SECTION 6
EMERGENCY RESPONSE CONTINGENCY PLAN

6.1 Introduction

The Emergency Response Contingency Plan outlines those procedures to be taken in the unlikely event of an accident, emergency, or unintentional release of toxic chemical agent while CWM is being transported onsite and stored at the IHF. These procedures deal specifically with the CWM IHF; however, they rely heavily on those emergency response procedures already prepared by the Army. They include:

- Site Safety Submission
- TEU Regulation 50-1
- TM 60A-1-1-11
- DA Pamphlet 50-6.

In addition, emergency response will consider the Emergency Response Guidebook developed by the Research and Special Programs Identification of the DOT and DA Contingency Plans and Procedures, including Army Regulation 200-1, Environmental Protection and Enhancement, Chapter 8, Oil and Hazardous Substance Spill Contingency and Emergency Response.

6.2 Objective

The primary concerns of emergency response to a chemical accident will be to protect human health by controlling chemical agent release and protecting the environment. It is essential that personnel be prepared in the event of an emergency. All emergency response operations should be performed in the safest manner and in accordance with preapproved contingency plans. The three major types of emergencies that can be encountered are: (1) spills that may include exposure to chemical or hazardous materials, (2) incidents requiring medical help, or (3) fire.

This Emergency Response Contingency Plan complies with 29 CFR 1910.120 and addresses the following elements:

- Planning
- Emergency recognition
- Personnel, authority, and communications
- Emergency alerting, reporting, and evacuation routes
- PPE and emergency equipment
- Procedures for decontamination and medical treatment.

As recommended by the USEPA, this Emergency Response Contingency Plan also includes sections that address procedures to protect the local affected population in the event of an accident or emergency. They are:

- First responders involving the IHF (TEU only)
- First responders not involving the IHF
- First aid and medical information
- Air monitoring plan
- Spill control and countermeasures plan.

6.3 Notifications

FTMC has authority during storage of the CWM. In the event of a chemical accident/incident (CAI), TEU personnel will assume immediate control of the scene and take necessary steps to save lives and protect property. FTMC will notify local and regional authorities in accordance with this Emergency Response Contingency Plan. The TEU personnel will assume a technical advisor role and cooperate fully with local authorities (for example, advice on need for evacuation, size of hazard area, and need for PPE).

6.4 Interim Holding Facility

These procedures outline operational tasks to be performed prior to storing CWM and in the event of an accident or incident involving the overpacked CWM.

6.4.1 Contingency Planning. TEU personnel responsible for responding to emergency conditions will review the emergency procedures described in the Site Safety Submission and ensure that all necessary emergency equipment is ready for use. All personnel training will have been completed prior to operations. All personnel will be briefed on their roles in emergencies, such as firefighting, cleanup, or first aid.

Medical support will be required to respond to chemical accidents or incidents that may affect workers or the public during the transportation or interim storage of the recovered CWM. The procedures provided in this Plan and the Site Safety Submission will address situations that could occur during onsite transportation and storage of recovered CWM.

6.4.2 Personnel. IHF operations will be conducted by TEU and will be done in close coordination with PMCD. The TEU will respond in the event of a CAI during onsite transportation or during storage of CWM. The TEU personnel are trained and equipped for responding to CAIs that may occur. The TEU will have limited capabilities of implementing the same primary public safety measures as those performed by community officials in fixed-site emergency response programs. The TEU will have the proper tools to perform monitoring, first aid, decontamination, fire protection, and leak control.

a. *Training and Certification.* All personnel who participate in the emergency response to a chemical accident will be trained in emergency procedures, first aid, use of PPE, and cardiopulmonary resuscitation (CPR) and will have the basic knowledge of agent exposure symptoms. At a minimum, this will include 29 CFR 1910.120(e) training. All emergency response organizations will have their supervisor and team members familiarize themselves with the Site Safety Submission, this IHF Plan, and the TEU

operations procedures and SOPs applicable to CWM decontamination and spill cleanup.

b. *The TEU Coordination with Support Personnel.* The TEU will be able to coordinate responses with other participating key organizations and local emergency response personnel, who, in turn, will provide them with response management expertise in areas such as public alert, notification, traffic and access control, assistance to affected populations, and initial medical intervention and care.

6.4.3 Emergency Response Resources.

a. *Local.* The Site Safety Submission will be reviewed by the TEU prior to acceptance of CWM at the IHF. This plan specifies the onsite emergency coordinators, local emergency response agencies, and safety and environmental officials. These resources are available for use, if necessary, in the event of a chemical emergency. Transportation of CWM to the IHF will be performed using an escort vehicle followed by the CWM transportation vehicle. Additional vehicles include:

(1) *Medical Support Vehicle.* A vehicle will be available to transport injured personnel to the identified emergency medical facilities.

(2) *Fire Truck Vehicle.* A fire truck will be onsite during recovery and transport operations at the IHF.

Phone contacts for local response resources are presented in the Site Safety Submission. The Site Safety Submission should be referred to for specific instructions and protocol for contacting emergency response organizations.

b. *State-Level Emergency Response Resources.* State-level emergency response resources may be needed to provide secondary supporting activities. However, the necessity for this type of response is remote due to the absence of the public within the operations area.

6.5 Contingency Plans

The Site Safety Submission will be used as a source of reference for emergency planning and implementation.

An accident during CWM transfer into or out of an IHF is more likely than an accident during storage. While the CWM is stored in an IHF, it is unlikely that an emergency will occur; however, this section incorporates those procedures and notifications necessary to respond to the incident.

During storage, emergency response will be provided by TEU when notified by CESAM or FTMC. TEU has been given special training to address response procedures, decontamination methods, and spill cleanup. Highlights of those procedures are provided in the following paragraphs, which outline the personnel, equipment, and procedures to be taken in the event of an emergency.

6.5.1 Hazards Associated with Chemical Warfare Materiel. Handling CWM is addressed in the TEU Operations Plan. Key procedures used to handle this type of situation are discussed in the following paragraphs. They include:

- Isolation
- Notification
- First aid
- Characterization
- Cleanup/disposal.

a. *Isolation.* The following steps are to be taken to isolate the leaking container from the other stored items:

(1) Upon observing a spill or detecting a leak, the TEU will immediately don their masks, proceed to a safe distance upwind, direct other personnel away from the spill, and initiate emergency response actions as appropriate.

(2) Sources of ignition within 50 feet of the spill, including vehicles, will be removed immediately.

(3) Workers who may have been in contact with spilled materials will undergo decontamination.

(4) TEU will take action to identify the contamination and mitigate leaking CWM.

b. *Notification.* The following steps are to be taken to notify the appropriate authorities of an emergency situation:

(1) FTMC is responsible for the FTMC area where the CAI occurred. Persons witnessing or discovering a CAI will contact emergency responders by calling 911.

(2) As conditions dictate, FTMC may make offsite notifications following the Site Safety Submission.

c. *First Aid.* The following actions will be taken, as appropriate:

(1) If workers are unable to evacuate themselves, their rescue will be the responders' first priority after inspecting the scene and securing the CWM.

(2) Responders will wear OSHA Level B, or equivalent, PPE to conduct emergency response actions.

d. *Characterization.* The following characterization steps may be performed:

(1) TEU will investigate the accident site to determine the condition of the involved cargo and areas of possible contamination. Reentry to the area will be conducted in the appropriate level of PPE.

(2) The following three hazard categories will apply, unless evidence indicates otherwise: oxidizing, corrosive, and acutely toxic by skin contact or inhalation (materiel will be presumed to volatilize significantly unless proven otherwise).

(3) At the discretion of the TEU, samples will be collected for field or laboratory testing.

(4) The area of the spill will be determined and documented. The quantity will be estimated. The area will be marked with stakes and barrier tape.

(5) Perimeter air monitoring using DAAMS, both upwind and downwind of the spill, will be conducted by TEU or ECBC. Spill site monitoring will be conducted in accordance with table 5-1.

e. *Cleanup/Disposal.* Damaged containers will be placed in MRCs (or drums of compatible construction) containing suitable loose sorbents. Empty drums will be maintained near the IHF. Contaminated tools and equipment for decontamination or disposal will be collected. Disposal will depend on the identity of the spilled materiel. Unidentified overpacked materiel will be stored in a secondary containment area, pending identification.

6.5.2 Fire. In the unlikely event that a fire during CWM transport or storage occurs, procedures for responding to fire events are as follows:

a. *Isolation.* Upon detecting a fire, the TEU will determine whether the fire is small enough to extinguish with either a portable extinguisher or water that is immediately available. Non-essential personnel will be directed away. First responders will attempt to extinguish the fire provided that:

(1) They are able to approach the fire from the upwind side or opposite to the direction of the fire's progress.

(2) A fire extinguisher rated ABC is readily available.

(3) No known complicating factors are present, such as the likelihood of rapid spread, imminent risk of explosion, or gross contamination. Conditions and common sense may dictate changes in sequence of actions.

(4) Personnel leaving a fire area will account for all other employees in the area as soon as possible.

b. *Notification.* FTMC and CESAM will be notified as soon as possible of the location, size, and nature of the fire/explosion. As conditions dictate, TEU personnel will declare an emergency, initiate the remedial procedures, request assistance from the local fire department, and make necessary notifications as listed in the emergency response notification list. The Site Safety Submission will provide additional details of local notification requirements.

c. *Rescue.* Rescue of employees unable to evacuate themselves will be the first priority of responders.

d. *Firefighting Procedures.* The procedure to perform firefighting involves:

(1) Stopping the transporter (if during movement)
(2) Sounding the alarm
(3) Using the fire extinguisher
(4) Requesting assistance from the fire department.

The following are guidelines to be followed during a response to a fire:

- No attempt should be made to extinguish large fires. These should be handled by the fire department.

- If human life appears to be in danger or if the spread of fire appears to be rapidly progressing, personnel should be moved further upwind, away from the fire.

e. *Fire Extinguishing.* There are three possible classes of fire extinguisher:

(1) Class A (wood, cloth, paper, rubber, many plastics, and ordinary combustible materials). Examples are:

- Water
- Water with 1-percent aqueous film forming foam (AFFF)
- Water with 5-percent AFFF or fluoroprotein
- Foam
- ABC dry chemical
- Halon 1211.

(2) Class B (flammable liquids, gases, and greases). Examples are:

- ABC dry chemical
- Purple K

- Halon 1211
- Carbon dioxide
- Water with 6-percent AFFF.

(3) Class C (energized electrical equipment). Examples are:

- ABC dry chemical
- Halon 1211
- Carbon dioxide.

f. *Protective Clothing.* Based on the conditions, first responders, the TEU or CEHNC personnel, will determine appropriate distances and selection of PPE. Firefighting turn-out gear may be required.

g. *Decontamination.* At the conclusion of firefighting activities, TEU will determine, to the extent practicable, the nature of the contaminants encountered during the incident. The TEU will arrange for equipment to be processed through decontamination, and/or labeled and isolated for further action.

6.5.3 Medical Emergencies. Unless their lives are endangered, seriously injured, or ill, personnel should not be moved until an assessment has been made by a person trained in first aid and CPR. If a CAI injury or illness occurs, full decontamination will be completed and first aid administered before transportation.

First aid should be administered while awaiting an ambulance or paramedics. All injuries and illnesses must be reported to FTMC and to the agency or contractor that employs the injured person. Any person transporting an injured/exposed person to a clinic or hospital for treatment should take along directions to the hospital and information concerning the nature of the injury or illness. Coordination with medical facilities is described in the Site Safety Submission.

6.5.4 Local Hospitals. The following hospital will be contacted for emergency care.

Stringfellow Memorial Hospital
301 East 18th Street
Anniston, Alabama
256-235-8900

6.5.5 Hazardous Material Handling. The onsite emergency response will be performed by the TEU. When a leak or spill occurs, immediate containment and preventive measures must be taken. Procedures for material handling are specified in TEU SOPs. Response operations will be monitored continuously. Upon completion of cleanup efforts for the accident, responsible personnel should notify FTMC and CESAM, collapse the exclusion area, and give the order to resume the transportation or storage operation.

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SECTION 7
ROLES AND RESPONSIBILITIES

The primary participating organizations include PMCD, CESAM, SBCCOM/TEU, FTMC, and CEHNC. The organization is shown in figure 2-1.

The participating organizations involved with onsite transportation and storage of recovered CWM have both shared and individual roles and areas of responsibility. For example, the IHF is operated by TEU for FTMC in close coordination with PMCD and other responsible organizations. The TEU will provide the personnel and equipment to perform the detailed assessment/removal of CWM, package and move recovered CWM to the IHF, and operate the IHF on an interim basis. Close coordination between all organizations will be maintained.

Common responsibilities include:

a. Coordinating with other organizations

b. Performing duties in accordance with accepted health and safety procedures

c. Using established supply procedures and providing the supplies necessary to support their operations

d. Providing emergency response support

e. Developing training plans for use by emergency response teams.

Specific responsibilities for each key organization associated with IHF operations are presented in the following paragraphs.

7.1 U.S. Army Program Manager for Chemical Demilitarization

During IHF activities, PMCD will:

a. Retain program responsibility for ensuring that CWM handling, transportation, storage, and disposal are accomplished in accordance with federal and state safety and environmental regulations; coordinate activities with supporting agencies to transfer and store CWM from investigation sites to the IHF

b. In coordination with TEU, safely maintain, on an interim basis, suspect CWM recovered during site remediation in preparation for final disposition

c. Accomplish an HA to address the relative risk of CWM storage and onsite transportation. Information on health hazards associated with CWM is provided in annex C.

d. Develop and oversee CWM handling programs, such as monitoring (section 5), inspecting, storing, transferring from storage, and emergency response (section 6)

e. Ensure accountability through proper documentation at FTMC

f. Ensure safe, environmentally acceptable storage, transportation, and disposal of CWM in close coordination with associated responsible organizations.

7.2 U.S. Army Corps of Engineers, Mobile District

As the agency conducting the remedial investigation, CESAM will:

a. Exercise site control, per this Plan and the local workplan, during all phases of the remedial investigation operations

b. In close coordination with FTMC, PMCD, CEHNC, and TEU, select the IHF location and exercise control of CWM in the IHF when TEU is not onsite

c. Coordinate standby decontamination, medical support, and emergency response with FTMC, CEHNC, and TEU as needed during all phases of operation

d. Oversee site operations conducted by the remedial investigation contractor and TEU to safely manage recovered CWM awaiting final disposition

e. Support routine maintenance of the IHF

f. Inspect IHF operations to ensure compliance with the CERCLA and this Plan

g. Provide physical security support for IHF operations

h. Coordinate with federal, state, and local environmental agencies.

7.3 U.S. Army Soldier and Biological Chemical Command/Technical Escort Unit/Edgewood Chemical Biological Center

SBCCOM/TEU/ECBC will be responsible for the following activities:

a. Provide support to local and overseeing agencies

b. Perform recovery operations of suspect CWM at FTMC

c. Provide personnel to transport CWM onsite and operate the IHF. TEU personnel will be trained to provide emergency first aid until relieved by responding medical teams in accordance with preapproved contingency plans.

d. Escort CWM during onsite transportation and operate the IHF

e. Perform work site monitoring during recovery, assessment, and packaging, and first entry, surveillance, and contingency monitoring for IHF operations

f. Inspect the IHF periodically for signs of deterioration or other damage that could lead to release of chemical agent

g. Provide first response during emergency situations that occur during recovery, overpacking, transportation, and storage operations

h. Train personnel in IHF operations, including proper lifting techniques and hazard communication training for all chemicals used at the site

i. Provide sampling capability (monitoring equipment and personnel) at IHF for first entry monitoring

j. If necessary, train CESAM contractor personnel to conduct surveillance monitoring of the IHF

k. Provide other direct support during storage of CWM.

7.4 U.S. Army Engineering and Support Center, Huntsville

a. Conduct intrusive investigations of the suspected CWM sites
b. Provide backup support to the TEU during recovery operations
c. Provide public affairs support to FTMC.

