sulfur Trioxide (FS), Titanium Tetrachloride (FM), White Phosphorus (WP).

SEVENTH HOUR

a. Incendiaries: Thermite (TH), Magnesium (TH), Oil Incendiaries (IM) (NP).

b. Treatment of Burns: White Phosphorus (WP) and Incendiaries (TH) (IM) (NP).

(3) Special medical instruction and training.

EIGHTH HOUR—MANAGEMENT AND TRANSPORT OF CHEMICAL WARFARE CASUALTIES IN NAVAL AND MARINE FORCES

a. General.
b. Principles of.
c. Transport of gas casualties:
    i. Afloat
    ii. Ashore
d. Aid stations for gas contaminated casualties:
    i. Afloat
    ii. Ashore

NINTH HOUR

a. Resuscitation and oxygen therapy as applied to gas casualties.
b. Contamination of food and water:
    i. General problems.
    ii. Kit, water testing and screening.
c. Gas defense bill: Application of bill to medical organization.

(4) Summary of course.

TENTH HOUR

a. Review.
b. Quiz.

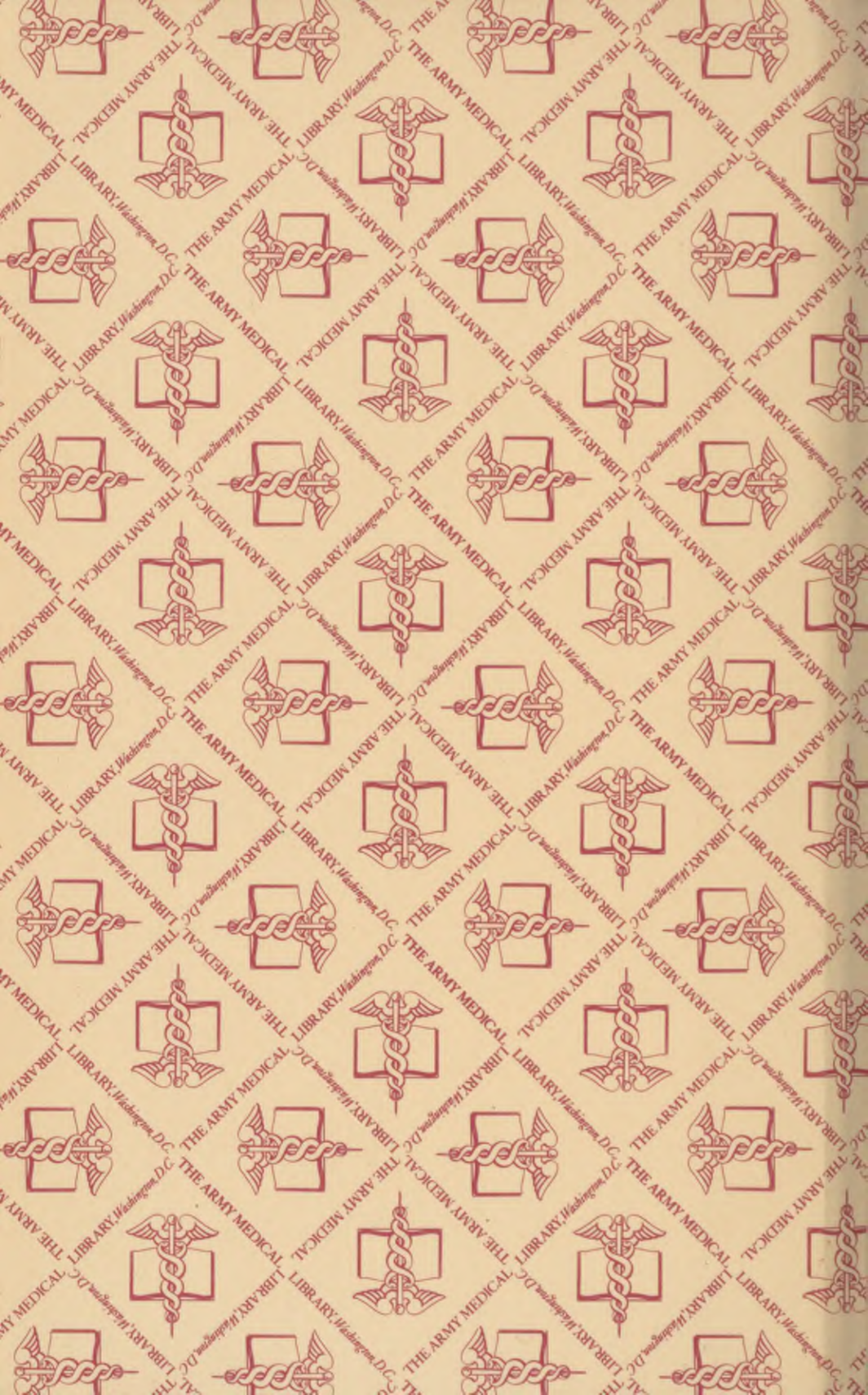
INDEX

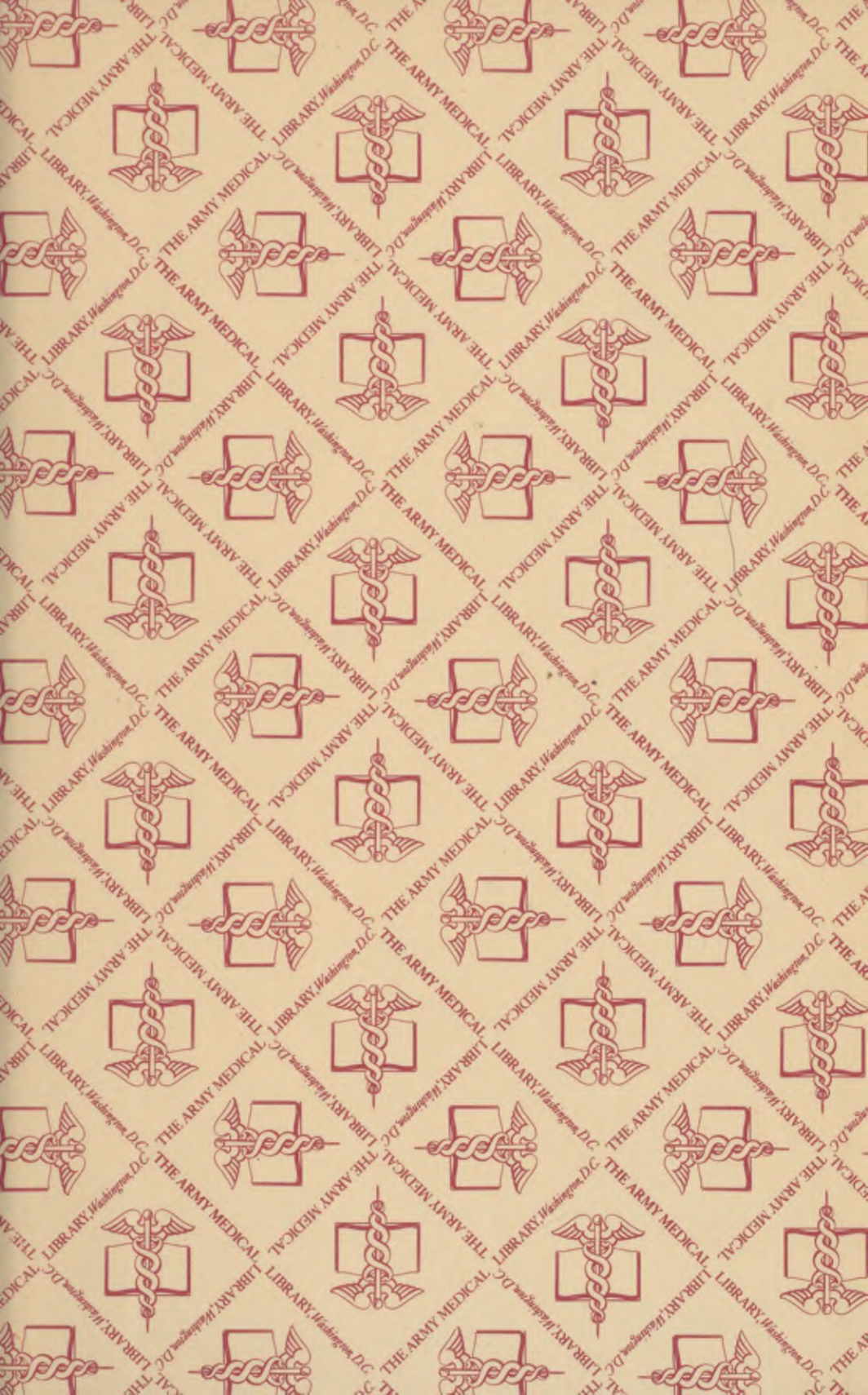
☆ 590990

CHEMICAL WARFARE REFERENCE CHART

Tactical Class	Physiological Class	Symbol	Name	Odor	Color and State	Persistence	Effect on Body	Protection	Self-Aid Must be Immediate
CASUALTY GASES	Blister Gases	**H**	Mustard	Garlic Horse-radish	Dark-oily Liquid Colorless Gas	1 Day to All Winter	No immediate symptoms. 3 to 36 hours later irritates Eyes, Skin, Nose, Lungs. Worse in Tropics.	Gas Masks Eye Shields Protective Clothing Protective Covers	EYES. Wash out with water. SKIN. Blot off liquid. Rub in ointment S-461 or S-330. Do not use in Eyes or on reddened Skin. CLOTHES. See L.
		HN	Nitrogen Mustards	Faint; Fishy	do	2 Hours to Days			
