

Blister Agents
Sulfur Mustard Agent H or HD (C₄H₈Cl₂S)
CAS 505-60-2, UN 2927;
and Sulfur Mustard Agent HT CAS 6392-89-8

Synonyms:

H and HD: Bis(2-chloroethyl) sulfide; bis(beta-chloroethyl) sulfide; di-2-chloroethyl sulfide; 1-chloro-2(beta-chloroethylthio)ethane; 2,2'-dichloroethyl sulfide; sulfur mustard; Iprit; Kampstoff "Lost"; mustard gas; senfgas, S-yperite; yellow cross liquid; yperite
HT: Mixture of bis(2-chloroethyl) sulfide and bis[2-(2-chloroethylthio)-ethyl]ether

People whose skin or clothing is contaminated with sulfur mustard can contaminate rescuers by direct contact or through off-gassing vapor.

- **Sulfur mustards are yellow to brown oily liquids with a slight garlic or mustard odor. Although volatility is low, vapors can reach hazardous levels during warm weather.**
- **Sulfur mustards are absorbed by the skin, causing erythema and blisters. Ocular exposure to these agents may cause incapacitating damage to the cornea and conjunctiva. Inhalation damages the respiratory tract epithelium and may cause death.**

Description

Sulfur mustards are vesicants and alkylating agents. They are colorless when pure but are typically a yellow to brown oily substance with a slight garlic or mustard odor. H contains about 20 to 30% impurities (mostly sulfur); distilled mustard is known as HD and is nearly pure; HT is a mixture of 60% HD and 40% agent T (a closely related vesicant with a lower freezing point). Sulfur mustards evaporate slowly. They are very sparingly soluble in water but are soluble in oils, fats, and organic solvents. They are stable at ambient temperatures but decompose at temperatures greater than 149°C.

Routes of Exposure

Inhalation

Sulfur mustards are readily absorbed from the respiratory tract; injury develops slowly and intensifies over several days. The odor of sulfur mustards does not provide adequate warning of detection. The LCt₅₀ (the product of concentration times time that is lethal to 50% of the exposed population by inhalation) is approximately 1,500 mg-min/m³. The vapors are heavier than air. When inhaled, these agents may cause systemic effects. The estimated Ct for airway injury is 100 to 200 mg-min/m³.

Skin/Eye Contact

Mustard vapor and liquid are absorbed through the eyes, skin, and mucous membranes. Clinical effects do not occur until hours after exposure. The median incapacitating dose for the vapor is 200 mg-min/m³. A Ct of 12 to 70 mg-min/m³ produces eye lesions. Direct contact with the liquid can cause skin and eye burns that develop an hour or more after exposure. A 10 µg droplet is capable of producing blisters. Skin, eye, and airway exposure to vapor sulfur mustard and skin and eye exposure to liquid mustard may cause systemic toxicity. The lethal dose is about 100 mg/kg or 1 to 1.5 teaspoons of liquid.

Ingestion

Ingestion may cause local effects and systemic absorption.

Sources/Uses

Sulfur mustards were first developed in the early-to-mid-1800s and were introduced as chemical warfare agents in 1917 during World War I. They have been used extensively in chemical warfare and remain a major threat. More than a dozen countries have sulfur mustard in their chemical arsenals. Destruction of U.S. stockpiles of chemical agents, including sulfur mustards, was mandated by the Chemical Weapons Convention to take place before April 2007..

Standards and Guidelines

Airborne Exposure Limit (as recommended by the Surgeon General’s Working Group, U.S. Department of Health and Human Services) is 0.003 mg/m³ as a time-weighted average (TWA) for the workplace.

Physical Properties

Table 1. Physical Properties of Sulfur Mustards

Property	Agent H and HD	
	Agent H and HD	Agent HT
Description	Colorless when pure but usually a pale yellow, dark brown or black oily liquid. The vapor is colorless	Clear yellowish liquid
Warning properties	Faint garlic or mustard odor (odor threshold 0.6 mg/m ³)	Slight garlic or mustard-like odor
Molecular weight	159.08 daltons	159.08 daltons (HD); 263.2 daltons (T)
Boiling point	(760 mm Hg) = 419 °F (217.5 °C)	(760 mm Hg) = >442 °F (>228 °C)
Freezing point	58.1 °F (14.5 °C)	32 to 34.3 °F (0 to 1.3 °C)
Specific gravity	1.27 g/mL (water = 1.0)	No data

Vapor pressure	0.072 mm Hg at 68 °F (20 °C); 0.11 mm Hg at 77 °F (25 °C)	No data
Vapor density	5.4 to 5.5 (air = 1.0)	6.92 (air = 1.0)
Liquid density	1.24 to 1.27 g/mL at 68 °F (20 °C)	1.27 g/mL
Flash point	221 °F (105 °C)	212 °F (100 °C)
Solubility in water	0.8 g/L at 68 °F (20 °C)	Practically insoluble
Volatility	600 mg/m ³ (20 °C)	No data
NAERG#	153	153

Incompatibilities

Sulfur mustards are rapidly corrosive to brass and steel at 149 °F (65 °C); they are destroyed by strong oxidizing agents. These agents hydrolyze to form hydrochloric acid (HCl) and thiodiglycol.