7.5 Fort McClellan

In its role as the supported organization, FTMC will:

a. Make an appropriate site available for location of the IHF

b. Coordinate with local agencies for emergency response and medical support

c. Conduct public affairs in coordination with PMCD Public Outreach and Information Office (POIO) and CEHNC Public Affairs Office (PAO)

d. Coordinate with state and local regulatory agencies.

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SECTION 8
PUBLIC OUTREACH

PMCD and PMNSCM are committed to two-way communications with stakeholders interested in the activities described in this IHF Plan. Coordination between FTMC PAO, CEHNC PAO, and PMCD POIO is critical to establishing and maintaining a timely, effective, and accurate information exchange among all interested parties and affected agencies. PMCD POIO should be consulted prior to all public outreach initiatives (that is, public meetings, official meetings, press releases, etc.) so public perception analyses and proactive strategies (position papers, Q&As, etc.) can be developed. All information about the IHF Plan will be distributed through PMCD.

FTMC has overall responsibility for public outreach involving this project and will be the focal point for public inquiries. FTMC will coordinate with all participating agencies to obtain information for public release and to ensure all agencies are aware of the public's concerns. Outreach efforts containing information about the storage of recovered CWM will be coordinated with PMCD POIO before implementation. Likewise, any public concerns relating to the storage of recovered CWM will be shared with PMCD POIO. PMCD/PMNSCM will support FTMC by preparing fact sheets, arranging for experts to answer questions, and integrating site-specific outreach activities into national and regional programs.

Public outreach activities will be planned to accommodate the degree of public interest and to address the specific concerns that are voiced. Specific outreach activities will include:

a. Making information available at a public repository

b. Conducting public availability sessions

c. Issuing press releases or notices prior to key events (such as to advertise an availability session, or announce the conclusion of operations)

d. Interacting with interested individuals, elected officials, and special interest groups.

e. Maintaining a list of interested parties and ensuring that these parties receive information that addresses their concerns

f. Maintaining an outreach presence at the work site or other designated location as warranted.

Annex H contains answers to questions that might be asked about this plan. Further questions should be directed to the individuals listed below. All information about this IHF Plan will be distributed through PMCD. Telephone numbers and points of contact include:

Mr. Hershel Chapman
FTMC PAO
Building 51
Buchner Circle
Ft. McClellan, AL 36205
256-848-5574
chapmanh@mcclellan-emh2.army.mil

Mr. Bob DiMichele
CEHNC PAO
P.O. Box 1600
Huntsville, AL 35807
256-895-1691.

For additional information or comments, contact:

Ms. Lousie Dyson
Project Manager for Non-Stockpile Chemical Materiel
Attn: SFAE-CD-P
Aberdeen Proving Ground, Maryland 21010-5401
Phone: 800-488-0648 or 410-436-4557
Fax: 410-436-7442
E-mail: ldyson@pmcd.apgea.army.mil.

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SECTION 9
CONCLUSIONS

This FTMC IHF Plan provides a scope of effort that is intended to support the remedial investigation of suspected CWM sites at FTMC. In the event that CWM is recovered, this Plan describes procedures and resources to safely handle, transport, and store the recovered CWM. The CWM will be managed, packaged, and stored as a hazardous waste.

No MCE was identified for the storage, handling, and onsite transportation of recovered CWM sealed in MRCs. None of the accident scenarios identified as leading to release of CWM met the definition of a credible event contained in DA Pam 385-61.

As part of the effort to determine if the proposed IHF operation can be performed in a safe manner, an HA was conducted to identify and evaluate the hazards associated with the proposed activities. The assessment (annex A) developed a comprehensive list of hazards associated with IHF operations. Seventeen hazards were identified from the concept of operations and from historical information. Risk assessment codes (RACs) were assigned to each hazard based on severity of consequence and frequency of occurrence. The HA concluded that onsite transportation and storage of the recovered CWM at FTMC can be performed safely, provided procedures described for the safe handling, movement, and storage of CWM are followed.

The HA calculated a total carrier accident probability for onsite transportation of 1.45×10^{-7}.

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ANNEX A

INTERIM HOLDING FACILITY HAZARD ANALYSIS

ANNEX A
INTERIM HOLDING FACILITY HAZARD ANALYSIS

1. INTRODUCTION

This hazard analysis (HA) was developed to support the Interim Holding Facility (IHF) Plan for Fort McClellan (FTMC), Alabama. It is the product of an analysis of hazards associated with handling, storage, and onsite transportation at FTMC and is performed in accordance with the Non-Stockpile Chemical Materiel Program (NSCMP) System Safety Management Plan (SSMP) [U.S. Army Chemical Materiel Destruction Agency (USACMDA), 1994]. Hazards of the recovery operation, including overpacking recovered items, are discussed in the Site Safety Submission hazard analysis. In the HA, potential incidents that could occur during handling, storage, and onsite transportation are discussed qualitatively. To assign relative values to potential risk, a risk assessment code (RAC) is identified for each hazard or hazardous condition. Recommended controls for reducing either the probability that a hazard will result in an accident or reducing the severity of the consequences of such an accident are included in the discussion of each hazard and summarized in paragraph 5 of this annex and in attachment A-1.

2. CONCEPT OF OPERATIONS

This section provides an overview of the activities performed for chemical warfare materiel (CWM) handling, onsite transportation, and storage. It also describes the IHF facility and the weather and geographic surroundings.

2.1 Interim Holding Facility Activities

IHF operations involve handling, storage, and onsite transportation activities for recovered CWM after the CWM has been sealed inside an overpack container.

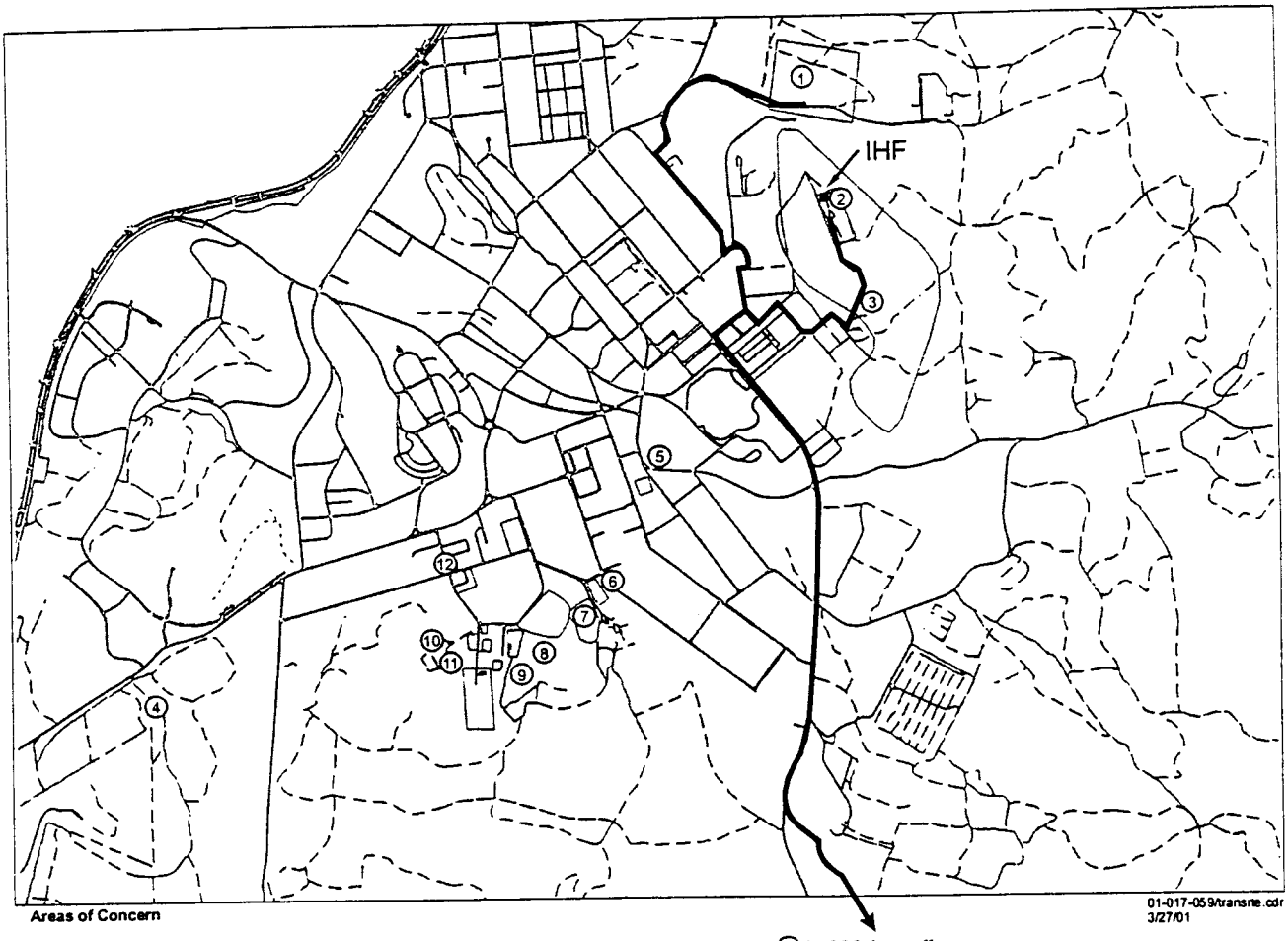
Handling includes lifting and placing of CWM into transport vehicles or into the IHF. For purposes of this HA, handling begins once the recovered CWM has been assessed and placed inside of a Department of Transportation (DOT)-approved multiple round container (MRC). Handling generally involves use of mechanical handling equipment such as a forklift or a dolly jack. Onsite transportation is the movement of CWM (inside an MRC) from the recovery site to the IHF for temporary storage. Onsite transportation will be performed with a suitable truck such as a half-ton pickup truck or larger vehicle. Storage will be conducted in an IHF described in paragraph 2.2. Throughout handling, onsite transport, and storage, monitoring will be conducted in accordance with the IHF plan and will include use of near real-time (NRT) monitors, Depot Area Air Monitoring System (DAAMS), and visual inspection of the MRC. Figure A-1 shows the location of the IHF and the proposed transportation routes from the four investigation sites discussed in the IHF Plan.

Personal protective equipment (PPE) and other safety equipment will be readily available while operations are being conducted within the IHF, but this equipment will not be stored at or within the IHF. For specific information on operations and transport routes, refer to section 4 of the IHF Plan.

2.2 Facility Description

The IHF is a portable storage building designed to store hazardous waste, and specifically, recovered CWM. The building is 8 feet wide by 16 feet long by 8 feet high and is capable of being transported on a flatbed truck without special Department of Transportation (DOT) permits.

The interior of the IHF is approximately 100 square feet of clear space for storage and a walkway. A sump equipped with an accessible exterior drain is located below the floor. The IHF has interior and exterior lights. The door is located in the center of the long side of the building and is equipped with two high security hooded locking hasps to accommodate padlocks.



Areas of Concern

① Training Area 31
② T-38 (Reservoir Ridge)
③ Smoke Ranges
④ T-4 Biological Warfare Area
⑤ Agent ID Area
⑥ Cane Creek Training Area
⑦ Naylor Field
⑧ Blacktop Training Area
⑨ Dog Training Area
⑩ Old Burn Pit
⑪ Field Personnel Decontamination Area
⑫ Old Toxic Training Area
⑬ Five Mustard Spill Sites (Not Shown)
⑭ Range 24A

Figure A-1. IHF Location and Ground Transportation Routes

The IHF has two monitoring ports for sampling the interior air of the IHF. Lightning protection will be installed in accordance with National Fire Protection Association (NFPA) Lightning Protection Code NFPA 78. The lightning protection will be tested in accordance with Army procedures. The IHF has an internal self-actuating, dry-chemical fire suppression unit and is constructed with 2-hour fire-rated walls.

2.3 Facility Location

FTMC is located in eastern Alabama approximately halfway between Birmingham, Alabama, and Atlanta, Georgia. FTMC is comprised of about 46,000 acres of wooded and hilly terrain. The IHF will be located in Area T-38, Area of Concern 2 in figure A-1.

2.3.1 Surroundings. The FTMC IHF will be located at the edge of the installation cantonment area. The nearest regularly occupied building is more than 122 meters from the IHF. The IHF area is a concrete pad surrounded by trees and grass.

2.3.2 Weather. FTMC enjoys a subtropical climate of long warm summers with periods of hot and humid weather and short mild winters. The average annual precipitation is 53 inches of rain, which includes little snow. Temperatures above 37°C occur occasionally while temperatures below -17°C are very rare. Severe weather in the form of thunderstorms occurs occasionally with most of the rain produced in April through October coming from thunderstorms. Some of these thunderstorms produce tornadoes. Destructive winds from hurricanes seldom occur in the area since FTMC is over 200 miles from the nearest coast.

2.4 Chemical Warfare Materiel Characterization

For the purpose of this plan, the potential chemical agents and industrial chemicals that may be recovered at FTMC are mustard (H or HD), lewisite (L), nitrogen mustard (HN-1), phosgene (CG), cyanogen chloride (CK), chloropicrin (PS), or GA simulant and

sarin (GB). These chemicals may be found in CAIS, munitions, or in bulk containers. Only items confirmed or suspected of containing chemical agent H, HD, HN-1, L, or GB (and CG in the case of a munition) will be stored in the IHF. CAIS items confirmed of containing industrial chemicals (CG, CK, PS, or GA simulant) will be turned over to the U.S. Army Corps of Engineers, Mobile District (CESAM) and disposed of using appropriate methods.

For the remainder of this document, the acronym CWM will refer to any of the recovered items individually or collectively unless the information being presented pertains only to one kind of agent or one type of CWM.

2.5 Containment Equipment

All recovered CWM will be placed in MRCs for transportation and storage in the IHF. MRCs provide a safe and logistically sound overpack for chemical munitions. The types of MRCs that will be used at FTMC are the MRC 7 x 27, which will be used for the recovered munition and CAIS, and the 55-gallon drum overpack, which will be used for the drum containing HD. Other sizes of MRCs may be used depending on the shape and condition of recovered items. Figures A-2 and A-3 show diagrams of these containers. MRCs were designed to:

a. Meet the hazardous material packaging criteria required by the DOT
b. Meet Army container requirements for original munitions
c. Provide long-term storage capability
d. Provide capability to be shipped by ground and air transportation.