		L	Lewisite	Geraniums	do	1 Day to 1 Week	Immediate stinging pain of Eyes and Skin. Irritates Nose, Throat, and Lungs. Worse in Tropics.		EYES. Squeeze ointment BAL into eyes. SKIN. Blot off liquid. Rub in ointment BAL. Do not use on reddened Skin. CLOTHES. Remove clothing contaminated and discard. Avoid fumes. Treat underlying Skin.
		ED	Ethyldichlorarsine	Biting and Stinging	Colorless or Brown Liquid Colorless Gas	1 to 12 Hours			
		PD	Phenyldichlorarsine	Shoe Polish	Clear Viscid Liquid	Hours to Days			
		Mixed	H and L HN and L, etc.	Combination of H and L	Combination of H and L		Combination of H. and L.		EYES. Ointment BAL. SKIN. Ointment S-461 or S-330. Remove. Use BAL. CLOTHES. As L.
	Choking Gases	**CG**	Phosgene	Musty Hay Green Corn	Colorless Gas	1 to 10 Minutes	Coughing. Choking. Difficulty in breathing. Fluid in Lungs.	Gas Masks	If breathing becomes difficult keep quiet and comfortably warm until given medical attention.
		DP	Diphosgene	do	do	30 Minutes			
		PS	Chlorpicrin	Flypaper Licorice	Yellow Oily Liquid Colorless Gas	1 Hour to 1 Week	Irritates Eyes. Same as CG.	Gas Masks	Rest and comfortably warm. Wash Eyes, Nose and Throat for irritation.
		CL	Chlorine	Chloride of Lime	Greenish Yellow Gas	10 Minutes to 1 Hour	Same as PS.	Gas Masks	Same as PS.
	Blood and Nerve Poisons	**AC**	Hydrocyanic Acid	Bitter Almonds	Colorless Liquid or Gas	1 to 10 Minutes	Dizziness, headache, coma.	Gas Masks	Whiffs of amyl nitrite. First aid if not breathing is artificial respiration.
		CC	Cyanogen Chloride	Biting	do	do	Irritates Eyes, Nose, Throat. Also as AC.	Gas Masks	