Health Effects

Sulfur mustards are vesicants causing skin, eye, and respiratory tract injury. Although these agents cause cellular changes within minutes of contact, the onset of pain and other clinical effects are delayed for 1 to 24 hours.

- **Sulfur mustards are alkylating agents that may cause bone marrow suppression and neurologic and gastrointestinal toxicity.**

Acute Exposure

Sulfur mustards are vesicants and alkylating agents; however, the biochemical mechanisms of action are not clearly understood. They are highly reactive and combine rapidly with proteins, DNA, or other molecules. Therefore, within minutes following exposure intact mustard or its reactive metabolites are not found in tissue or biological fluids. Sulfur mustards also have cholinergic activity, stimulating both muscarinic and nicotinic receptors. The onset of clinical symptoms and their time of onset depend on the severity of exposure (Table 1). The death rate from exposure to sulfur mustard is low (2 to 3% during World War I). Death usually occurs between the 5th and 10th day due to pulmonary insufficiency complicated by infection due to immune system compromise.

Ocular

The eye is the most sensitive tissue to sulfur mustard effects. Sulfur mustard vapor or liquid may cause intense conjunctival and scleral pain, swelling, lacrimation, blepharospasm, and photophobia; however, these effects do not appear for an hour or more. Miosis due to cholinergic effects may occur. High concentrations of vapor or liquid can cause corneal edema, perforation, blindness, and later scarring.

Dermal

Direct skin exposure to sulfur mustards causes erythema and blistering. Generally, a pruritic rash will develop within 4 to 8 hours followed by blistering 2 to 18 hours later. Contact with the vapor may result in first and second degree burns, while contact with the liquid typically produces second and third degree chemical burns. An area of burn covering 25% or more of the body surface area may be fatal.

Respiratory

Dose-dependent inflammatory reactions in the upper and lower airway begin to develop several hours after exposure and progress over several days. Burning nasal pain, epistaxis, sinus pain, laryngitis, loss of taste and smell, cough, wheezing, and dyspnea may occur. Necrosis of respiratory epithelium can cause pseudomembrane formation and local airway obstruction.

<i>Gastrointestinal</i>	Ingestion may cause chemical burns of the GI tract and cholinergic stimulation. Nausea and vomiting may occur following ingestion or inhalation. Early nausea and vomiting is usually transient and not severe. Nausea, vomiting, and diarrhea occurring several days after exposure indicates damage to the GI tract and thus is a poor prognostic sign.
<i>CNS</i>	High doses of sulfur mustards can cause hyperexcitability, convulsions, and insomnia.
<i>Hematopoietic</i>	Systemic absorption of sulfur mustard may induce bone marrow suppression and an increased risk for fatal complicating infections, hemorrhage, and anemia.
<i>Delayed Effects</i>	Years after apparent healing of severe eye lesions, relapsing keratitis or keratopathy may develop.
<i>Potential Sequelae</i>	Persistent eye conditions, loss of taste and smell, and chronic respiratory illness including asthmatic bronchitis, recurrent respiratory infections, and lung fibrosis may persist following exposure to sulfur mustards.
Chronic Exposure	Prolonged or repeated acute exposure to sulfur mustards may cause cutaneous sensitization and chronic respiratory disease. Repeated exposures result in cumulative effects because mustards are not naturally detoxified by the body.
<i>Carcinogenicity</i>	The International Agency for Research on Cancer (IARC) has classified sulfur mustard as carcinogenic to humans (Group 1). Epidemiological evidence indicates that repeated exposures to sulfur mustard may lead to cancers of the upper airways.
<i>Reproductive and Developmental Effects</i>	There is limited evidence that repeated exposures to sulfur mustards may cause defective spermatogenesis years after exposure. Sulfur mustard has been implicated as a potential developmental toxicant because of its similarity to nitrogen mustard; however, data are inconclusive.