2.5.1 Multiple Round Container Leak Testing. With the addition of many tests that simulated the temperature and vibrations MRCs are likely to experience during their serviceable life, the test procedures for MRCs (including the MRC 7 x 27 and the 55-gallon drum overpack) exceeded DOT requirements. The goal of the testing is to

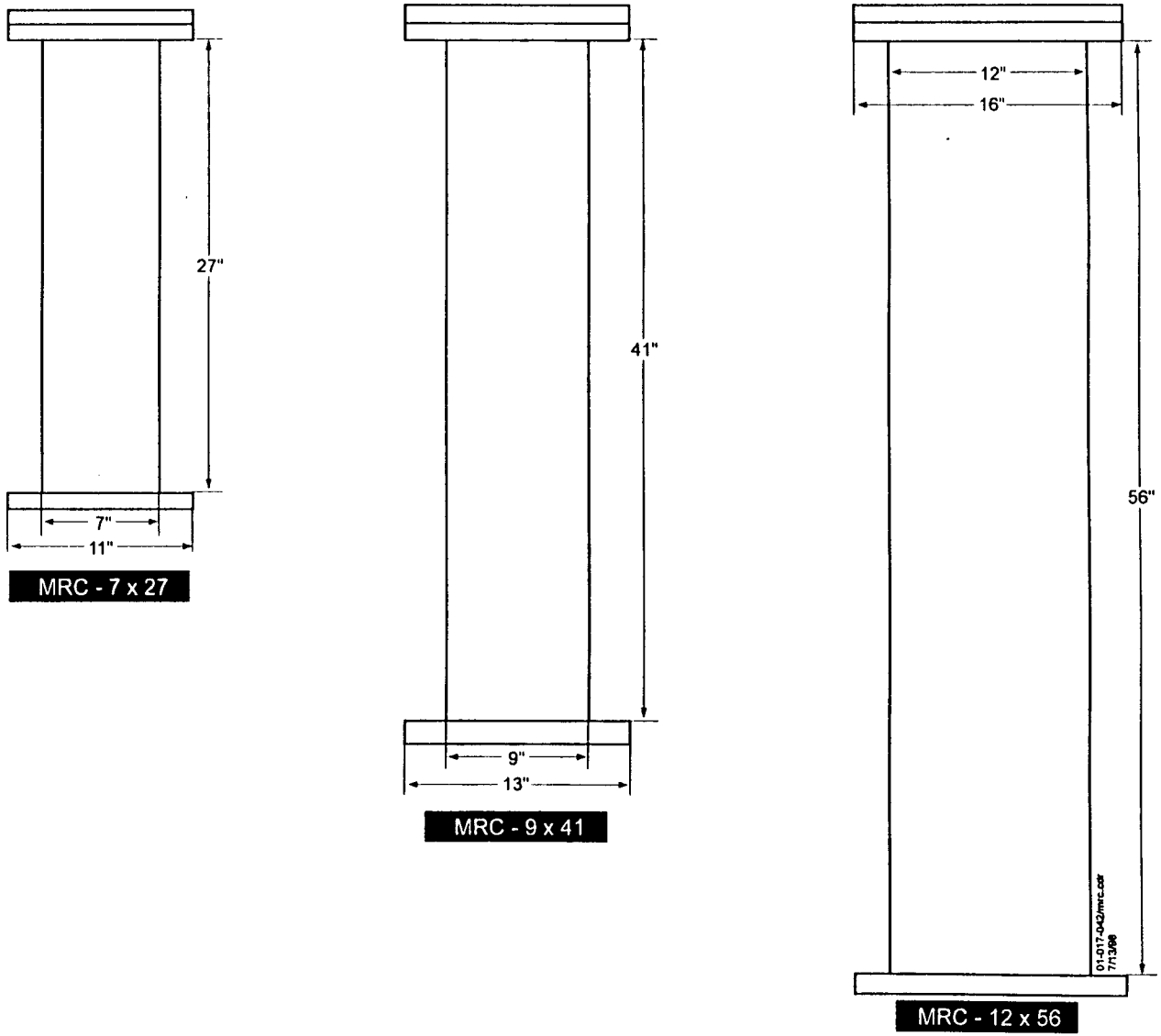
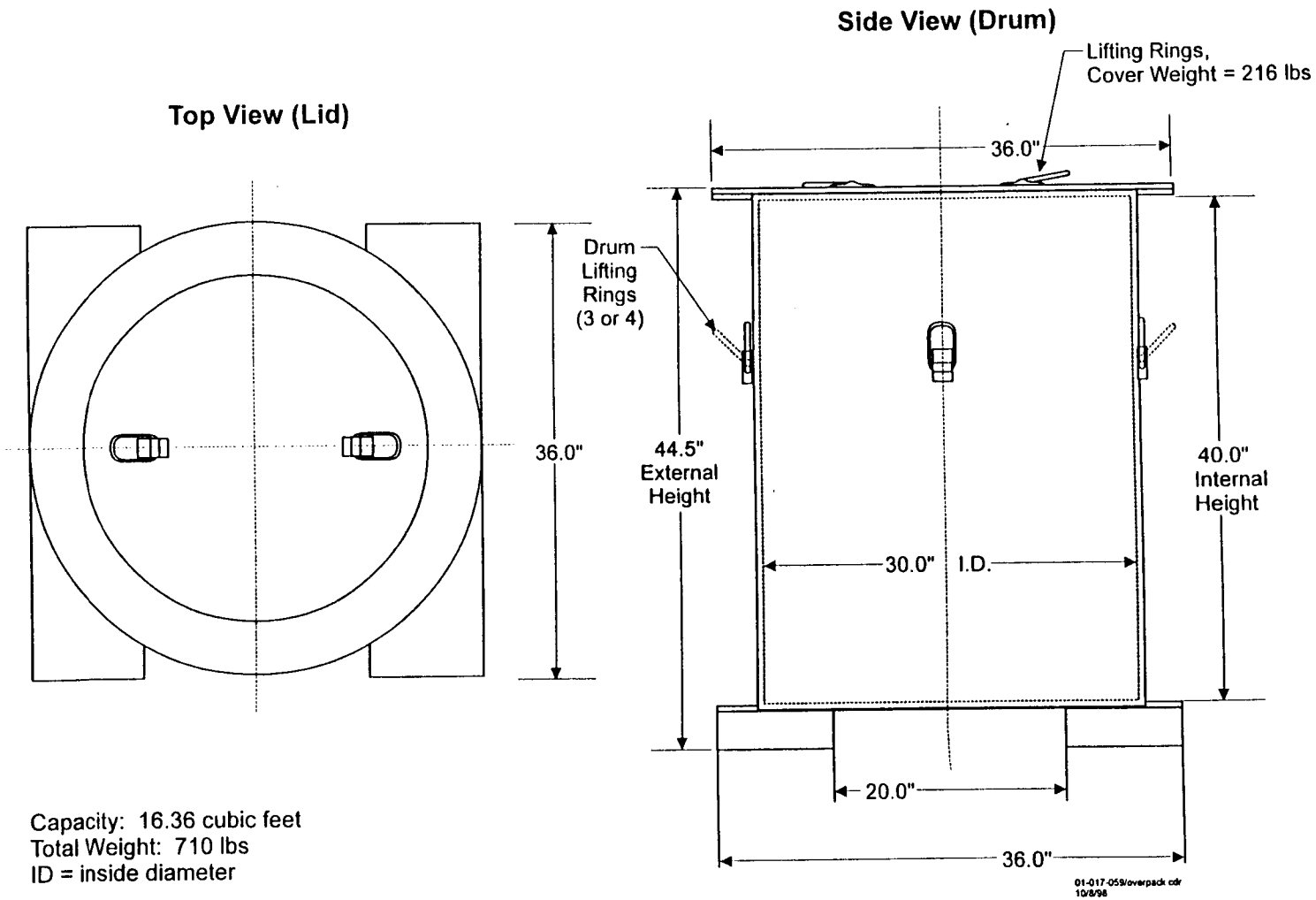


Figure A-2. Multiple Round Containers



Capacity: 16.36 cubic feet
Total Weight: 710 lbs
ID = inside diameter

Figure A-3. 55-Gallon Drum Overpack

ensure the integrity, survivability, and serviceability of the containers through multiple reuses. At a minimum, the MRCs were subjected to tests in accordance with the following standards:

- American Society for Testing and Materiels (ASTM) E-499-73 Method A, Helium Leak Testing
- Military Standard (MIL-STD)-453C and MIL-STD-1264B, Radiographic Testing
- Technical Provision (TP)-94-01, Transportability Testing
- MIL-STD-810E Method 514.4, Low and High Frequency Tests
- United Nations Performance Oriented Packaging tests in accordance with 49 CFR Section 178.600, Testing of Non-bulk Packagings and Packages
- MIL-STD-1660 Tests, First Article Tests (compression, vibration, drop, and incline plane).

As a result of this rigorous testing, MRCs, including the MRC 7 x 27 and the 55-gallon drum overpack, have been approved by the DOT and the Army for transportation and storage of recovered CWM.

3. HAZARD ANALYSIS

To aid in the evaluation of identified hazards, potential incident and accident scenarios have been defined and RACs have been assigned in accordance with the NSCMP SSMP. The RACs are based on combinations of hazard severity categories and hazard probability (or frequency of occurrence) categories. Definitions of the hazard severity

and hazard probability categories are listed in tables A-1 and A-2, respectively, and the RAC matrix is given in table A-3.

Paragraphs 3.1 through 3.3 of this annex provide a narrative of potential hazard scenarios, the controls currently in place to mitigate each hazard, and recommendations that will reduce the severity of a hazard or the probability that it will occur, and hence, reduce the RAC ranking. Each hazard is assigned two RAC values. An initial RAC is assigned without accounting for accident prevention measures, while a controlled RAC takes into account efforts to mitigate either the probability that the hazard will result in an accident, or the severity of the accident should one occur. Both the initial RAC and the controlled RAC are reported in attachment A-1. Hazards assigned a RAC 1 or RAC 2 require corrective action prior to implementation of the IHF plan. A RAC 3 or RAC 4 represents that the operation can be conducted safely without any mitigation efforts. However, for RAC 3 hazards, reasonable efforts to reduce accident probability or severity must be implemented even when these efforts do not change the RAC rating.

3.1 Hazards During Storage

3.1.1 Aircraft Crashes into IHF Causing Agent Release. The initiator for this accident scenario is failure of a helicopter or fixed-wing aircraft that results in a crash into the IHF causing fire and a release of agent from the MRCs. The frequency of this event is considered improbable (probability category E) and severity is considered critical (severity category II). This results in the assignment of a RAC 3 (IIE). The structural integrity of the MRCs and the fact that any agent released that is not consumed by fire would be carried to a relatively high altitude by the heat of the fire before dispersing, tends to reduce the frequency of an agent release affecting people. However, the frequency of this event remains improbable (probability category E). The consequence associated with the event also remains critical (severity category II). Based on these frequency and consequence categories, the controlled RAC assigned to this event is RAC 3 (IIE).

Table A-1. Hazard Severity Categories

Description	Category	Mishap Definition
Catastrophic	I	May cause death, system loss, or severe environmental damage.
Critical	II	May cause severe injury, severe occupational illness, or major system or environmental damage.
Marginal	III	May cause minor injury, minor occupational illness, or minor system or environmental damage.
Negligible	IV	May cause less than minor injury, occupational illness, or less than minor system or environmental damage.

Source: Non-Stockpile Chemical Materiel Program System Safety Management Plan (U.S. Army, Chemical Materiel Destruction Agency, 1994).

Table A-2. Hazard Probability Categories

Frequency of Occurrence	Level	Description
Frequent	A	Will be continuously experienced.
Probable	B	Will occur frequently in the life of the system.
Occasional	C	Will occur several times in the life of the system.
Remote	D	Unlikely, but can reasonably be expected to occur in the life of the system.
Improbable	E	Unlikely, but possible to occur in the life of the system.

Source: Non-Stockpile Chemical Materiel Program System Safety Management Plan (U.S. Army, Chemical Materiel Destruction Agency, 1994).

Table A-3. Risk Assessment Codes

Frequency of Occurrence	Consequence Category			
	I Catastrophic	II Critical	III Marginal	IV Negligible
A - Frequent	1	1	1	3
B - Probable	1	1	2	3
C - Occasional	1	2	3	4
D - Remote	2	2	3	4
E - Improbable	3	3	3	4

Hazard Risk Index	Risk Assessment Code	Action Required
IA, IB, IC, IIA, IIB, IIIA	1	Unacceptable - immediate corrective action required. Asst. Sec. Army Decision.
ID, IIC, IID, IIIB	2	Undesirable - reduced priority, corrective action required. Project Manager for Non-Stockpile Chemical Materiel decision.
IE, IIE, IIIC, IIID, IIIE, IVA, IVB	3	Acceptable - low priority for corrective action (may not warrant action). System Safety Program Manager decision.
IVC, IVD, IVE	4	Acceptable - no corrective action required.

Source: Non-Stockpile Chemical Materiel Program System Safety Management Plan (U.S. Army, Chemical Materiel Destruction Agency, 1994)

3.1.2 Fires. Fires at the IHF may be ignited by lightning or spread from another fire in the vicinity of an IHF. Neither the MRCs nor the construction materials of the IHF are flammable. A fire is very unlikely to cause a failure of an MRC. This scenario is assigned a severity of II, critical, and an unmitigated probability of D, remote, resulting in an RAC of 2 (IID). The following mitigation procedures are recommended:

a. No unknown or flammable materials should be stored in the IHF.

b. Other heat sources should not be kept in close proximity to the IHF.

c. Lightning protection devices should be installed and tested in accordance with National Fire Protection Association (NFPA) 78, or equivalent code.

d. A firebreak should be maintained by removing combustible material (wood, packaging, leaves, long grass, etc.) within 50 feet of the IHF.

With these mitigation measures, the hazard probability is reduced to E, improbable, resulting in a mitigated RAC 3 (IIE).

3.1.3 Earthquake Damages IHF Causing Agent Release. The initiator for this accident is an earthquake that exceeds the design criteria for the IHF. The collapse of the IHF damages an MRC resulting in agent release. The structural design criteria for the IHF is a 0.4 g (acceleration due to gravity) earthquake. The probability of an earthquake of this magnitude during IHF operations is remote (probability category D), with a catastrophic consequence (severity category I). This results in a RAC 2 (ID). The ruggedness of the MRC and the light weight of the IHF rafters should prevent damage to the MRCs even if the building is damaged. This reduces the consequence to marginal (severity category III) with no change in probability. This event is assigned a controlled RAC 3 (IIID).

3.1.4 Agent Leak. An MRC containing a leaking CWM item could release chemical agent vapors if the MRC flange cover was not completely sealed. As a result, workers

could be exposed to danger. This scenario is assigned a severity of II, critical. Possible causes include minor defects in manufacturing of the MRCs, or incorrect assembly in the field. Both of these events are considered remote (probability D), resulting in an unmitigated RAC 2 (IID).

First entry monitoring will be conducted prior to entry into the IHF. TEU personnel are trained and equipped to conduct such monitoring, and to respond safely to any leaks detected. With this mitigation, the probability of worker injury is reduced to E, improbable, resulting in a mitigated RAC 3 (IIE).

3.1.5 Tornado Damages IHF Causing Agent Release. The initiator of this accident scenario is a tornado that would damage the structural integrity of the IHF. Tornadoes are likely in the vicinity of FTMC, but the probability of a tornado damaging the IHF is estimated as remote (probability category D), with a marginal consequence (severity consequence III). This results in a RAC 3 (IIID). Winds associated with tornadoes are dispersive in nature, which tends to minimize the exposure of the public to agent that may be released. The ruggedness of the MRC should prevent damage to an MRC even if the IHF is damaged. The consequence from this accident is expected to be negligible (severity category IV). There is no change in the probability category. Based on these frequency and consequence categories, the controlled RAC 4 (IVD) is assigned to this event.

3.1.6 Hurricane Damages IHF Causing Agent Release. The initiator of this accident scenario is a hurricane that would damage the IHF. The probability of this event is estimated to be remote (probability category D) and of critical consequence (consequence category II), for a RAC 2 (IID). The ruggedness of the MRC and light weight of the IHF rafters should prevent damage to an MRC even if the building is damaged. The consequence is considered to be negligible (severity category IV). There is no change in probability category. Based on these frequency and consequence categories, the controlled RAC assigned to this event is 4 (IVD).

3.2 Hazards During Handling

3.2.1 Multiple Round Container Improperly Sealed. A slow leak of chemical agent vapor could result if CWM is ruptured during movement and the MRC is not completely sealed. This event has a marginal consequence (category III) with an occasional frequency (occurrence category C) and is assigned a RAC 3 (IIIC). The container should be pressure checked before use and all gaskets and seals inspected. Surveillance monitoring will detect low-level leaks during storage. Implementing these recommendations reduces the frequency of occurrence to remote (category D), but the marginal consequence (category III) remains the same. This results in the assignment of a controlled RAC 3 (IIID).