HARASSING GASES	Tear Gases	**CN**	Chloracetophenone	Apple Blossoms	Cloud of Particles, Droplets	10 Minutes to Weeks	Irritates Eyes. Heavy concentration irritates Nose, Throat, and Lungs. Also burns and blisters the skin in warm climates.	Gas Masks	Wash out Eyes with water and wash Skin with soap and water. Face upwind. Additional self-aid usually not necessary.
		CNS	Chloracetophenone Solution	Fly Paper	do	1 Hour to 1 Week			
		CNB	Chloracetophenone Training Solution	Sweetish Benzine	do	Not determined			
		BBC	Brombenzyl Cyanide	Sour Fruit	Colorless Liquid or Gas	Days to Weeks			
	Vomiting Gases	**DM**	Adamsite	Coal Smoke	Yellow Cloud	10 Minutes	Irritates Eyes, Nose, and Throat. Vomiting, headache.	Gas Masks	Sniff chloroform. Keep masked. Lift mask only when actually vomiting. Additional self-aid usually not necessary.
		DA	Diphenylchloarsine	Shoe Polish	White or Gray Cloud	5 to 10 Minutes			
		DC	Diphenylcyanarsine	Garlic Bitter Almonds	White Cloud	do			
SCREENING SMOKES		**HC**	Hexachlorethane Mixture	Sharp; Stinging	White to Gray Smoke	While Burning	Heavy concentration irritates Eyes, Nose, and Throat. FS and FM liquid burns Skin.	Gas Masks for heavy concentrations.	Wash out Eyes if irritating. Wash Skin burns with water. Additional self-aid usually not necessary.
		FS	Sulfur Trioxide	do	Dense White Smoke	5 to 10 Minutes			
		FM	Titanium Tetrachloride	do	White Smoke	10 Minutes			
		WP	White Phosphorus	None or Burning Matches	Burns to White Smoke in Air	10 Minutes	Burns Skin.	Avoid burning particles.	Keep wet with water or cover with copper sulfate. Remove particles. Do not use grease, salve.
INCENDIARIES		**TH**	Thermite Magnesium Bomb	None	White Hot Metal; Burns with White Light		Heat, burns.	do	Cool burning material and remove. Treat as any burn.
		IM NP	Thickened Gasoline	Burning Oil	Yellow Jelly Black Smoky Flame			do	