Table 1. Clinical Effects and Time of Onset by Severity of Exposure to Sulfur Mustard

Tissue	Severity of exposure	Clinical effects	Time to first effect
Eyes	Mild	Tearing, itching, burning, gritty feeling	4-12 hours
	Moderate	Above effects and reddening, lid edema, moderate pain	3-6 hours
	Severe	Marked lid edema, possible corneal damage, severe pain	1-2 hours
Airways	Mild	Rhinorrhea, sneezing, epistaxis, hoarseness, hacking cough	6-24 hours
	Severe	Above effects and productive cough, mild to severe dyspnea	2-6 hours
Skin	Mild	Erythema	2-24 hours
	Severe	Erythema and vesication	2-24 hours

Prehospital Management

Victims whose skin or clothing is contaminated with liquid sulfur mustard can contaminate rescuers by direct contact or through off-gassing vapor.

Sulfur mustards are extremely toxic and may damage the eyes, skin, and respiratory tract and suppress the immune system. Although these agents cause cellular changes within minutes of contact, the onset of pain and other symptoms is delayed.

There is no antidote for sulfur mustard toxicity. Decontamination within 1 or 2 minutes after exposure is the only effective means of decreasing tissue damage. Sodium thiosulfate given IV within minutes after exposure may prevent lethality.

Hot Zone

Responders should be trained and appropriately attired before entering the Hot Zone. If the proper personal protective equipment (PPE) is not available, or if the rescuers have not been trained in its use, call for assistance in accordance with local Emergency Operational Guides (EOG). Sources of such assistance include local Hazmat teams, mutual aid partners, the closest metropolitan strike system (MMRS) and the U.S. Soldier and Biological Chemical Command (SBCCOM)-Edgewood Research Development and Engineering Center SBCCOM may be contacted (from 0700-1630 EST call 410-671-4411 and from 1630-0700 EST call 410-278-5201), ask for the Staff Duty Officer.

Rescuer Protection

Sulfur mustard vapor and liquid are readily absorbed by inhalation and ocular and dermal contact.

Respiratory protection: Pressure-demand, self-contained breathing apparatus (SCBA) is recommended in response situations that involve exposure to any amount of sulfur mustard.

Skin/ocular protection: Personal protective equipment (PPE) and butyl rubber chemical-protective gloves are recommended at all times when these chemicals are suspected to be involved.

Multi-Casualty Triage

Chemical casualty triage is based on walking feasibility, respiratory status, age, and additional conventional injuries. The triage officer must know the natural course of a given injury, the medical resources immediately available, the current and likely casualty flow, and the medical evacuation capabilities. General principles of triage for chemical exposures are presented in the

box on the following page. There are four triage categories: immediate (priority 1), delayed (priority 2), minimal (priority 3), and expectant (priority 4). Clinical signs and effects of sulfur mustards associated with each of these categories are presented in Table 2.

Before transport, all casualties must be decontaminated. If needed, consult with the base station physician or the regional poison control center for advice concerning management of multiple casualties.

Because signs and symptoms of exposure do not occur for several hours postexposure, patients should be observed for at least 6 hours or sent home with instructions to return immediately if symptoms develop. Patients whose clinical effects and time of onset indicate moderate or severe exposure (see Table 1) and patients who have ingested sulfur mustard should be transported to a medical facility for evaluation.

Symptoms may not develop for 24 hours. Patients who are seen at least 24 hours after exposure and whose symptoms indicate mild exposure (see Table 1) may be sent home after treatment and once their names, addresses, and telephone numbers have been recorded. They should be advised to rest and to seek medical care promptly if additional symptoms develop (see *Follow-up Instructions*, included with the *Sulfur Mustard Patient Information Sheet* below).

Consult with the base station physician, closest Metropolitan Medical Response System, or the regional poison control center for advice regarding triage of multiple victims.

General principles of triage for chemical exposures are as follows:

1. Check triage tag/card for any previous treatment or triage.
2. Survey for evidence of associated traumatic/blast injuries.
3. Observe for sweating, labored breathing, coughing/vomiting, secretions.
4. Severe casualty triaged as immediate if assisted breathing is required.
5. Blast injuries or other trauma, where there is question whether there is chemical exposure, victims must be tagged as immediate in most cases. Blast victims evidence delayed effects such as ARDS, etc.
6. Mild/moderate casualty: self/buddy aid, triaged as delayed or minimal and release is based on strict follow up and instructions.
7. If there are chemical exposure situations which may cause delayed but serious signs and symptoms, then overtriage is considered appropriate to the proper facilities that can observe and manage any delayed onset symptoms.
8. Expectant categories in multi-casualty events are those victims who have experienced a cardiac arrest, respiratory arrest, or continued seizures immediately. Resources should not be expended on these casualties if there are large numbers of casualties requiring care and transport with minimal or scant resources available.