3.2.2 Multiple Round Container Punctured. While loading or unloading the cargo truck or moving an MRC from the truck to the IHF, it is possible for the MRC to fall from the forklift to the ground. While falling, it is possible for the MRC to hit the edge of the forklift, or a protruding object. Due to the rigorous construction of the MRCs and the test results generated, it is expected that the MRC will not be punctured. This produces a severity category III (marginal) and a frequency of C (occasional) for a RAC 3 (IIIC). To reduce the likelihood of an MRC being dropped, forklift operators will be trained and certified for forklift operations, preventive maintenance will be performed on the forklift, the forklift will be equipped with a backup alarm, and a ground guide will be used to direct the forklift operator. Implementation of these mitigating measures reduces the accident frequency to improbable (probability category E), which results in a controlled RAC 3 (IIIE).

3.2.3 Dropping of a Multiple Round Container. An MRC may be dropped during loading or unloading operations. Drop testing indicates that there is little chance of an MRC being breached by the short drop that could occur during loading and unloading operations. If dropping an MRC causes the CWM inside to leak, cushioning material within the MRC would absorb the agent. This hazard is judged to be catastrophic (category I), but such an event is judged to be remote (category D). Therefore, a RAC 2

(ID) is assigned. To alleviate some of the possible dangers that could occur from dropping an MRC, it is recommended that workers minimize MRC handling. Implementation of this mitigator will reduce the frequency of an MRC being dropped and lead to an event judged to be improbable (category E). Therefore, a controlled RAC 3 (IE) is assigned.

3.2.4 Lifting Injuries. A worker might be injured while trying to lift an MRC. Lifting injuries are judged to be critical (severity category II), but such an event is judged to be remote (probability category D). Therefore, a RAC 2 (IID) is assigned. Workers are trained in lifting techniques to avoid back injuries. Mechanical lifting aids will be used when necessary. Implementation of these mitigators reduces the probability for this event to improbable (probability category E) with no change in severity category. This allows for an assignment of a controlled RAC 3 (IIE).

3.2.5 Crushing Injuries. The possibility of a worker being pinned or crushed between a transport vehicle and a stationary object must be considered. This hazard is judged to be catastrophic (category I) with its occurrence being remote (category D), resulting in assignment of a RAC 2 (ID). The IHF plan requires the use of ground guides. This procedure, combined with the requirements of a backup alarm on the truck and not allowing vehicles to be driven within 5 feet of the IHF, will further reduce the frequency to improbable (category E). Implementation of these mitigators results in a controlled RAC 3 (IE) for crushing injuries.

3.2.6 Pinching Injuries. Workers will be transporting MRCs from the recovery sites and the IHF. The possibility of a worker's hands or feet being pinched between two objects must be considered. Pinching hazards are considered to be remote (probability category D), but critical (severity category II), resulting in a RAC 2 (IID). Potential pinching hazards will be covered in the daily safety briefing. Workers will work in teams and wear leather gloves and safety shoes to reduce the probability and severity of injuries to hands and feet caused by pinching. Implementation of these mitigators reduces the frequency to improbable (probability category E) with no change in severity category. This results in a controlled RAC 3 (IIE) for pinching hazards.

3.2.7 Tripping and Falling. Tripping and falling injuries are judged to be critical (severity category II), but such events are judged to be remote (probability category D). Therefore, a RAC 2 (IID) is assigned. Overpacks should be stored in the appropriate place, and as with other materials, should not be placed in aisles. Implementation of these mitigators reduces the frequency of the event to improbable (probability category E) with no change in severity category. This allows for an assignment of a controlled RAC 3 (IIE).

3.2.8 Improper Handling of Decontaminants. Decontaminants are available onsite for use during contingency operations. Table 2 of Army Technical Manual (TM) 60A-1-1-11 lists the following decontaminants:

- Decontaminating solution (DS2)
- Sodium hydroxide (caustic soda)
- Calcium hypochlorite (HTH)
- Sodium carbonate (washing soda)
- Alcoholic caustic solution.

Most of these materials are hazardous and require special handling. Exposure of workers may occur during the mixing of decontaminants or if a container is broken during handling. This scenario is assigned a severity of II, critical, and a probability of D, remote, resulting in a RAC 2 (IID).

TM 60A-1-1-11 specifies that workers wear PPE while mixing decontaminants. The U.S. Army Technical Escort Unit (TEU) personnel are trained in proper mixing techniques and in the proper selection and donning of PPE. With proper training and equipment, the severity is mitigated to III, marginal, resulting in a controlled RAC 3 (IIID).

3.3 Hazard During Onsite Transportation

3.3.1 Lightning Strike. The possibility of lightning striking the truck during onsite transportation should be considered. A lightning strike could result in a fuel fire and accident which could breach an overpack and release agent. Lightning striking the transport vehicle is considered to be improbable (probability category E) with a critical consequence (severity category I), giving this event a RAC 3 (IE). It is recommended that transportation occur only during clear weather. In addition, overpacks should be secured with tie-downs and braces. This mitigation would reduce the consequence to marginal (severity category III) with no change in probability category. This results in a controlled RAC 3 (IIIE).

3.3.2 Single or Multiple Vehicle Accident. The cargo truck could have an accident while transporting recovered CWM. The truck could be involved in a single-vehicle or multiple-vehicle accident, either of which could result in damage to an MRC and leaking of agent. Hazards that could result in a truck accident include mechanical malfunction, driver error, and an accident with a wild animal. These types of accidents are considered to be catastrophic (severity category I), but since the probability of an accident is considered improbable (probability category E), the resulting uncontrolled RAC is 3 (IE). An accident probability of 1.45×10^{-7} (see attachment A-2) was calculated for onsite transportation. The calculation takes into account such safety factors as using an experienced driver, driving in clear weather, and performing preventive maintenance on the truck. These safety measures will reduce the probability of an accident; however, the event retains the same severity and probability categories and is assigned a controlled RAC 3 (IE).

3.3.3 Tornado. If the truck carrying recovered CWM were struck by a tornado, an MRC could be breached and agent released. This would result in a RAC 2 (ID). Weather reports should be checked for indications of tornado activity before transport of the CWM. Transporting recovered CWM only during good weather, reduces the likelihood of a tornado striking the truck to improbable, giving this event a controlled RAC 3 (IE).

4. MAXIMUM CREDIBLE EVENT

The maximum credible event (MCE) is defined as a worst-case accident scenario resulting in the release of chemical warfare agent and that has a reasonable probability of occurrence. The HA considered accident scenarios that could occur during storage, handling, and onsite transportation of recovered CWM sealed in MRCs and concluded that none of the accident scenarios met the requirement of being both credible and leading to a release of agent.

5. MITIGATION OF HAZARDS

Throughout the report, as possible events have been described, mitigating actions have been recommended. Table A-1-1 in attachment A-1 contains a summary of the handling, transportation, and storage events; possible incidents; and hazards associated with the incidents. In addition, the following paragraphs provide more specific information on how to mitigate hazards associated with handling, transporting, and storing CWM.

The location of the IHF separates it from public areas of the installation. MRCs are substantial and should reduce the possibility of an accidental release caused by natural events such as earthquakes or severe weather. The location is accessible by road. Two-way radio and cellular telephone communications are available.

First entry monitoring will be conducted in accordance with the IHF Plan. Monitoring will include low-level monitoring by MINICAMS® and a visual inspection of the MRCs. This inspection and monitoring will reduce the probability of leaks occurring and will preclude workers from unknowingly entering an immediately dangerous to life and health contaminated area.

When handling CWM, workers should minimize the handling of MRCs to reduce the likelihood of dropping one. Workers will wear work gloves, safety shoes, and use

proper lifting techniques and lifting mechanisms. TEU personnel are trained in proper handling techniques and in the use of PPE.

For onsite transportation of CWM, low-level NRT monitoring of CWM will be performed prior to loading the CWM into an MRC, and the MRC will be monitored after it has been packed. Containers will not be stacked and bracing and tie-downs will be used to secure MRCs on the truck. The speed of the vehicle will be limited to 25 miles per hour.

To prevent toppling during storage, containers will not be stacked inside the IHF. Low-level NRT monitoring of the IHF will be performed. MRCs will not be stored in aisles, lightning protection will be provided on the IHF, and a fire break will be maintained around the IHF. Fire extinguishers will be available at all times.

TEU personnel will conduct recovery and IHF operations. They are trained in spill response procedures for the chemicals of concern. Emergency Response Plans are in place that identify procedures to implement and sources of assistance should there be an accident or incident. The use of PPE will protect TEU workers from hazards resulting from release of agent. Radio communication is available in the event of an accident.

Implementation of these mitigators can reduce both the severity and probability of hazards that can occur.

6. SUMMARY

A hazard assessment that encompasses the risk potential of handling, storing, and onsite transportation has been performed for the IHF at FTMC. The proposed site for the IHF is acceptable. Hazards were identified from the concept of operations and from historical information, and RACs were assigned based on consequence severity and frequency of occurrence. There were 17 hazards identified; all were assigned a controlled RAC 3 or 4. A summary of the identified hazards, along with the assigned RACs are given in table A-4. It is concluded that the operation can be safely conducted.

Table A-4. Summary of Identified Hazards and Risk Assessment Codes

Item	Hazard	Uncontrolled RAC	Controlled RAC
	Storage		
01	Aircraft crashes into IHF causing agent release	3	3
02	Fires caused by lightning, improper location of flammable materials, electrical equipment malfunction, or other heat source	2	3
03	Earthquake damages IHF causing agent release	2	3
04	Agent leak caused by improper sealing of stored MRC	2	3
05	Tornado damages IHF causing agent release	3	4
06	Hurricane damages IHF causing agent release	2	4
	Handling		
07	MRC improperly sealed	3	3
08	MRC punctured	3	3
09	Dropping of an MRC	2	3
10	Lifting injuries	2	3
11	Crushing injuries	2	3
12	Pinching injuries	2	3
13	Tripping/falling injuries	2	3
14	Improper handing of decontaminants	2	3
	Onsite Transportation		
15	Lightning strike	3	3
16	Single- or multiple-vehicle accident	3	3
17	Tornado	2	3

Notes:

CWM = chemical warfare materiel
IHF = interim holding facility
MRC = multiple round container
RAC = risk assessment code

ATTACHMENT A-1

HAZARD CONTROL LOG WORKSHEETS

Table A-1-1. IHF Hazards

Item	Hazardous Condition	Cause	Effect	RAC	Recommendation	Resolution	Controlled RAC	Remarks
Hazards During Storage								
001	Destruction of IHF	Aircraft crash	Fire; agent not consumed in fire becomes buoyant and is dispersed at height	3 (IIE)	No mitigation possible		3 (IIE)	
002	Fire at IHF	Electrical equipment malfunction, lightning, or other heat source ignites combustible material in vicinity of IHF	Possible agent release	2 (IID)	Do not store flammable materials in or near IHF; install electrical equipment in accordance with electrical code; maintain firebreak; provide lighting protection.		3 (IIE)	MRCs have not been fire tested but are expected to survive all but severe fires. Severe fires would consume agent.
003	Collapse of IHF	Earthquake	None; MRCs should survive	2 (ID)	No mitigation possible or required		3 (IIID)	Ruggedness of MRC should prevent damage.
004	Agent leak	MRC not sealed properly	Toxic atmosphere inside IHF	2 (IID)	Conduct monitoring prior to entry; respond to detected leaks in proper PPE.		3 (IIE)	TEU personnel are extensively trained in leak detection and response:

Table A-1-1. IHF Hazards (Continued)

Item	Hazardous Condition	Cause	Effect	RAC	Recommendation	Resolution	Controlled RAC	Remarks
005	Damage to IHF	Tornado	Release of agent	3 (IIID)	Perform operations during clear weather; use MRCs; have emergency response plan.		4 (IVD)	
006	Damage to IHF	Hurricane	Release of agent	2 (IID)	Perform operations during clear weather; secure MRCs.		4 (IVD)	Ruggedness of MRC should prevent damage.
Hazards During Handling								
007	Uncontrolled release of hazardous chemicals	MRC is not sealed properly or is not vapor tight	Slow leak of chemical agent vapor if CWM was broken during transport	3 (IIIC)	Monitor to detect low-level leaks.		3(IIID)	
008	Uncontrolled release of hazardous chemicals	MRC punctured in fall from forklift		3 (IIIC)	Use qualified equipment operators, avoid excessive moving of MRCs.		3 (IIIE)	
009	Uncontrolled release of hazardous chemicals	Dropping of an MRC		2 (ID)	Minimize handling of MRCs.		3 (IE)	
010	Personal injury	Lifting injury		2 (IID)	Train workers in good lifting techniques and use of mechanical lifting devices.		3 (IIE)	
011	Personal injury	Crushing injury		2 (ID)	Work in teams and use ground guides driving motorized equipment around other workers. Do not drive cargo vehicle within 5 feet of IHF or other structures.		3 (IE)	

Table A-1-1. IHF Hazards (Continued)

Item	Hazardous Condition	Cause	Effect	RAC	Recommendation	Resolution	Controlled RAC	Remarks
012	Personal injury	Pinching injury		2 (IID)	Wear work gloves and safety shoes. Include pinching injuries in safety briefing.		3 (IIE)	
013	Physical hazard	Tripping and falling	Personal injury	2(IID)	Store MRCs properly, keep walkways clear.		3(IIE)	
014	Chemical injury	Improper handling of decontamination chemicals	Personal injury	2(IID)	Train personnel in proper mixing techniques and PPE selection.		3 (IIID)	
Hazards During Onsite Transportation								
015	Fire	Lightning		3 (IE)	Conduct transport operations in good weather.		3 (IIIE)	
016	Truck accident	Single- or multiple-vehicle accident	Personal injury or release of agent	3(IE)	Close roads to other vehicles or use escort vehicles. Use only qualified drivers.		3(IE)	
017	Truck accident	Tornado	Personal injury or release of agent	2 (ID)	Check weather reports prior to travel. Execute road movement in good weather only.		3(IE)	

Notes:

AR = Army Regulation
CWM = chemical warfare materiel
IHF = interim holding facility
MRC = multiple round container
PPE = personal protective equipment
RAC = risk assessment code
TEU = U.S. Army Technical Escort Unit

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ATTACHMENT A-2

DERIVATION OF TRUCK ACCIDENT RATES

ATTACHMENT A-2
DERIVATON OF TRUCK ACCIDENT RATES

This attachment presents a derivation of truck accident rates for the specific road types to be used for transporting CWM from the recovery sites to the IHF. These accident rates are derived by modifying published highway truck accident rate data to account for situation-specific factors. The modifications are made on the basis of the analyst's judgment and supplementary accident data. This approach is taken because the published highway truck accident rates reflect average conditions – generally less stringent controls on traffic, speed, driver training, and other factors than will be the case for CWM transport. A similar analysis approach has previously been used for CWM transport and successfully defended (Rhyne et al., 1985 and 1988).

The truck accident rate data used as a basis for this analysis are described in section A-2.1. An analysis of the factors that affect accident rates and development of the adjusted rates used in this HA are presented in section A-2.2. In section A-2.3, the adjusted accident rates are coupled with mileage estimates for the chosen transport route to estimate the probability of a truck accident during the movement of CWM.

A-2.1 Truck Accident Rates By Highway Class

Truck accident rates have been compiled as a function of road type and surrounding population by various researchers since the early 1980s. The most widely cited values are those published by Harwood and Russell (1990). These rates are presented in table A-2-1. More recently, published data were reviewed for this analysis; however, the Harwood and Russell data are judged to be the best available. The "base" accident rate used in this analysis is the value for two-lane, rural roads, 2.19×10^{-6} accidents per mile. This road type is most similar to the types of roads that make up the CWM transport routes.

Table A-2-1. Truck Accident Rates by Highway Class

Roadway Type	Truck Accident Rate(accidents/mile)
Rural	
Two-lane	2.19×10^{-6}
Multilane, undivided	4.49×10^{-6}
Multilane, divided	2.15×10^{-6}
Freeway	6.40×10^{-7}
Urban	
Two-lane	8.66×10^{-6}
Multilane, undivided	1.39×10^{-5}
Multilane, divided	1.25×10^{-5}
Freeway	2.18×10^{-6}
One-way street	9.70×10^{-6}

Source: Harwood and Russell (1990)

A-2.2 Modification of Accident Rates

A partial listing of the factors that are believed to affect truck accident rates is shown in table A-2-2 (Harwood and Russell, 1990). Data are lacking to correlate accident rates with most of these factors. In addition, some of these factors (for example, time of day and type of truck) are constant for the chosen ground transportation route. The effects of such "global" factors on accident rates are discussed in section A-2.2.1.