Physiological Class	Symbol	Name	Odor	Color and State
Blister Gases	H	Mustard	Garlic Horse-radish	Dark-oily Liquid Colorless Gas
	HN	Nitrogen Mustards	Faint; Fishy	do
	L	Lewisite	Geraniums	do
	ED	Ethyldichlorarsine	Biting and Stinging	Colorless or Brown Liquid Colorless Gas
	PD	Phenyldichlorarsine	Shoe Polish	Clear Viscid Liquid
	Mixed	H and L HN and L, etc.	Combination of H and L	Combination of H and L
Choking Gases	CG	Phosgene	Musty Hay Green Corn	Colorless Gas
	DP	Diphosgene	do	do
	PS	Chloropicrin	Fly-paper Licorice	Yellow Oily Liquid Colorless Gas
	CL	Chlorine	Chloride of Lime	Greenish Yellow Gas
Poisonous Mists and Blood	AC	Hydrocyanic Acid	Bitter Almonds	Colorless Liquid or Gas
	CC	Cyanogen Chloride	Biting	do
Tear Gases	CN	Chloracetophenone	Apple Blossoms	Cloud or Particles; Droplets
	CNS	Chloracetophenone Solution	Fly Paper	do
	CNB	Chloracetophenone Tearing Solution	Sweetish Bromine	do
	BBC	Bromobenzyl Cyanide	Sour Fruit	Colorless Liquid or Gas
Vomiting Gases	DM	Adamsite	Coal Smoke	Yellow Cloud
	DA	Diphenylchlorarsine	Shoe Polish	White or Gray Cloud
	DC	Diphenylcyanarsine	Garlic Bitter Almonds	White Cloud
Smoke	HC	Hexachlorethane Mixture	Sharp; Stinging	White to Gray Smoke
	FS	Sulfur Trioxide	do	Dense White Smoke
	FM	Titanium Tetrachloride	do	White Smoke
	WP	White Phosphorus	None or Burning Matches	Burns to White Smoke in Air
Incendiary	TH	Thermite Magnesium Bomb	None	White Hot Metal; Burns with White Light
	IM NP	Thickened Gasoline	Burning Oil	Yellow Jelly Black Smoky Flame


THE ARMY MEDICAL LIBRARY, Washington, D.C.


THE ARMY MEDICAL LIBRARY, Washington, D.C.