1. *Immediate*: casualties who require lifesaving care within a short time, when that care is available and of short duration. This care may be a procedure that can be done within minutes at an emergency treatment station (e.g., relief of an airway obstruction, administering antidotes) or may be acute lifesaving surgery.

2. *Delayed*: casualties with severe injuries who are in need of major or prolonged surgery or other care and who will require hospitalization, but delay of this care will not adversely affect the outcome of the injury (e.g., fixation of a stable fracture).

3. *Minimal*: casualties who have minor injuries, can be helped by nonphysician medical personnel, and will not require hospitalization.

4. *Expectant*: casualties with severe life-threatening injuries who would not survive with optimal medical care, or casualties whose injuries are so severe that their chance of survival does not justify expenditure of limited resources. As circumstances permit, casualties in this category may be reexamined and possibly be retriaged to a higher category.

Table 2. Triage for Mustard Agent Casualties

Category (Priority)	Time of Onset	Clinical Signs and Symptoms
Immediate (1)	<4 up to 12 hours post exposure	Lower respiratory signs (dyspnea)
Delayed (2)	> 4 hours (eye and skin); or >12 hours (respiratory) post exposure	Eye lesions with impaired vision; skin lesion covering 2 to 50% of body surface area for liquid exposure or any body surface burn for vapor exposure; lower respiratory symptoms (cough with sputum production, dyspnea)
Minimal (3)	> 4 hours post exposure	Minor eye lesion with no vision impairment; skin lesion < 2% of body surface area in noncritical areas; minor upper respiratory symptoms (cough, sore throat).
Expectant (4)	< 4 hours post exposure	Lower respiratory signs (dyspnea); skin lesion covering 50% or more of body surface area from liquid exposure

ABC Reminders

Quickly ensure that the victim has a patent airway. Maintain adequate circulation. If trauma is suspected, maintain cervical immobilization manually and apply a cervical collar and a backboard when feasible. Apply direct pressure to stop arterial bleeding, if present.

Victim Removal

If victims can walk, lead them out of the Hot Zone to the Decontamination Zone. Victims who are unable to walk may be removed on backboards or gurneys. If these are not available, carefully carry or drag victims to safety.

Decontamination Zone

Decontamination within 1 or 2 minutes following exposure is the only effective means for decreasing tissue damage. Later decontamination is not likely to improve the victim's condition but will protect other personnel from exposure. Decontaminable gurneys and back boards should be used if available when managing casualties in a contaminated area. Decontaminable gurneys are made of a monofilament polypropylene fabric that allows drainage of liquids, does not absorb chemical agents, and

is easily decontaminated. Fiberglass back boards have been developed specifically for use in HAZMAT incidents. These are nonpermeable and readily decontaminated. The **Chemical Resuscitation Device** is a bag-valve mask equipped with a chemical agent cannister that can be used to ventilate casualties in a contaminated environment.

Rescuer Protection

Personnel should continue to wear the same level of protection as required in the Hot Zone (see *Rescuer Protection* under *Hot Zone*, above).

ABC Reminders

Quickly ensure that the victim has a patent airway. Maintain adequate circulation. Stabilize the cervical spine with a decontaminable collar and a backboard if trauma is suspected. Administer supplemental oxygen if cardiopulmonary compromise is suspected. Assist ventilation with a bag-valve-mask device equipped with a cannister or air filter if necessary. Direct pressure should be applied to control bleeding, if present.

Basic Decontamination

Early decontamination, preferably within 1 or 2 minutes after exposure, is the only way to reduce tissue damage. Flush the eyes immediately with water for about 5 to 10 minutes by tilting the head to the side, pulling eyelids apart with fingers, and pouring water slowly into eyes. Do not cover eyes with bandages.

If exposure to liquid agent is suspected, victims should remove all clothing and wash skin with soap and water. If shower areas are available, showering with water alone will be adequate. However, in those cases where water is in short supply, and showers are not available, an alternative form of decontamination is to use 0.5% sodium hypochlorite solution or absorbent powders such as flour, talcum powder, or Fuller's earth. If exposure to vapor only is certain, remove outer clothing and wash with soap and water or 0.5% solution of sodium hypochlorite. Place contaminated clothes and personal belongings in a sealed double bag.

In cases of ingestion, **do not induce emesis**. There is no evidence that administration of activated charcoal is beneficial.

Transfer to Support Zone

As soon as basic decontamination is complete, move the victim to the Support Zone.

Support Zone

Be certain that victims have been decontaminated properly (see *Decontamination Zone*, above). Victims who have undergone decontamination pose no serious risk of secondary

contamination to rescuers. In such cases, Support Zone personnel require no specialized protective gear.