Factors that are specific to certain portions of the route are discussed separately in section A-2.2.2.

Table A-2-2. Partial Listing of Factors Considered to Affect Truck Accident Rates

Truck Type or Configuration	Highway
Number of trailers	Function
Number of axles on tractor/trailer(s)	Access control
Cab type	Number of lanes
Cargo area configuration	Lane width
	Shoulder width
Truck Size and Weight	Shoulder surface
Width of trailer	Median width
Length, overall	Horizontal alignment
Length, trailer(s)	Vertical alignment
Empty/loaded	Surface condition (wet/dry/etc.)
Weight, gross	Pavement condition
Weight, trailer	Pavement type
Truck Operations	Traffic
Cargo type	Volume (average daily traffic)
Operator type	Volume (day/night)
Trip type	Percent trucks
Truck Driver	Environment
Age	Visibility
Experience with rig	Weather
Hours of service	Light
Driver condition	
	Temporal Factors
Location	Month/season of year
State	Day of week
Urban/rural	Time of day

Source: Harwood and Russell (1990)

A-2.2.1 Global Factors. Table A-2-3 shows the fractional distribution of truck accidents by accident type. The base case (column 2) shows the average accident distributions described in safety literature. Columns 3 through 6 show how various administrative controls and physical factors can effect accident distributions. The modified fractional distributions shown in the table reflect the cumulative effect of the listed factors, moving from left to right across the table. For example, the distribution shown for operation-specific factors also includes the effects of safe drivers. The effects of these administrative controls and physical factors on the accident type distribution and on accident rate are described in the following paragraphs.

Effects of Safe Drivers. TEU personnel who will operate the cargo trucks and escort vehicles are certified as being proficient. They have passed a physical examination as required by the Motor Carrier Safety Regulations. Their training includes en route procedures, accountability, load limitations, vehicle maintenance standards, and cargo-specific handling procedures. Before movement of any CWM, TEU personnel ensure that the vehicle maintenance documentation is current, inspect the transportation documentation, and inspect the loading of the CWM cargo. Each vehicle will have a driver and one assistant. The TEU Officer in Charge has the responsibility of ensuring that both are alert. The distance between vehicles will be at least one car length for each 10 miles per hour of vehicle speed. Truck speed should be limited to 25 miles per hour.

The TEU's safety practices are at least as sound as those of commercial trucking firms that emphasize a good safety culture. Trucking firms that strongly emphasize safety can achieve a factor of 10 reduction in accident rate (Anonymous, 1990; Anonymous, 1994; Wilson, 1990; U.S. Congress, Office of Technology Assessment, 1988). Truck drivers who reduce their overall accident rate do so primarily by reducing the number of accidents for which they are at fault and to a lesser extent by lowering the accident

Table A-2-3. Truck Accident Type Distributions

Tractor-Trailer Accident Type	Fractional Distribution				
	Base Case[a]	With Safe Drivers Considered	With Operation-Specific Factors Considered	With Escort Considered	With Road Closure Considered
Non-collision					
• Ran off road	0.062	0.00062	0.00012	0.00008	0.00008
• Jackknife	0.077	0.00077	0.00000	0.00000	0.00000
• Overturn	0.072	0.00072	0.00014	0.00009	0.00009
• Separation of units	0.004	0.00004	0.00000	0.00000	0.00000
• Fire	0.006	0.00006	0.00001	0.00001	0.00001
• Other	0.009	0.00009	0.00002	0.00001	0.00001
Collision with					
• Fixed object	0.114	0.00114	0.00023	0.00015	0.00015
• Parked vehicle	0.093	0.00093	0.00019	0.00013	0.00013
• Train	0.005	0.00005	0.00000	0.00000	0.00000
• Non-motorist (for example, pedestrian)	0.015	0.00015	0.00000	0.00000	0.00000
• Other	0.034	0.00034	0.00007	0.00005	0.00005
Multiple-vehicle accident					
• Head-on collision	0.015	0.00280	0.00056	0.00028	0.00002
• Rear-end collision	0.133	0.02490	0.00498	0.00249	0.00025
• Sideswipe	0.185	0.03460	0.00692	0.00346	0.00017
• Angle	0.103	0.01930	0.00386	0.00193	0.00010
• Other	0.070	0.01310	0.00262	0.00131	0.00006
TOTAL	0.997	0.09960	0.01972	0.00999	0.00102
Net Reduction Factor	1	10	50	100	977

[a] Source: Harwood and Russell (1990)

rates of other truck and car drivers by driving defensively. A driver has much more control over single-vehicle accidents than multiple vehicle accidents; safe drivers cannot always prevent other drivers from causing multiple-vehicle accidents.

The second column of table A-2-3 shows the fractional distribution of accident types for average truck drivers, and the third column of this table shows the estimated distribution of accident types for safe drivers (that is, those who achieve a factor of 10 reduction in accident rate). Safe driving practices are most effective in lowering the rate of single-vehicle accidents. Therefore, the distribution in the third column was obtained by (1) lowering the fraction of single-vehicle accident types by a factor of 100 and (2) lowering the fractions of multiple-vehicle accident types such that the overall accident rate reduction factor is 10, as reported in the literature. Mathematically, this procedure is expressed as follows:

$$\frac{A}{100} + \frac{B}{X} = \frac{0.997}{10}$$

where:

A = Fraction of single-vehicle accidents

B = Fraction of multiple-vehicle accidents

X = Reduction factor to be determined for multiple-vehicle accidents.

Values of A and B are obtained from the second column of table A-2-3. Application of this model yields an accident rate reduction factor of 5.34 for multiple-vehicle accidents.

Effects of Operation-Specific Factors. The following factors are expected to produce an additional factor of 5 reduction in accident rate for all accident types.

- Transport of CWM will only occur in good weather.

- Transport of CWM will only occur during daylight hours.

- Trips will be short, which will minimize boredom and fatigue.

- Line-of-sight conditions along the chosen route will be excellent.

- Drivers of vehicles with CWM cargo will be expected to be even more cautious than the typical safe commercial truck driver.

- The TEU's management is more effective than the management of the average trucking firm.

The net result of these considerations is an additional factor of 5 reduction in accident rate. The combination of safe drivers and these operation-specific factors can be expected to reduce the accident rate by a factor of 50 below the published value for two-lane, rural roads.

Effects of Escorting the Cargo Truck. An escort vehicle will precede the cargo truck during ground transportation of CWM. The escort vehicle will be marked with warning signs. Oncoming traffic will not be stopped, and same-direction passing will not be prohibited. The presence of the escort vehicle will alert drivers of other vehicles, thus reducing the rate of multiple-vehicle collisions by a factor of at least 2. The escort vehicle will also reinforce safe driving requirements on the driver of the cargo vehicle; therefore, the rate of single-vehicle collisions is expected to be reduced by an additional factor of 1.5. The overall effect of escorting on the estimated accident rate is a factor of 2 reduction above the reductions achieved by safe driving and operation-specific factors. The cumulative effect of the global factors (safe drivers, operation-specific factors, and escorting) is then a factor of 100 reduction in accident rate, leading to a modified rate of 2.19×10^{-8} accidents per mile.

Effects of Closing Roads. Though road closures are not planned for this project, the rate of most multiple-vehicle accidents could be reduced by an additional factor of 20 by closing the roads along the chosen routes to all other traffic during the CWM transfers. Such accidents would not be completely eliminated because of the possibility of

persons ignoring road closure signs and barricades. The rate of rear-end collisions would only be reduced by an estimated factor of 10 by this action because the escort vehicle could be involved in a rear-end collision with the cargo truck. Single-vehicle accident rates would not be reduced by closing roads.

Closing the roads along the routes to other traffic would further reduce the expected accident rate by approximately a factor of 10.

The cumulative effect of the global factors (safe drivers, operation-specific factors, and escorting) reduces the accident rate by a factor of 100, yielding a modified rate of 2.19×10^{-8} accidents per mile.

A-2.2.2 Route Segment-Specific Factors

The ground transportation routes to the IHF are all two-lane, rural. As discussed previously, the effect of safe drivers, operation-specific factors, and escorting reduces the accident yield by a factor of 100, yielding a modified rate of 2.19×10^{-8} accidents per mile. The accident rate will not increase or decrease based upon local factors and will remain at 2.19×10^{-8} for all ground transportation segments.

A-2.3 Summary

The modified accident rates for the various route segments are shown in table A-2-4 along with the total mileage for each segment. The product of accident rate (accidents per mile) and the mileage for a segment yields the probability of experiencing an accident on that segment for a given trip. The probabilities for the segments in a given route are summed to estimate the accident probability for the route.

Table A-2-4. Modified Accident Rates and Accident Probabilities for Ground Transportation Route

Route Segment	Accident Rate (per mile)	Segment Length (miles)	Number of Trips	Accident Probability
AOC 1 to IHF	2.19×10^{-8}	2.3	1	5.04×10^{-8}
AOC 2 to IHF	2.19×10^{-8}	0	2	0
AOC 3 to IHF	2.19×10^{-8}	0.1	1	0.22×10^{-8}
AOC 24 to IHF	2.19×10^{-8}	4.2	1	9.20×10^{-8}
Total ground transport accident probability				1.45×10^{-7}

Note:

AOC = area of concentration
IHF = interim holding facility

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ANNEX B

CHEMICAL AND PHYSICAL DATA

Table B-1. Chemical and Physical Properties of Chemical Agents of Concern

Chemical Name	Levinstein Mustard (H) 70% bis (2-Chloroethyl) sulfide 30% Higher Molecular Weight Polysulfides	Distilled Mustard (HD) Diethyl, 2,2-dichloride sulfide [bis(2-Chloroethyl) sulfide]	Nitrogen Mustard (HN-1) 2,2'-dichlorotriethyl amine	Sarin (GB) Isopropyl methyl phosphonofluoridate	Lewisite (L) Dichloro (2-chlorovinyl) arsine
Short Name	Levinstein Mustard (H)	Distilled Mustard (HD)	Nitrogen Mustard (HN-1)	Sarin (GB)	Lewisite (L)
Chemical Formula	$C_4H_8Cl_2S$	$C_4H_8Cl_2S$	$C_6H_{13}Cl_2N$	$C_4H_{10}O_2PF$	$C_2H_2AsCl_3$
Molecular Weight	159.08 (pure mustard)	159.08	170.08	140.1	207.32
Physical State	Amber to brown oily liquid	Pale yellow oily liquid	Pale amber to yellow oily liquid	Colorless liquid	Colorless to brownish liquid
Vapor Density (relative to air)	Generally exceeds 5.5	5.5	5.9	4.9	7.2
Liquid Density	1.27 g/mL at 25°C	1.27 g/mL at 25°C	1.09 g/mL at 25°C	1.09 g/mL at 25°C	1.89 g/mL at 20°C
Solid Density	N/A	Crystal, 1.37 g/cm^3 at 0°C	N/A	N/A	N/A
Normal Freezing Point	8°C	14.45°C	-34°C	-56°C	-18°C ± at 0.1°C
Boiling Point	Decomposes at about 180°C	217°C extrapolated	66°C at 3 torr 88.5°C at 12 torr 194°C at 760 torr Decomposes before boiling at 760 torr	158°C	190°C
Vapor Pressure	Impurities tend to lower vapor pressure below 0.11 mm Hg	0.11 mm Hg at 25°C	0.25 mm Hg at 25°C	2.9 mm Hg at 25°C	0.394 mm Hg at 20°C
Volatility	Approximately 920 mg/m^3 at 25°C (reported for HD)	610 mg/m^3 at 20°C 920 mg/m^3 at 25°C	2,290 mg/m^3 at 25°C	4,100 mg/m^3 at 0°C 22,000 mg/m^3 at 25°C 29,800 mg/m^3 at 30°C	4,480 mg/m^3 at 20°C
Viscosity	3.95 centistokes at 25°C (HD)	3.95 centistokes at 25°C	N/A	N/A	2.05 centipoise at 77°F
Solubility	0.092 g/100 g H_2O at 22°C. Completely soluble in acetone, CCl_4, CH_3Cl tetrachloroethane, ethyl benzoate, and ether. Completely soluble in 92.5% ethanol above 28.6°C.	0.092 g/100 g H_2O at 22°C. Completely soluble in acetone, CCl_4, CH_3Cl tetrachloroethane, ethyl benzoate, and ether. Completely soluble in 92.5% ethanol above 28.6°C.	Very slightly soluble in water. Freely soluble in acetone and other organic solvents.	Soluble in water.	Insoluble in water and dilute mineral acids. Soluble in organic solvents and oils. Miscibile with other chemical warfare agents.
Heat of Combustion	4,500 cal/g	756.03 kcal/mole	N/A	N/A	N/A
Latent Heat of Vaporization	94 cal/g	94 cal/g	N/A	80 cal/g	58 cal/g
Latent Heat of Fusion	26.5 cal/g	26.5 cal/g	N/A	N/A	Unknown
Special Properties			Polymerizes slowly. Hydrolyzes slowly in water.	Decomposes at 150°C	

Table B-1. Chemical and Physical Properties of Chemical Agents of Concern (Continued)

Chemical Name	Levinstein Mustard (H) 70% bis (2-Chloroethyl) sulfide 30% Higher Molecular Weight Polysulfides	Distilled Mustard (HD) Diethyl, 2,2-dichloride sulfide [bis(2-Chloroethyl) sulfide]	Nitrogen Mustard (HN-1) 2,2'-dichlorotriethyl amine	Sarin (GB) Isopropyl methyl phosphonofluoridate	Lewisite (L) Dichloro (2-chlorovinyl) arsine
Flash Point	105°C	105°C (Can be ignited by large explosive charges)	High enough not to interfere with military use	Nonflammable	Does not flash
DOT Classification	Poison A	Poison A	Poison A	Poison A	Poison A
Corrosivity	Brass rapidly corroded. Cast iron poor	Brass rapidly corroded at 65°C; 0.0001 inch/month at 65°C on steel	Corrosive to ferrous alloys beginning at 65°C	Slightly corrosive to steel	None if dry
Decontaminants	Bleaching powder, sodium hypochlorite	Bleaching powder, sodium hypochlorite, fire	Bleach, fire	Bleach slurry, dilute alkali, hot soapy water	Bleach powder, sodium hypochlorite, fire, caustic soda
Stabilizers Commonly Used	Can be stabilized with acridine or naphthoquinoline	Can be stabilized with acridine or naphthoquinoline	N/A	None	

Notes:

cal/g = calorie per gram
DOT = Department of Transportation
g = gram
g/cm^3 = gram per cubic centimeter
g/mL = gram per milliliter
kcal = kilocalorie
mg/m^3 = milligram per cubic meter
mm Hg = millimeters of mercury
N/A = not available