ABC Reminders

Quickly ensure that the victim has a patent airway. If trauma is suspected, maintain cervical immobilization manually and apply a cervical collar and a backboard when feasible. Ensure adequate respiration; administer supplemental oxygen if cardiopulmonary compromise is suspected. Maintain adequate circulation. Establish intravenous access if necessary. Attach a cardiac monitor. Direct pressure should be applied to stop bleeding, if present.

Additional Decontamination

In cases of ingestion, **do not induce emesis**. If the victim is alert and able to swallow, give 4 to 8 ounces of milk or water to drink. There is no evidence that administration of activated charcoal is beneficial.

Advanced Treatment

Intubate the trachea in cases of respiratory compromise. When the patient's condition precludes endotracheal intubation, perform cricothyrotomy if equipped and trained to do so.

Treat patients who have bronchospasm with bronchodilators.

Trauma patients who are comatose, hypotensive, or have seizures or cardiac dysrhythmias should be treated according to advanced life support (ALS) protocols.

Transport to Medical Facility

Report the condition of the patient, treatment given, and estimated time of arrival at the medical facility to the base station and the receiving medical facility.

Emergency Department Management

Patients whose skin or clothing is contaminated with liquid sulfur mustard can contaminate rescuers by direct contact or through off-gassing vapor.

Sulfur mustards are extremely toxic and may damage eyes, skin, and respiratory tract and suppress the immune system. Although these agents cause cellular changes within minutes of contact, the onset of pain and other symptoms is delayed. Thus, patients arriving immediately from the scene of exposure are not likely to have signs and symptoms.

There is no antidote for sulfur mustard toxicity. Decontamination of all potentially exposed areas within minutes after exposure is the only effective means of decreasing tissue damage. Thus, by the time a patient arrives in the emergency department, decontamination can only prevent secondary exposure to medical staff; it does not limit the patient's injury. Medical treatment is supportive.

Decontamination Area

Previously decontaminated patients may be treated or held for observation. Others require decontamination as described below.

ABC Reminders

Evaluate and support the airway, breathing, and circulation. Intubate the trachea in cases of respiratory compromise. If the patient's condition precludes intubation, surgically create an airway.

Treat patients who have bronchospasm with bronchodilators.

Patients who are comatose or hypotensive, or have seizures or ventricular dysrhythmias due to other exposures or trauma should be treated in the conventional manner.

Personal Protection

If contaminated patients are expected to arrive at the Emergency Department, they must be decontaminated before being allowed to enter the facility. Decontamination can take place inside the hospital only if there is a decontamination facility with negative air pressure and floor drains to contain contamination. Personnel should wear the same level of protection required in the Hot Zone (see *Rescuer Protection* under Hot Zone, above).

Basic Decontamination

Flush the eyes with water for about 5 to 10 minutes. Do not cover eyes with bandages; if necessary, use dark or opaque goggles to relieve discomfort from photophobia.

If a liquid splash is suspected, clothing must be removed and the patient showered using soap and water. Showering should be accomplished using warm water and low water pressure to reduce the potential for agent penetration of the skin. If the patient was exposed to vapor only, remove outer clothing and wash exposed skin with soap and water. Place contaminated clothes and personal belongings in a sealed double bag.

In cases of ingestion, **do not induce emesis**. If the victim is alert and able to swallow, give 4 to 8 ounces of milk or water to drink if not already administered. There is no evidence that administration of activated charcoal is beneficial.

Treatment Area

Be certain that appropriate decontamination has been carried out (see *Decontamination Area*, below).

ABC Reminders

Evaluate and support the airway, breathing, and circulation (as in *ABC Reminders*, above). Establish intravenous access and continuously monitor cardiac rhythm in seriously ill patients.

Patients who are comatose, hypotensive, or who have seizures or ventricular dysrhythmias due to other exposures or trauma should be treated in the conventional manner.

Triage

Patients arriving at the emergency department directly from the scene of potential exposure (within 30-60 minutes) will rarely have symptoms. Following decontamination, patients with signs of airway involvement should be admitted directly to the Critical Care Unit. The others should be observed for at least 6 hours. Patients arriving later should be evaluated as described below. **The sooner after exposure that symptoms occur, the more likely they are to progress and become severe.**

Eye Exposure

Mild conjunctivitis beginning more than 12 hours after exposure is unlikely to progress to a severe lesion. The patient should have a thorough eye examination (including a test for visual acuity). The patient should be treated with a soothing eye solution, such as Visine or Murine, sent home, and told to return if there is worsening. Conjunctivitis beginning earlier and other effects such as lid swelling and signs/symptoms of inflammation indicate a need for inpatient care and observation.