Table B-2. Chemical and Physical Properties of Industrial Chemicals of Concern

Chemical Name	Phosgene (CG) Carbonyl Chloride	Chloropicrin (PS)	Cyanogen Chloride (CK)	Chloroform, Trichloromethane	Benzonitrile (GA Simulant)	Ethyl Malonate (GA Simulant) (Diethyl malonate)	Ethyl Heptanoate (Ethyl Oenanthate; heptanoic acid ethyl ester; ethyl n-heptoate; oenanthic ether; congnac oil, synthetic; oil of grapes)
Short Name	Phosgene (CG)	Chloropicrin (PS)	Cyanogen Chloride (CK)	Chloroform	Benzonitrile (GA Simulant)	Ethyl Malonate (GA Simulant)	Ethyl Malonate (GA Simulant)
Chemical Formula	CCl_2O	Cl_3CNO_2	CClN	$CHCl_3$	C_7H_5N	$C_7H_{12}O_4$	$C_9H_{18}O_2$
Molecular Weight	98.92	164.38	61.48	119.4	103.12	160.17	158.24 gram/mole
Physical State	Colorless gas at room temperature	Slightly oily liquid	Colorless liquid	Colorless liquid	Liquid, odor of volatile oil of almond	Colorless liquid with sweet ester odor	Colorless liquid
Vapor Density (relative to air)	3.4	5.6	2.1	4.13	3.6	5.52	N/A
Liquid Density	1.37 g/mL at 20°C	1.66 g/mL at 20°C	1.186 g/mL at 20°C	1.47 g/mL at 20°C	1.010 g/mL at 15°C	1.055 g/mL	0.863 g/mL at 25°C
Solid Density	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Normal Freezing Point	-128°C	-69.2°C	-6.9°C	-63.5°C	-12.75°C	-50°C	-66°C
Boiling Point	7.6°C	112°C	13.8°C	61.2°C	188 to 191°C	199°C	189°C
Vapor Pressure	1,400 mm Hg at 25°C 1,173 mm Hg at 20°C	18.3 mm Hg at 20°C	1,000 mm Hg at 25°C	159 mm Hg at 20°C	1 mm Hg at 20°C	1 mm Hg at 40°C	N/A
Volatility	4,300,000 mg/m^3 at 7.6°C	165,000 mg/m^3 at 20°C	6,132,000 mg/m^3 at 25°C	100% at 20°C	N/A	N/A	N/A
Viscosity	0.27 centistokes at 0°C	N/A	N/A	N/A	1.054 centistokes at 100°F	N/A	0.0111 g/cm/sec at 25°C
Solubility	Very slight solubility in water and decomposed by it. Freely soluble in benzene, toluene, glacial acetic acid, and most organic solvents.	Insoluble in water. Soluble in organic solvents, liquid organophosphorus compounds, mustards, phosgene, diphosgene, and Cl_2.	Soluble in water (6.9 g/100 g H_2O at 20°C), alcohol, and ether. Many mixtures with organic solvents are unstable.	0.79 g/100 g H_2O at 20°C. Miscible with alcohol, benzene, ether, carbon tetrachloride, carbon disulfide, and oils.	1 g/100 g H_2O at 100°C. Miscible with common organic solvents.	1 g/50 mL H_2O, miscible with alcohol and ether.	Insoluble in water. Miscible with alcohol, ether, chloroform.
Heat of Combustion	41.8 kcal/mole	N/A	N/A	N/A	N/A	N/A	N/A
Latent Heat of Vaporization	59 cal/g	57.3 cal/g	103 cal/g	N/A	N/A	N/A	N/A
Latent Heat of Fusion	N/A	N/A	41.8 cal/g	N/A	N/A	N/A	N/A
Special Properties	Decomposes at 800°C. Reacts with water to form HCl and CO.		Polymerizes in water; decomposes above 100°C. CK will stand for 30 days at 65°C without excessive decomposition; polymerizes between 40 and 60 days to form $CNCl_3$, a solid. May explode.	Pure chloroform is light sensitive and is usually stabilized with 0.75% ethanol.			

Table B-2. Chemical and Physical Properties of Industrial Chemicals of Concern (Continued)

Chemical Name	Phosgene (CG) Carbonyl Chloride	Chloropicrin (PS)	Cyanogen Chloride (CK)	Chloroform, Trichloromethane	Benzonitrile (GA Simulant)	Ethyl Malonate (GA Simulant) (Diethyl malonate)	Ethyl Heptanoate (Ethyl Oenanthate; heptanoic acid ethyl ester; ethyl n-heptoate; oenanthic ether; congnac oil, synthetic; oil of grapes)
Flash Point	Does not flash	Not flammable, but with strong ignition-heated material in confinement will detonate	Does not flash	Nonflammable	71°C	100°C	66°C (151°F)
DOT Classification	Poison A	Poison A	Poison A	Poison A	Poison	Not Regulated	N/A
Corrosivity	Not corrosive when dry, no appreciable corrosion of steel. Extremely corrosive in presence of moisture.	If dry, has little or no effect on metals	Not corrosive, will polymerize to form solid cyanuric chloride which is corrosive	Chemically active with metals such as aluminum or magnesium powder, sodium, and potassium	N/A	N/A	N/A
Decontaminants	Water followed by 10% solution of caustic soda or sodium carbonate	Large amounts of water or rinse with 5% solution of bisulfite	Aeration, NaOH solution	Sand, diatomaceous earth, and kitty litter are used as absorbent material	Sand, diatomaceous earth, and kitty litter are used as absorbent material	Sand, diatomaceous earth, and kitty litter are used as absorbent material	Large amounts of water
Stabilizers Commonly Used	Stable when dry		Lab sample - 5% anhydrous, powdered TSPP; propylene oxide; or $AsCl_3$	0.75% Ethanol			

Notes:

cal/g = calorie per gram
DOT = Department of Transportation
DS2 = decontaminating solution number 2
g = gram
g/cm^3 = gram per cubic centimeter
g/mL = gram per milliliter
kcal = kilocalorie
mg/m^3 = milligram per cubic meter
mm Hg = millimeters of mercury
N/A = not available
NaOH = sodium hydroxide
TSPP = tetrasodium pyrophosphate

ANNEX C

MATERIAL SAFETY DATA SHEETS

ANNEX C
MATERIAL SAFETY DATA SHEETS

The following pages provide examples of Material Safety Data Sheets (MSDSs) for the chemical agents discussed in this document. Preference was given to Department of Army data sheets prepared by Edgewood Chemical Biological Center (ECBC) [formerly Edgewood Research, Development and Engineering Center (ERDEC)].

Distilled Mustard (HD) - Edgewood Research, Development and Engineering Center, 28 September 1999.

Levinstein Mustard (H) - Department of the Army, Special Report EO-SR-74001, Chemical Agent Data Sheets, Volume 1, pp. 29 through 31, December 1974.

Lewisite (L) - Edgewood Research, Development and Engineering Center, 4 October 1999.

Nitrogen Mustard (HN-1) - Edgewood Research, Development and Engineering Center, 12 January 1990.

Sarin (GB) - Edgewood Research, Development and Engineering Center, 29 September 1999.

Chloroform - Mallinckrodt Inc., 1 January 1987.

Phosgene (CG) - Liquid Air Corporation, 1 January 1987.

Cyanogen Chloride (CK) - Atomergic Chemetals Corporation, 30 June 1987.

Chloropicrin (PS) - U.S. Department of Health and Human Services, September 1978.

GA-simulant:	**Benzonitrile** - Aldrich Chemical, 8 January 1992.
	Diethyl Malonate - Fluka Chemical Corp., 2 June 1994.
	Ethyl Heptanoate - Aldrich Chemical, 9 May 1995.

Material Safety Data Sheet

Distilled Mustard (HD)

Date: 22 September 1988
Revised: 29 September 1999

In the event of an emergency:
Telephone the SBCCOM Operations
Center's 24-hour emergency
Number: 410-436-2148

Section I - General Information

Manufacturer's Address:
U.S. Army Soldier and Biological Chemical Command (SBCCOM)
Edgewood Chemical Biological Center (ECBC)
ATTN: AMSSB-RCB-RS
Aberdeen Proving Ground, MD 21010-5424

CAS Numbers 505-60-2, 39472-40-7, 68157-62-0

Chemical Name: Bis-(2-chloroethyl)sulfide

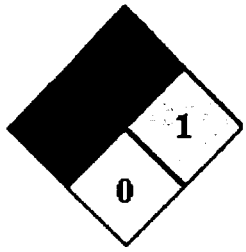
Trade name and synonyms:
H; HD; HS
Mustard Gas
Sulfur mustard; Sulphur mustard gas
Sulfide, bis (2-chloroethyl)
Bis(beta-chloroethyl)sulfide
1,1'-thiobis(2-chloroethane)
1-chloro-2(beta-chloroethylthio)ethane
Beta, beta'-dichlorodiethyl sulfide
2,2'dichlorodiethyl sulfide
Di-2-chloroethyl sulfideBeta, beta'-dichloroethyl sulfide Iprit S-Lost;
S-yperite; Schewefel-lost
Senfgas
Yellow Cross Liquid
Yperite;Y

EA 1033

Chemical Family: Chlorinated sulfur compound

Formula/Chemical Structure:
C4 H8 C12 S

Cl CH2 CH2--S--CH2 CH2 Cl



NFPA 704 Signal:

Health - 4
Flammability - 1
Reactivity - 1
Special - 0

Section II - Ingredients

Ingredients/Name: Sulfur Mustard

Percentage by Weight: 100%

Threshold Limit Value (TLV): 0.003mg/m^3

Section III - Physical Data

Boiling Point °F (°C): Calculated 423.5 °F (217.5 °C) (decomposed)

Vapor Pressure (mm Hg):

0.069 @ 20 °C
0.11 @ 25 °C

Vapor Density (Air = 1): 5.5

Solubility (g/100g solvent): Negligible in water (0.92 @ 22 °C). Soluble in fats and oils, gasoline, kerosene, acetone, carbon tetrachloride, alcohol, tetrachloroethane, ethylbenzoate, and ether. Miscible with the organophosphorus nerve agents.

Specific Gravity ($H_2$0=1): 1.27 @ 25 °C

Freezing/Melting Point (°C): 14.45

Liquid Density (g/mL):

1.274 g/mL @ 20 °C
1.268 g/mL @ 25 °C

Volatility (mg/m^3):

600 @ 20 °C
910 @ 25 °C

Viscosity (Centipoise): 5.175 @ 20 °C

Molecular Weight (g/mol): 159.08

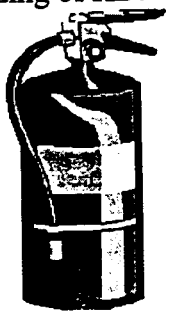
Appearance and Odor: Normally amber to black colored liquid with garlic or horseradish odor. Water clear if pure. The odor threshold for HD is 0.6 mg/m^3 (0.0006 mg/L).

Section IV - Fire and Explosion Data

Flashpoint: 105 °C (Can be ignited by large explosive charges)

Flammability Limits (% by volume): Unknown

Extinguishing Media: Water, fog, foam, CO_2. Avoid use of extinguishing methods that will cause splashing or spreading of HD.



Special Fire Fighting Procedures: All persons not engaged in extinguishing the fire should be immediately evacuated from the area. Fires involving HD should be contained to prevent contamination to uncontrolled areas. When responding to a fire alarm in buildings or areas containing agents, firefighting personnel should wear full firefighter protective clothing (flame resistant) during chemical agent firefighting and fire rescue operations. Respiratory protection is required. Positive pressure, full facepiece, NIOSH-approved self-contained breathing apparatus (SCBA) will be worn where there is danger of oxygen deficiency and when directed by the fire chief or chemical accident/incident (CAI) operations officer. In cases where firefighters are responding to a chemical accident/incident for rescue/reconnaissance purposes, they will wear appropriate levels of protective clothing (See Section VIII). Do not breathe fumes. Skin contact with agent must be avoided at all times. Although the fire may destroy most of the agent, care must still be taken to ensure the agent or contaminated liquids do not further contaminate other areas or sewers. Contact with the agent, liquid or vapor, can be fatal.

Section V - Health Hazard Data

Airborne Exposure Limit (AEL): The AEL for HD is 0.003 mg/m^3 as found in "DA Pam 40-173, Occupational Health Guidelines for the Evaluation and Control of Occupational Exposure to Mustard Agents H, HD, and HT." To date, the Occupational Safety and Health Administration (OSHA) has not promulgated a permissible exposure concentration for HD.

Effects of Overexposure: HD is a vesicant (causing blisters) and alkylating agent producing cytotoxic action on the hematopoietic (blood-forming) tissues which are especially sensitive. The rate of detoxification of HD in the body is very slow and repeated exposures produce a cumulative effect. HD has been found to be a human carcinogen by the International Agency for Research on Cancer (IARC).

Median doses of HD in man are:
LD50 (skin) = 100 mg/kg
ICt50 (skin) = 2000 mg-min/m^3 at 70 - 80 °F (humid environment)
= 1000 mg-min/m^3 at 90 °F (dry environment)
ICt50 (eyes) = 200 mg-min/m^3
ICt50 (inhalation) = 1500 mg-min/m^3
LD50 (oral) = 0.7 mg/kg
Maximum safe Ct for skin and eyes are 5 and 2 mg-min/m^3, respectively.

Acute Physiological Action of HD is Classified as Local and Systemic.

Local Actions: HD effects both the eyes and the skin. Skin damage occurs after percutaneous absorption. Being lipid soluble, HD can be absorbed into all organs. Skin penetration is rapid without skin irritation. Swelling (blisters) and reddening (erythema) of the skin occurs after a latency period of 4-24 hours following the exposure, depending on degree of exposure and individual sensitivity. The skin healing process is very slow. Tender skin, mucous membrane and perspiration-covered skin is more sensitive to the effects of HD. HD's effect on the skin, however, is less than on the eyes. Local action on the eyes produces severe necrotic damage and loss of eyesight. Exposure of eyes to HD vapor or aerosol produces lacrimation, photophobia, and inflammation of the conjunctiva and cornea.

Systemic Actions: Occurs primarily through inhalation and ingestion. The HD vapor or aerosol is less toxic to the skin or eyes than the liquid form. When inhaled, the upper respiratory tract (nose, throat,

trachea) is inflamed after a few hours latency period, accompanied by sneezing, coughing, and bronchitis, loss of appetite, diarrhea, fever, and apathy. Exposure to nearly lethal doses of HD can produce injury to bone marrow, lymph nodes, and spleen as shown by a drop in white blood cell count, thus resulting in increased susceptibility to local and systemic infections. Ingestion of HD will produce severe stomach pains, vomiting, and bloody stools after a 15-20 minute latency period.

Chronic Exposure: HD can cause sensitization, chronic lung impairment,(cough, shortness of breath, chest pain), cancer of the mouth, throat, respiratory tract and skin, and leukemia. It may also cause birth defects.

Emergency and First Aid Procedures:

Inhalation: Hold breath until respiratory protective mask is donned. Remove from the source **Immediately**. If breathing is difficult, administer oxygen. If breathing has stopped, give artificial respiration. Mouth-to-mouth resuscitation should be used when approved mask-bag or oxygen delivery systems are not available. Do not use mouth-to-mouth resuscitation when facial contamination is present. Seek medical attention **Immediately**.

Eye Contact: Speed in decontaminating the eyes is absolutely essential. Remove the person from the liquid source, flush the eyes **Immediately** with water for at least 15 minutes by tilting the head to the side, pulling the eyelids apart with the fingers and pouring water slowly into the eyes. Do not cover eyes with bandages but, if necessary, protect eyes by means of dark or opaque goggles. Transfer the patient to a medical facility **Immediately**.

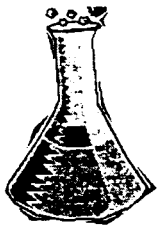
Skin Contact: Don respiratory protective mask. Remove the victim from agent sources **Immediately**. Immediately wash skin and clothes with 5% solution of sodium hypochlorite or liquid household bleach within one minute. Cut and remove contaminated clothing, flush contaminated skin area again with 5% sodium hypochlorite solution, then wash contaminated skin area with soap and water. Seek medical attention **Immediately**.

Ingestion: Do not induce vomiting. Give victim milk to drink. Seek medical attention **Immediately**.

Section VI - Reactivity Data

Stability: Stable at ambient temperatures. Decomposition temperature is 100-351 °F (149-117 °C). Mustard is a

persistent agent depending on pH and moisture and has been known to remain active for up to three years in soil.



Incompatibility: Rapidly corrosive to brass @ 65 °C. Will corrode steel at a rate of 0.0001 in. of steel per month @ 65 °C.

Hazardous Decomposition: Mustard will hydrolyze to form HCl and thiodiglycol.

Hazardous Polymerization: Does not occur.

Section VII - Spill, Leak, and Disposal Procedures

Steps To Be Taken In Case Material Is Released Or Spilled: Only personnel in full protective clothing (See Section VIII) will be allowed in an area where HD is spilled. See Section V for emergency and first aid instructions.

Recommended Field Procedures: The HD should be contained using vermiculite,diatomaceous earth, clay, or fine sand and neutralized as soon as possible using copious amounts of 5.25% sodium hypochlorite solution. Scoop up all material and place in an approved DOT container. Cover the contents with decontaminating solution as above. The exterior of the container will be decontaminated and labeled according to EPA and DOT regulations. All leaking containers will be over packed with sorbent (e.g. vermiculite) placed between the interior and exterior containers. Decontaminate and label according to EPA and DOT regulations. Dispose of the material in accordance with waste disposal methods provided below. Conduct general area monitoring with an approved monitor to confirm that the atmospheric concentrations do not exceed the airborne exposure limits (See Sections II and VIII). If 5.25% sodium hypochlorite solution is not available then the following decontaminants may be used instead and are listed in the order of preference: Calcium Hypochlorite, contamination Solution No. 2 (DS2), and Super Tropical Bleach Slurry (STB).

Warning: Pure, undiluted calcium hypochlorite (HTH) will burn on contact with liquid HD.

Recommended Laboratory Procedures:

Decontamination solution for each gram of HD. Allow 24 hours for decontamination to take place. Agitate solution at least one hour. Agitation is not necessary after the first hour. Testing for presence of active chorine by use of

acidic potassium iodide solution to give free iodine color. Adjust the resulting solution pH to between 10 and 11.

Place three millileters (ml) of decontaminated solution in a test tube. Add several crystals of potassium iodine and swirl to dissolve. Add 3 ml of 50 wt.% sulfuric acid:water and swirl. IMMEDIATE iodine color shows the presence of active chlorine. If negative, add additional decontaminant to the decontamination solution, wait two hours, and test again for active chlorine. This works for either 5.5% sodium hypochlorite or 10% calcium hypochlorite decontamination solution.

Scoop up all materials and clothing and place in an approved DOT container. The exterior of the container will be decontaminated and labeled according to EPA and DOT regulations. All leaking containers will be over packed with sorbent (e.g. vermiculite) placed between the interior and exterior containers. Decontaminate and label according to EPA and DOT regulations. Dispose of the material in accordance with waste disposal methods provided below. Conduct general area monitoring with an approved monitor to confirm that the atmospheric concentrations do not exceed the airborne exposure limits (See Section VIII).

Note: Surfaces contaminated with HD, then rinsed and decontaminated may evolve sufficient HD vapor to produce a physiological response. HD on laboratory glassware may be oxidized by its vigorous reaction with concentrated nitric acid.

Waste Disposal Method: Open pit burning or burying of HD or items containing or contaminated with HD in any quantity is prohibited. Decontamination of waste or excess material shall be accomplished according to the procedures outlined above and can be destroyed by incineration in EPA approved incinerators according to appropriate provisions of Federal, State, and local Resource Conservation Recovery Act (RCRA) regulations.

Note: Some decontaminant solutions are hazardous waste according to RCRA regulations and must be disposed of according to those regulations.

Section VIII - Special Protection Information

Respiratory Protection:

Concentration

<= 0.003 mg/m^3 as an 8-hr TWA

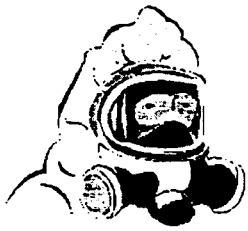
Respiratory Protective Equipment

Protective mask not required to be worn provided that:

(a) Monitoring will be conducted to confirm that engineering controls are properly maintaining concentrations <= 0.003 mg/m^3 as an 8-hr TWA.

(b) M40-series mask is available for emergency escape purposes.

(c) Exposure has been limited to the extent practicable by engineering controls (remote operations, ventilation, and process isolation) and work practices.



If these conditions are not met, then follow the guidance for >=0.003 mg/m^3 as an 8-hr TWA.

Concentration

>= 0.003 mg/m^3 as an 8-hr TWA

Respiratory Protective Equipment

NIOSH/MSHA approved, pressure demand full face piece SCBA suitable for use in high agent concentrations with protective ensemble. (See DA Pam 386-61 for examples).

Ventilation

Local Exhaust: Mandatory. Must be filtered or scrubbed. Air emissions shall meet local, state, and federal regulations.

Special: Chemical laboratory hoods will have an average inward face velocity of 100 linear feet per minute (lfpm) ±20% with the velocity at any point not deviating from the average face velocity by more than 20%. Existing laboratory hoods will have an inward face velocity of 150 lfpm ±20%. Laboratory hoods will be located such that cross drafts do not exceed 20% of the inward face velocity. A visual performance test using smoke producing devices will be performed in assessing the ability of the hood to contain agent HD.

Other: Recirculation of exhaust air from agent areas is prohibited. No connection between agent area and other areas through the ventilation system is permitted. Emergency backup power is necessary. Hoods should be tested semiannually or after modification or maintenance operations. Operations should be performed 20 centimeters inside

hoods.

Protective Gloves: Butyl Rubber gloves M3 and M4 Norton, Chemical Protective Glove Set

Eye Protection: As a minimum, chemical goggles will be worn. For splash hazards use goggles and face shield.

Other Protective Equipment: For laboratory operations, wear lab coats, gloves, and have mask readily accessible. In addition, daily clean smocks, foot covers, and head covers will be required when handling contaminated lab animals.

Monitoring: Available monitoring equipment for agent HD is the M8/M9 detector paper, blue band tube, M256/M256A1 kits, bubbler, Depot Area Air Monitoring System (DAAMS), Automated Continuous Air Monitoring System (ACAMS), CAM-M1, Hydrogen Flame Photometric Emission Detector (HYFED), the Miniature Chemical Agent Monitor (MINICAM), and Real Time Analytical Platform (RTAP). Real-time, low-level monitors (with alarm) are required for HD operations. In their absence, an Immediately Dangerous to Life and Health (IDLH) atmosphere must be presumed. Laboratory operations conducted in appropriately maintained and alarmed engineering controls require only periodic low-level monitoring.

Section IX - Special Precautions

Precautions To Be Taken In Handling and Storing: When handling agents, the buddy system will be incorporated. No smoking, eating, or drinking in areas containing agents is permitted. Containers should be periodically inspected for leaks, (either visually or using a detector kit). Stringent control over all personnel practices must be exercised. Decontaminating equipment will be conveniently located. Exits must be designed to permit rapid evacuation. Chemical showers, eyewash stations, and personal cleanliness facilities must be provided. Wash hands before meals and shower thoroughly with special attention given to hair, face, neck, and hands using plenty of soap and water before leaving at the end of the work day.

Other Precautions: HD should be stored in containers made of glass for Research, Development, Test and Evaluation (RDTE) quantities or one-ton steel containers for large quantities. Agent containers will be stored in a single containment system within a laboratory hood or in a double-containment system.

For additional information see "AR 385-61, The Army Toxic Chemical Agent Safety Program," "DA Pam 385-61, Toxic Chemical

Agent Safety Standards," and "DA Pam 40-173, Occupational Health Guidelines for the Evaluation and Control of Occupational Exposure to HD Agents H, HD, and HT."

Section X - Transportation Data

Note: Forbidden for transport other than via military (Technical Escort Unit) transport according to 49 CFR 172

Proper Shipping Name: Toxic liquids, n.o.s.

DOT Hazard Class: 6.1, Packing Group I, Hazard Zone B

DOT Label: Poison

DOT Marking: Toxic liquids, n.o.s. Bis-(2-chloroethyl) sulfide UN 2810, Inhalation Hazard

DOT Placard: Poison

Emergency Accident Precautions and Procedures: See Sections IV, VII, and VIII.

Precautions To Be Taken In Transportation: Motor vehicles will be placarded regardless of quantity. Drivers will be given full information regarding shipment and conditions in case of an emergency. AR 50-6 deals specifically with the shipment of chemical agents. Shipment of agents will be escorted in accordance with AR 740-32.

The Edgewood Chemical Biological Center (ECBC), Department of the Army, believes that the data contained herein are actual and are the results of the tests conducted by ECBC experts. The data are not to be taken as a warranty or representation for which the Department of the Army or ECBC assumes legal responsibility. They are offered solely for consideration. Any use of this data and information contained in this MSDS must be determined by the user to be in accordance with applicable Federal, State, and local laws and regulations.

Addendum A

Additional Information For Thickened HD

Trade Name and Synonyms: Thickened HD, THD

Trade Name and Synonyms for Thickener:
Acrylic acid butyl ester

Polymer with styrene
Butyl acrylate-styrene polymer
Butyl acrylate-styrene copolymer
N-Butyl acrylate-styrene polymer
Polymer with styrene acrylic acid butyl ester
2-Propenoic acid
Butyl ester
Polymer with ethenylbenzene Acronal 4D
Acronal 290D
Acronal 295D Mowilith DM60
Sokrate LX 75
OSH22097

Hazardous Ingredients: Styrene-butyl acrylate copolymer is used to thicken HD and is not known to be hazardous except in a finely-divided, powder form.

Physical Data: Essentially the same as HD.

Fire and Explosion Data: Same as HD and slight fire hazard when exposed to heat or flame.

Health Hazard Data: Same as HD except for skin contact. For skin contact, don respiratory protective mask and remove contaminated clothing IMMEDIATELY. IMMEDIATELY scrape the HD from the skin surface, then wash the contaminated surface with acetone. Seek medical attention IMMEDIATELY.

Spill, Leak, and Disposal Procedures: If spills or leaks of HD occur, follow the same procedures as those for HD, but dissolve THD in acetone before introducing any decontaminating solution. Containment of THD is generally not necessary. Spilled THD can be carefully scraped off the contaminated surface and placed in a fully removable head drum with a high density, polyethylene lining. THD can then be decontaminated, after it has been dissolved in acetone, using the same procedures used for HD. Contaminated surfaces should be treated with acetone, then decontaminated using the same procedures as those used for HD.

Note: Surfaces contaminated with THD and then rinse-decontaminated may evolve sufficient HD vapor to produce a physiological response.

Special Protection Information: Same as HD.

Special Precautions: Same as HD with the following addition. Handling the THD requires careful observation of the "stringers" (elastic, thread like attachments) formed when the agents are transferred or dispensed. These stringers must be broken cleanly

before moving the contaminating device or dispensing device to another location, or unwanted contamination of a working surface will result. Avoid contact with strong oxidizers, excessive heat, sparks, or open flame.

Transportation Data: Same as HD.

This page last updated on 21 September 2000

1. Chemical Code or EA Number: H

2. Chemical Name: Levinstein Mustard. Composed of about 70% Bis (2-chloroethyl) sulfide and 30% of usually higher MW polysulfides.

3. Chemical Formulae:

   a. Empirical.

   b. Structural.

4 - 17. Most Levinstein H consists of about 70% pure H with about 30% of polysulfides. The percent of pure H in Levinstein H varies from sample to sample and therefore no specific data can be given on its colligative properties.

The biological properties of H are similar to those given for HD (q.v.).

18. Molecular Weight: Average MW varies with purity, but is generally higher than that of pure mustard (159.08).

19. Purity Range (average):

   a. Laboratory Sample.

   b. Plant Sample. 64 to 69 wt%.

20. Physical Appearance: Amber to dark brown liquid.

21. Vapor Density, Relative to Air: Varies with MW, generally exceeds value for HD of 5.5.

22. Liquid Density: 1.27 g/ml 0 25° C; fairly constant, independent of product purity.

23. Solid Density:

   a. Bulk Density. Not applicable.

   b. Crystal Density. Not applicable.

Levinstein Mustard

24. Normal Freezing Point or Melting Point: approx. 8° C.

25. Boiling Point: Varies with product composition; decomposes around 130° C.

26. Vapor Pressure :

    No general value since vapor pressure varies with purity of sample. High molecular weight impurities of H tend to lower vapor pressure below 0.11 torr reported for HD.

27. Volatility: approx. 920 mg/m^3 @ 25° C (reported for HD).

28. Viscosity: See HD.

29. Flash Point: 105° C.

30. Autoignition Temperature: Unknown.

31. Latent Heat of Vaporization: In the range of 94 cal/g reported for HD.

32. Latent Heat of Fusion: See HD.

33. Vapor-Air-Explosive Hazard Range: Not available.

34. Relative Persistency:

    a. Soil. Persistent.

    b. Surface (Wood, Methal, Masonry, Rubber, Paint).

    c. Water. Persistent due to low solubility.

35. Solubility: Similar to HD.

36. Thermal Decomposition Rate (half-life): See HD.

37. Heat of Combustion: 4500 cal/g (calculated from bomb calorimetry for products given in Item 38).

38. Products of Combustion: CO_2, Cl_2, H_2O, H_2SO_4, HCl (bomb calorimetry).

39. Rate of Hydrolysis: See HD.

40. Hydrolysis Products: See HD.

41. Corrosive Properties: Brass rapidly corroded; cast iron poor.

42. Detection Methods and Equipment:

Spotted Disk (SD) Test, Dragendorff Test.

For Liquid: ABCM8 detector paper; M6A1 detector paper.
For Vapor: M15A2, M18A2, M19 kits
(DB-3 Test, blue band detector tube)

43. Decontaminants:

a. Personnel. Flush eyes with H_2O. Protective ointment M1, M5 ointment; M13 kit (liquid on skin). M13 Kit - outer clothing. Shower with soap and water.

b. Equipment. Bleaching powder, DANC, DS2, sodium hypochlorite, fire.

c. Areas. Terrain: Aeration. STB slurry applied by M9 or M12A1 decontaminating apparatus.

44. DOT Classification: Poison A.

45. Stabilizer Utilized:

a. Laboratory Sample. See HD.

b. Production Sample.

46. Types of Containers Required for Storage:

a. RDT&E Quantities. Glass.

b. Stockpile Quantities. One-ton containers, 55-gallon steel drums, steel cylinders.

47. O-D Classification: 3
Compatability Group: A
Chemical Group: A

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Material Safety Data Sheet

Lewisite

Date: 16 April 1988
Revised: 4 October 1999

In the event of an emergency
Telephone the SBCCOM Operations
Center's 24-hour emergency
Number: 410-436-2148

Section I - General Information

Manufacturer's Address:
U.S. Army Soldier and Biological Chemical Command (SBCCOM)
Edgewood Chemical Biological Center (ECBC)
ATTN: AMSSB-RCB-RS
Aberdeen Proving Ground, MD 21010-5424

CAS Registry Number: 541-25-3

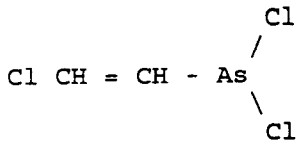
Chemical Name: Dichloro- (2-chlorovinyl) arsine

Trade name and synonyms:
Arsine, (2-chlorovinyl) dichloro-
Arsonous dichloride, (2-chloroethenyl)
Chlorovinylarsine dichloride
2-Chlorovinyldichloroarsine
Beta-Chlorovinyldichloroarsine
Lewisite
L
EA 1034

Chemical Family: Arsenical (vesicant)

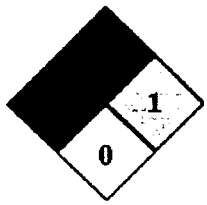
Formula/Chemical Structure:

$C_2 H_2 As C_{13}$



NFPA 704 Signal:

Health - 4
Flammability - 1
Reactivity - 1
Special - 0



Section II - Ingredients

Ingredients/Name: Lewisite

Percentage by Weight: 100%

Threshold Limit Value (TLV): 0.003 mg/m^3 (This is a ceiling value)

Section III - Physical Data

Boiling Point °F (°C): Calculated 374 °F (190 °C)

Vapor Pressure (mm Hg): 0.22 @ 20 °C 0.35 @ 25 °C

Vapor Density (Air=1): 7.1

Solubility (g/100g solvent): Insoluble in water and dilute mineral acids. Soluble in organic solvents, oils and alcohol.