Skin Exposure

A small area of erythema beginning later than 12 hours after exposure is unlikely to progress to a significant lesion. The patient should be examined, treated with a soothing lotion, sent home, and instructed to return if progression occurs. A patient with a significant area of erythema or one seen earlier with a

significant area of erythema with or without blistering should be admitted for further evaluation.

Airway Exposure

A patient with a mild, non-productive cough, irritation of the nose and sinuses, and/or a sore throat that began later than 12 hours after exposure should be told to use a cool steam vaporizer and lozenges or cough drops and sent home with instructions to return if the symptoms worsen. Patients with more severe effects (laryngitis, shortness of breath, a productive cough) seen at any time postexposure should be admitted directly to the Critical Care Unit once decontamination has been assured. Those with less severe effects should be admitted to a routine care ward.

Ingestion Exposure

Do not induce emesis. If a large dose has been ingested and the patient's condition is evaluated within 30 minutes after ingestion, cautious orogastric lavage might remove ingested material. However, the risk of potential bleeding and perforation must be considered. There is no evidence that activated charcoal is beneficial.

*Antidotes and
Other Treatments*

There is no antidote for sulfur mustard. Treatment is supportive.

Laboratory Tests

Routine laboratory studies should be done for all patients requiring admission. These include CBC, glucose, and serum electrolytes. Chest x-ray and pulse oximetry (or ABG measurements) are recommended for inhalation exposures. A test for urine thiodiglycol, a metabolite of mustard, can be performed at specialized laboratories, but is not a routine laboratory measure.

Disposition

As discussed above, consider hospitalizing patients who have had significant exposures.

Delayed Effects

Significant systemic absorption of sulfur mustard may produce a fall in the leukocyte count beginning on days 3 to 5. Erythrocytes and thrombocytes may subsequently fall if bone marrow damage is severe and in this case the risk of life-threatening infection rises.

Patient Release

Patients who have sustained mild exposure (see Table 1) may be discharged. Discharged patients should be advised to rest and to seek medical care promptly if symptoms progress (see, *Follow-up Instructions*, included with the *Sulfur Mustard Patient Information Sheet* below).

Reporting Other people may still be at risk in the setting where this incident occurred or away from the setting due to secondary contamination. If a public health risk exists, notify your state or local health department or other responsible public agency.

General Medical Management

Since there are no immediate effects from mustard, most patients will go home or elsewhere from the incident and present to a medical facility hours later when effects occur. These patients must not be allowed to enter the facility until they have been decontaminated.

Patients whose skin or clothing is contaminated with liquid sulfur mustard can contaminate medical personnel and others by direct contact or through off-gassing vapor.

Sulfur mustards are extremely toxic and may damage the eyes, skin, and respiratory tract and suppress the immune system. Although these agents cause cellular changes within minutes of contact, the onset of pain and other symptoms is delayed.

There is no antidote for sulfur mustard toxicity. Medical treatment is supportive.

Decontamination Area

A patient who arrives at a general medical facility (non-emergency) probably will not have undergone decontamination. Such a patient must be decontaminated as described below before being allowed to enter the facility.

ABC Reminders

Patients may have other injuries and must be evaluated using the concepts of BLS and ALS.

Personal Protection

Medical personnel or others (e.g., HAZMAT personnel) must meet incoming patients outside the facility or, if available, in the facility's decontamination area. Decontamination can take place inside the medical facility only if there is a decontamination area with negative air pressure and floor drains to contain contamination. Personnel must wear protection required in the Hot Zone (see *Rescuer Protection* under Hot Zone, above).

Basic Decontamination

A patient who has arrived directly from the scene must be decontaminated before being admitted to the facility. If a liquid splash is suspected, clothing must be removed and the patient showered using soap and water. Showering should be accomplished using cool water and enough water pressure to quickly reduce the potential for agent penetration of the skin. If the patient was exposed to vapor only, removal of outer clothing and flushing of exposed skin (face, hair, and arms/hands) with soap and water or water alone is adequate. Place contaminated clothes and personal belongings in a sealed double bag.

A patient who has gone home and bathed and changed clothes may be considered decontaminated; however, the home will require decontamination. Otherwise, patients should undergo the decontamination procedures described above.

Initial Evaluation

Patients arriving at the medical facility directly from the scene of potential exposure (within 30–60 minutes) will rarely have signs and symptoms. Patients with signs of airway involvement should be admitted directly to the Critical Care Unit once decontamination has been assured. The others should be observed for at least 6 hours.

Patients arriving later should be evaluated as described below. The sooner after exposure signs and symptoms occur, the more likely they are to progress and become severe (see Table 1).