Specific Gravity (H_20=1): 1.891 @ 20 °C

Freezing/Melting Point (°C): -18.2 to 0.1 (Depending on purity)

Liquid Density (g/mL): 1.888 @ 20 °C

Volatility (mg/m^3): 2,500 @ 20 °C

Viscosity (Centipoise): 2.257 @ 20 °C

Molecular Weight (g/mol): 207.32

Appearance And Odor: Pure Lewisite is a colorless oily liquid. "War gas" is amber to dark brown liquid. A characteristic odor is usually geranium-like; very little odor when pure.

Section IV - Fire and Explosion Data

Flashpoint: Does not flash

Flammability Limits (% by volume): Not Applicable

Extinguishing Media: Water, fog, foam, CO_2. Avoid use of extinguishing methods that will cause splashing or spreading of L.

Special Fire Fighting Procedures: All persons not engaged in extinguishing the fire should be immediately evacuated from the area. Fires involving L should be contained to prevent contamination to uncontrolled areas. When responding to a fire alarm in buildings or areas containing agents, fire-fighting personnel should wear full firefighter protective clothing (flame resistant) during chemical agent fire-fighting and fire rescue operations. Respiratory protection is required. Positive pressure, full facepiece, NIOSH-approved self-contained breathing apparatus (SCBA) will be worn where there is danger of oxygen deficiency and when directed by the fire chief or chemical accident/incident (CAI) operations officer. In cases where firefighters are responding to a chemical accident/incident for rescue/reconnaissance purposes they will wear appropriate levels of protective clothing (See Section VIII).

Do not breathe fumes. Skin contact with agents must be avoided at all times. Although the fire may destroy most of the agent, care must still be taken to assure the agent or contaminated liquids do not further contaminate other areas or sewers. Contact with the agent liquid or vapor can be fatal.

Unusual Fire and Explosion Hazards: None known

Section V - Health Hazard Data

Airborne Exposure Limit (AEL): The permissible airborne exposure concentration of L for an 8-hour workday or a 40-hour workweek is an 8-hour time weighted average (TWA) of 0.003 mg/m^3 as a ceiling value. A ceiling value may not be exceeded at any time. The ceiling value for Lewisite is based upon the present technologically feasible detection limits of 0.003 mg/m^3. This value

can be found in "DA Pam 40-173, Occupational Health Guidelines for the Evaluation and Control of Occupational Exposure to Mustard H, HD, and HT." To date, however, the Occupational Safety and Health Administration (OSHA) has not promulgated permissible exposure concentration for L.

Effects Of Overexposure: L is a vesicant (blister agent), also, it acts as a systemic poison, causing pulmonary edema, diarrhea, restlessness, weakness, subnormal temperature, and low blood pressure. In order of severity and appearance of symptoms, it is a blister agent, a toxic lung irritant, absorbed in tissues, and a systemic poison. When inhaled in high concentrations, L may be fatal in as short a time as 10 minutes. L is not detoxified by the body. Common routes of entry into the body are ocular, percutaneous, and inhalation.

Lewisite is generally considered a suspect carcinogen because of its arsenic content.

Toxicological Data:

Man:

LCt50 (inhalation, man) = 1200 - 1500 mg min/m^3
LCt50 (skin vapor exposure, man) = 100,000 mg min/m^3
LDLO (skin, human) = 20 mg/kg
LCt50 (skin, man): >1500 mg/min^3. L irritates eyes and skin and gives warning of its presence. Minimum effective dose (ED min) = 200 mg/m^3 (30 min).
ICt50 (eyes, man): <300 mg min/m^3.

Animal:

LD50 (oral, rat) = 50 mg/kg
LD50 (subcutaneous, rat) = 1 mg/kg
LCtLO (inhalation, mouse) = 150 mg/m^3 10m
LD50 (skin, dog = 15 mg/kg)
LD50 (skin, rabbit) = 6 mg/kg
LD50 (subcutaneous, rabbit) = 2 mg/kg
LD50 (intravenous, rabbit) = 2 mg/kg
LD50 (skin, guinea pig) = 12 mg/kg
LD50 (subcutaneous, guinea pig) = 1 mg/kg
LCt50 (inhalation, rat) = 1500 mg min/m^3 (9 min)
LD50 (vapor skin, rat) = 20,000 mg min m 25 min)
LD50 (skin, rat) = 15 - 24 mg/kg
LD50 (ip, dog) = 2 mg/kg

Acute Exposure:

Eyes: Severe damage. Instant pain, conjunctivitis and blepharospasm leading to closure of eyelids, followed by corneal scarring and iritis. Mild exposure produces reversible eye damage if decontaminated instantly. More permanent injury or blindness is possible within one minute of exposure.

Skin: Immediate stinging pain increasing in severity with time. Erythema (skin reddening) appears within 30 minutes after exposure accompanied by pain with itching and irritation for 24 hours. Blisters appear within 12 hours after exposure with more pain that diminishes after 2-3 days. Skin burns are much deeper than with HD. Tender skin, mucous membrane, and perspiration-covered skin are more sensitive to the effects of L. This, however, is counteracted by L's hydrolysis by moisture, producing less vesicant and higher vapor pressure product.

Respiratory Tract: Irritating to nasal passages and produces a burning sensation followed by profuse nasal secretions and violent sneezing. Prolonged exposure causes coughing and production of large quantities of froth mucus. In experimental animals, injury to respiratory tracts, due to vapor exposure is similar to mustards; however, edema of the lung is more marked and frequently accompanied by pleural fluid.

Systemic Effects: L on the skin, and inhaled vapor, cause systemic poisoning. A manifestation of this is a change in capillary permeability, which permit's loss of sufficient fluid from the bloodstream to cause hemoconcentration, shock and death. In nonfatal cases, hemolysis of erythrocytes has occurred with a resultant hemolytic anemia. The excretion of oxidized products into the bile by the liver produces focal necrosis of that organ, necrosis of the mucosa of the biliary passages with periobiliary hemorrhages, and some injury to the intestinal mucosa. Acute systematic poisoning from large skin burns cause's pulmonary edema, diarrhea restlessness, weakness, subnormal temperature, and low blood pressure in animals.

Chronic Exposure: Lewisite can cause sensitization and chronic lung impairment. Also, by comparison to agent mustard and arsenical compounds, it can be considered as a suspected human carcinogen.

Emergency And First Aid Procedures:

Inhalation: Hold breath until respiratory protective mask is donned. Remove from the source **Immediately**. If breathing is difficult, administer oxygen. If breathing has stopped, give artificial respiration. Mouth-to-mouth resuscitation should be used when approved mask-bag or oxygen delivery systems are not available. Do not use mouth-to-

mouth resuscitation when facial contamination is present. Seek medical attention **Immediately**.

Eye Contact: Speed in decontaminating the eyes is absolutely essential. Remove the person from the liquid source, flush the eyes **Immediately** with water for at least 15 minutes by tilting the head to the side, pulling the eyelids apart with the fingers and pouring water slowly into the eyes. Do not cover eyes with bandages but, if necessary, protect eyes by means of dark or opaque goggles. Transfer the patient to a medical facility **Immediately.**

Skin Contact: Don respiratory protective mask. Remove the victim from agent sources immediately. **Immediately** wash skin and clothes with 5% solution of sodium hypochlorite or liquid household bleach within one minute. Cut and remove contaminated clothing, flush contaminated skin area again with 5% sodium hypochlorite solution, then wash contaminated skin area with soap and water. Seek medical attention **Immediately**.

Ingestion: Do not induce vomiting. Give victim milk to drink. Seek medical attention **Immediately.**

Section VI - Reactivity Data

Stability: Stable in steel or glass containers at temperatures below 50 °C

Incompatibility: Corrosive to steel at a rate of 1×10^{-5} to 5×10^{-5} in/month at 65 °C

Hazardous Decomposition Products: Reasonably stable; however, in presence of moisture, it hydrolyses rapidly, losing its vesicant property. It also hydrolyses in acidic medium to form HC1 and non-volatile (solid) chlorovinylarsenious oxide, which is less vesicant than Lewisite. Hydrolysis in alkaline medium, as in decontamination with alcoholic caustic or carbonate solution or DS2, produces acetylene and trisodium arsenate (Na_3 As 0_4). Therefore, decontaminated solution would contain toxic arsenic.

Hazardous Polymerization: Does not occur.

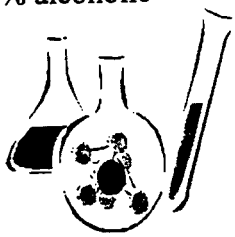
Section VII - Spill, Leak, And Disposal Procedures

Steps To Be Taken In Case Material Is Released Or Spilled: If leaks or spills of L occur only personnel in full protective clothing will be allowed in the area (See Section VIII). See Section V for

emergency and first aid instructions.

Recommended Field Procedures: Lewisite should be contained using vermiculite, diatomaceous earth, clay, or fine sand and neutralized as soon as possible using copious amounts of alcoholic caustic, carbonate, or Decontaminating Agent (DS2). Caution must be exercised when using these decontaminates since acetylene will be given off. Household bleach can also be used if accompanied by stirring to allow contact. Scoop up all material and place in a DOT approved container. Cover the contents with decontaminating solution as above. After sealing, the exterior decontaminated and labeled according to EPA and DOT regulations. All leaking containers will be over packed with sorbent (e.g. vermiculite) placed between the interior and exterior containers. Decontaminate and label according to EPA and DOT regulations. Dispose of decontaminate according to Federal, state, and local laws. Conduct general area monitoring to confirm that the atmospheric concentrations do not exceed the airborne exposure limits (See Sections II and VIII).

Recommended Laboratory Procedures: A 10 wt.% alcoholic sodium hydroxide solution is prepared by adding 100 grams of denatured ethanol to 900 grams of 10 wt.% NaOH in water. A minimum of 200 grams of decon is required for each gram of L. The decon and agent solution is agitated for a minimum of one hour. At the end of the hour the resulting pH should be checked and adjusted to above 11.5 using additional NaOH, if required. It is permitted to substitute 10 wt.% alcoholic sodium carbonate made and used in the same ratio as the NaOH listed above. Reaction time should be increased to 3 hours with agitation for the first hour. Final pH should be adjusted to above 10. Scoop up all material and place in an approved DOT container. Cover the contents with decontaminating solution as above. The exterior of the container will be decontaminated and labeled according to EPA and DOT regulations. All leaking containers will be over packed with sorbent (e.g., vermiculite) placed between the interior and exterior containers. Decontaminate and label according to EPA and DOT regulations. Dispose of the material in accordance with waste disposal methods provided below. Conduct general area monitoring with an approved monitor to confirm that the atmospheric concentrations do not exceed the airborne exposure limits (See Sections II and VIII).



It is permitted to substitute 5.25% sodium hypochlorite for the 10% alcoholic sodium hydroxide solution above. Allow one hour with agitation for the reaction. Adjustment of the pH is not required. Conduct general area monitoring to confirm that the atmospheric concentrations do not exceed the airborne exposure limit (See Section VIII).

Waste Disposal Method: All neutralized material should be collected and contained for disposal according to land ban RCRA regulations or thermally decomposed in an EPA permitted incinerator equipped with a scrubber that will scrub out the chlorides and equipped with an electrostatic precipitator or other filter device and containerize and label according to DOT and EPA regulations. The arsenic will be disposed of according to land ban RCRA regulations. Any contaminated materials or protective clothing should be decontaminated using alcoholic caustic, carbonates, or bleach analyzed to assure it is free of detectable contamination (3X) level. The clothing should then be sealed in plastic bags inside properly labeled drums and held for shipment back to the DA issue point.

Note: Some decontaminate solutions are hazardous waste according to RCRA regulations and must be disposed of IAW those regulations.

Section VIII - Special Protection Information

Concentration	Respiratory Protective Equipment
< 0.003 mg/m^3	A full face piece, chemical canister, air-purifying protective mask will be on hand for escape. M40-series masks are acceptable for this purpose. Other masks certified as equivalent may be used.
> or = 0.003 mg/m^3 or unknown	NIOSH/MSHA approved pressure demand full face piece SCBA suitable for use in high Lewisite concentrations with protective ensemble (See DA Pam 385-61 for examples).

Ventilation

Local Exhaust: Mandatory. Must be filtered or scrubbed. Air emissions shall meet local, state and federal regulations.

Special: Chemical laboratory hoods will have an average inward face velocity of 100 linear feet per minute (lfpm) ±20% with the velocity at any point not deviating from the average face velocity by more than 20%. Existing laboratory hoods will have an inward face velocity of 150 lfpm ±20%. Laboratory hoods will be located such that cross drafts do not exceed 20% of the inward face velocity. A visual performance test using smoke producing devices will be performed in assessing the ability of the hood to contain Lewisite.

Other: Recirculation of exhaust air from agent areas is prohibited. No connection between agent area and other areas through the ventilation system is permitted. Emergency backup power is necessary. Hoods should be tested semiannually or after modification or maintenance operations. Operations should be performed 20 centimeters inside hoods.

Protective Gloves: Butyl Rubber gloves M3 and M4
Norton, Chemical Protective Glove Set

Eye Protection: As a minimum, chemical goggles will be worn. For splash hazards use goggles and face shield.

Other Protective Equipment: For laboratory operations, wear lab coats, gloves and have mask readily accessible. In addition, daily clean smocks, foot covers, and head covers will be required when handling contaminated lab animals.

Monitoring: Available monitoring equipment for agent Lewiste is the M18A2 (yellow band), bubblers (arsenic and GC method), and M256 and A1 kits.

Real-time, low-level monitors (with alarm) are required for Lewisite operations. In their absence, an Immediately Dangerous to Life and Health (IDLH) atmosphere must be presumed. Laboratory operations conducted in appropriately maintained and alarmed engineering controls require only periodic low-level monitoring.

Section IX - Special Precautions

Precautions To Be Taken In Handling And Storing: When handling agents, the buddy system will be incorporated. No smoking, eating, or drinking in areas containing agents is permitted. Containers should be periodically inspected for leaks, (either visually or using a detector kit). Stringent control over all personnel practices must be exercised. Decontaminating equipment will be conveniently located. Exits must be designed to permit rapid evacuation. Chemical showers, eyewash stations, and personal cleanliness facilities must be provided.

Wash hands before meals and shower thoroughly with special attention given to hair, face, neck, and hands using plenty of soap and water before leaving at the end of the workday.

Other Precautions: L should be stored in containers made of glass for Research, Development, Test and Evaluation (RDTE) quantities or one-ton steel containers for large quantities. Agent will be stored in a single containment system within a laboratory hood or in a double containment system.

For additional information see "AR 385-61, The Army Toxic Chemical Agent Safety Program," "DA Pam 385-61, Toxic Chemical Agent Safety Standards," and "DA Pam 40-173, Occupational Health Guidelines for the Evaluation and Control of Occupational Exposure to Mustard Agents H, HD, and HT."

Section X - Transportation Data

Note: Forbidden for transport other than via military (Technical Escort Unit) transport according to 49 CFR 172

Proper Shipping Name: Toxic liquids, n.o.s.

Dot Hazard Class: 6.1, Packing Group I

Dot Label: Poison

Dot Marking: Toxic liquids, n.o.s.
Dichloro-(2-chlorovinyl)arsine UN 2810

Dot Placard: Poison

Emergency Accident Precautions And Procedures: See Sections IV, VII, and VIII.

Precautions To Be Taken In Transportation: Motor vehicles will be placarded regardless of quantity. Drivers will be given full information regarding shipment and conditions in case of an emergency. AR 50-6 deals specifically with the shipment of chemical agents. Shipment of agents will be escorted in accordance with AR 740-32.

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