Eye Exposure

Mild conjunctivitis beginning more than 12 hours after exposure is unlikely to progress to a severe lesion. The patient should have a thorough eye examination (including a test for visual acuity). The patient should be treated with a soothing eye solution such as Visine or Murine, sent home, and told to return if there is worsening. Conjunctivitis beginning earlier and other effects such as lid swelling and signs/symptoms of inflammation indicate admission.

Skin Exposure

A small area of erythema beginning later than 12 hours after exposure is unlikely to progress to a significant lesion. The patient should be examined, treated with a soothing lotion, sent home, and instructed to return if progression occurs. A patient with a significant area of erythema or one seen earlier with a significant area of erythema with or without blistering should be admitted for further evaluation.

Airway Exposure

A patient with a mild, non-productive cough, irritation of the nose and sinuses, and/or a sore throat that began later than 12 hours after exposure should be told to use a cool steam vaporizer and lozenges or cough drops and sent home with instructions to return if the symptoms worsen. Patients with more severe effects (laryngitis, shortness of breath, a productive cough) seen at any time postexposure should be admitted directly to the Critical Care Unit once decontamination has been assured. Those with less severe effects should be admitted to a routine care ward.

Ingestion Exposure

Do not induce emesis. If a large dose has been ingested and the patient's condition is evaluated within 30 minutes after ingestion, cautious orogastric lavage might remove ingested material.

However, the risk of potential bleeding and perforation must be considered. There is no evidence that activated charcoal is beneficial.

Medical Management

General

There is no antidote for sulfur mustard. Management is supportive.

A guideline is to keep the wounds (skin, eye, airway) free from infection. A patient with severe skin burns may require care in a burn unit.

Skin Exposure

Most burns are second degree although third degree burns may occur after liquid exposure. In general, small blisters (i.e., <1cm) remain roofed and larger ones (i.e., >1cm) should be unroofed. This is a controversial issue, but many feel that the roof will eventually come off anyway. Blister fluid does not contain mustard or other toxic substances. The denuded area should be irrigated two or three times a day using a whirlpool if the lesion is large (the patient should be given ample amounts of a systemic analgesic beforehand). This should be followed by liberal application of a topical antibiotic. Skin lesions may take many months to heal. Fluids are not lost as they are in thermal burns, and fluid replacement should be according to the general needs of the patient and not according to "burn therapy" formulas. Systemic antibiotics should be used when there are signs of infection and a culture indicates the responsible organism. Patients with a large area of second or third degree burns should be transferred to a Burn Unit for further care and reverse isolation.

Eye Exposure

Eye lesions range from conjunctivitis to involvement of the entire eye including cornea and lids. Erosion of or perforation of the cornea may occur with very severe exposure to liquid, but this is rare. Readily available eye solutions may suffice for conjunctivitis. More severe lesions should be treated with a topical mydriatic (e.g., atropine), topical antibiotics, and vaseline or similar substance applied to the lid edges several times a day. Topical analgesics should be used only for an initial examination (including slit lamp and a test of visual acuity), but not after. Pain should be controlled with systemic analgesics. Once the lid edema and blepharospasm subside and the eyes are open, dark glasses may reduce the discomfort of photophobia. Some authorities feel that topical steroids (used within the first 24 hours only) may reduce inflammation.

Inhalation Exposure

Airway damage may range from irritation of the nose and sinuses, to pharyngitis, to destruction of the airway mucosa from the upper airways to the smallest bronchiole. Airway damage is a common cause of death. Upper airway irritation (nose, sinuses, pharynx) may benefit from cool steam inhalation and cough drops or lozenges. A patient with signs of airway damage below the pharynx should be provided with oxygen- assisted ventilation as necessary (with PEEP); at the first sign of damage of the larynx or below, the patient should be intubated and transferred to the Critical Care Unit. Bronchodilators should be used if there are signs of bronchoconstriction; steroids might be used if the usual bronchodilators are not effective, but otherwise steroids are not of proven value. Daily sputum cultures should be done and systemic antibiotics should be begun with signs of infection and an identified organism. A chemical pneumonitis may occur in the first several days with infiltrates on X-ray, an increase in WBC, and a fever, but this is generally sterile. Organisms generally are not the cause until the third or fourth day postexposure, and antibiotics should not be used prophylactically. Patients with airway damage below the pharynx should be managed on the Critical Care Unit by a physician experienced in the management of complicated pulmonary and airway injuries.

Bone Marrow

If the bone marrow has been damaged, the white blood cell count in the peripheral blood will start to decrease at about days 3 to 5 after exposure. This decrease may be followed by a decrease in red blood cells and platelets. Often, this decrease is not marked and the marrow recovers. Transfusions may be useful. Treatment with granulocyte colony-stimulating factor (GCSF) has been successful experimentally with nitrogen mustard. Marrow transplants have not been attempted, but might be useful. A patient with a marked decrease in white blood cell count should be transferred to an Oncology or Burn Unit for reverse isolation.

Laboratory Evaluation

Routine laboratory studies for admitted patients include glucose, serum electrolytes, and daily CBC. Chest x-ray and pulse oximetry (or ABG measurement) should be done frequently on all patients with inhalation effects. A test for urinary thioglycol (a metabolite of mustard) can be performed at specialized laboratories, but is not a routine laboratory measure.

**Disposition and
Follow-up**

Patients with moderate to severe exposures will require hospitalization, as described above.

Patient Release

Patients who have sustained mild exposure (see Table 1), may be discharged. Discharged patients should be advised to rest and to seek medical care promptly if symptoms progress (see below, *Follow-up Instructions*, included with the *Sulfur Mustard Patient Information Sheet*).

Follow-up

Follow-up evaluation of respiratory, neurological, and bone marrow function should be arranged for severely exposed patients.

Reporting

Other people may still be at risk in the setting where this incident occurred or away from the setting due to secondary contamination. If a public health risk exists, notify your state or local health department or other responsible public agency.

Blister Agents
Sulfur Mustard (H, HD, and HT)
Patient Information Sheet

This handout provides information and follow-up instructions for persons who have been exposed to sulfur mustard.

What are sulfur mustards?

Sulfur mustards are yellowish to brown liquids that have been used as chemical warfare agents since 1917.

What immediate health effects can result from exposure to sulfur mustards?

Sulfur mustards produce blistering and cell damage, but symptoms are delayed for hours. They cause damage to the skin, eyes, and respiratory tract. The eyes are the most sensitive. Nausea and vomiting may occur within the first few hours after exposure. Skin rashes, blisters, and lung damage may develop within a few hours of exposure but may take 12 to 24 hours to develop. Sulfur mustard can also suppress the immune system.

Can sulfur mustard poisoning be treated?

There is no antidote for sulfur mustard, but its effects can be treated and most exposed people recover. Immediate decontamination reduces symptoms. People who have been exposed to large amounts of sulfur mustard will need to be treated in a hospital.

Are any future health effects likely to occur?

Adverse health effects, such as chronic respiratory diseases, may occur from exposure to high levels of these agents. Severe damage to the eyes and skin may be present for a long time following the exposure.

What tests can be done if a person has been exposed to sulfur mustards?

There are no routine tests to determine if someone has been exposed to sulfur mustard. Thiodiglycol (a break-down product of mustard) may be detected in the urine up to 2 weeks following exposure; however, this test is available only in several specialized laboratories.

Where can more information about sulfur mustards be found?

More information about sulfur mustard can be obtained from your regional poison control center; the Agency for Toxic Substances and Disease Registry (ATSDR); your doctor; or a clinic in your area that specializes in toxicology or occupational and environmental health. Ask the person who gave you this form for help locating these telephone numbers.

Follow-up Instructions

Keep this page and take it with you to your next appointment. Follow *only* the instructions checked below.

Call your doctor or the Emergency Department if you develop any unusual signs or symptoms within the next 24 hours, especially:

- coughing, wheezing, shortness of breath, or discolored sputum
- increased pain or discharge from injured eyes
- increased redness, pain, or a pus-like discharge from injured skin
- fever or chills

No follow-up appointment is necessary unless you develop any of the symptoms listed above.

Call for an appointment with Dr. _____ in the practice of _____.

When you call for your appointment, please say that you were treated in the Emergency Department at _____ Hospital by _____ and were advised to be seen again in _____ days.

Return to the Emergency Department/ _____ Clinic on (date) _____ at _____ AM/PM for a follow-up examination.

Do not perform vigorous physical activities for 1 to 2 days.

You may resume everyday activities including driving and operating machinery.

Do not return to work for _____ days.

You may return to work on a limited basis. See instructions below.

Avoid exposure to cigarette smoke for 72 hours; smoke may worsen the condition of your lungs.

Avoid drinking alcoholic beverages for at least 24 hours; alcohol may worsen injury to your stomach or have other effects.

Avoid taking the following medications: _____

You may continue taking the following medication(s) that your doctor(s) prescribed for you: _____

Other instructions: _____

• Provide the Emergency Department with the name and the number of your primary care physician so that the ED can send him or her a record of your emergency department visit.

• You or your physician can get more information on the chemical by contacting: _____ or _____, or by checking out the following Internet Web sites: _____; _____.

Signature of patient _____ Date _____

Signature of physician _____ Date _____