***A**gent*
***C**haracteristics*
&
***T**oxicology*

***F**irst*
***A**id &*
***S**pecial*
***T**reatment*

ACT FAST

Second Edition

Student Manual

January 2001

TABLE OF CONTENTS

PURPOSE OF COURSE v
PREFACE vi

CHAPTER 1 AN INTRODUCTION TO THE STUDY GUIDE 1-1
1.1 Introduction 1-2
1.2 Orientation to ACT FAST Training 1-4

CHAPTER 2. BACKGROUND INFORMATION 2-1
2.1 General Information on the Chemical Stockpile 2-3

CHAPTER 3. LOCAL RESPONSE INFORMATION AND PROCEDURES 3-1
3.1 How To Use This Chapter 3-3
3.2 What You Should Know That IS NOT In This Study Guide 3-4
3.3 Local Community Response Procedures 3-5
3.4 Site Specific Information 3-6

CHAPTER 4. CHEMICAL AGENTS: CHARACTERISTICS AND EFFECTS 4-1
4.1 Nerve Agents: A Description 4-4
4.2 Blister Agents (Vesicants): A Description 4-14

CHAPTER 5. SIGNS AND SYMPTOMS 5-1
5.1 Signs and Symptoms of Nerve Agent Exposure 5-4
5.2 Signs and Symptoms of Blister Agent Exposure 5-17

CHAPTER 6. FIRST AID AND SPECIAL TREATMENT (FAST) 6-1
6.1 Protecting Yourself: Zones, PPE, and Decontamination 6-4
6.2 Nerve Agent Exposure: Initial First Aid Treatment 6-7
6.3 Blister Agent Exposure: Initial First Aid Treatment 6-17

APPENDIX A. SOURCE DOCUMENTS AND REVIEW PUBLICATIONS A-1

APPENDIX B. GLOSSARY B-1

APPENDIX C. MATERIAL SAFETY DATA SHEETS (MSDS)..... C-1

APPENDIX D. SELF CHECK ANSWERS D-1

Purpose of Course

The intent of the course is to instruct pre-hospital emergency medical personnel on how to care for patients that may have been exposed to chemical warfare agents and assumed to have already been decontaminated. This course is designed primarily for emergency medical technicians with basic life support credentials. These individuals are referred to in the text as pre-hospital emergency medical personnel.

Preface

We hope that you have the opportunity to participate in an in-class session. In fact, you are strongly encouraged to attend the class being offered for your area. By attending this class you will not only have a chance to discuss and ask questions about the information provided in this study guide, but you will also gain hands-on experience that cannot be obtained through the guide alone.

This Student/Self Study Guide was designed to accompany the in-class training sessions by providing you with all the essential information to be covered. However, if you are using this guide in a "self-study" mode, stringent efforts have been made to provide the available facts and information needed to ensure your personal safety and the well-being of the people you treat.

Although chances are you will never need to treat or decontaminate patients of the chemicals stored at the depots, your time in this effort will be well spent. The situations presented in this guide are worst case scenarios; they are not intended to suggest that release of chemicals is likely nor that injuries would occur in the event of a release. The evidence suggests otherwise. But, we believe in being prepared and want to help those of you who provide initial emergency medical care to prepare yourselves for that low-probability event.

In the years since the original Act Fast training materials were published, knowledge of the chemical warfare agents and understanding of their effects on the human body have advanced. In addition, procedures for treating civilian victims for exposure to the agents have been refined. This Second Edition of Act Fast has been developed to incorporate the latest knowledge and treatment techniques.

This training material is based on information from several expert sources. **Acknowledgement** is particularly owed to the following organizations:

- U.S. Army
  - Medical Research Institute of Chemical Defense
  - Program Manager for Chemical Demilitarization
  - Soldier Biological and Chemical Defense Command

- U.S. Public Health Service, Centers for Disease Control and Prevention
- Science Applications International Corporation
- Federal Emergency Management Administration

Oak Ridge National Laboratory

Students undertaking this course should have already completed several of the CSEPP training courses. These programmatic **prerequisites** are listed below. Your state and local CSEPP offices may have identified other prerequisites.

- Chemical Awareness
- Response Phase Decontamination
- Personal Protective Equipment
- Use of Auto-Injectors by Civilian Emergency Medical Personnel to Treat Civilians Exposed to Nerve Agent

CHAPTER 1 AN INTRODUCTION TO THE GUIDE

Objectives This chapter is designed to introduce you to the Student Manual. To a limited degree, it may be used for self-study. Unlike other chapters that support required learning objectives (what is expected of you after completing that chapter), this chapter does not cover nerve or blister agent information. Instead, it describes how this information is organized in the guide so that you can learn quicker and easier.

1.1 Introduction

What Is In This Chapter?

This chapter is your introduction to the study guide and organization of the topics that it covers: nerve and blister chemical agents and procedures for Emergency Medical Technicians (EMTs) and other pre-hospital emergency medical personnel responding to accidental releases.

The topics covered in this chapter are:

- Who Is This Book Written For?
- What Is The Purpose of This Book?
- Why is this Training Important?
- How Should This Study Guide Be Used?
- Relationship to this course to other training materials
- The Organization of the Subject-Matter Information:
  - Keyed Learning
  - Self-Checks
  - Final Quiz
  - Objectives

Why Is This Important?

Recent research reveals that learning is more efficient if a structure, or organizational framework, for the information to be learned is taught along with the information itself.

Putting this principle into practice, this guide provides you with a "blueprint" that shows the logical presentation of the information in addition to the actual information.

This chapter explains the blueprint-like structure for the information you are about to learn: First Response Treatment for Patients of Blister and Nerve Agent Chemical Exposure. This structure is provided to you by:

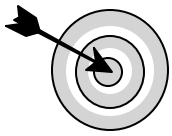
- introducing the guide in this first chapter,
- other features designed to keep your learning on target.

Learn This

A "Learn This" section is included in the introduction portion of each chapter. It tells exactly what is considered to be THE important information in that particular chapter.

Although there is no *medical subject-matter* covered in Chapter 1, it will help you when learning other chapters if you learn:

- how to use this guide
- how the "keyed learning feature" works.



It should not take long to realize that the Self-Check, or testing section, very closely resembles the "Learn This" of each chapter (they are almost identical). However, in Chapter 1, none of the information covered is "testable". Because it is introductory information only, there is no Self-Check section nor is material covered in Chapter 1 on the Final Quiz.

1.2 Orientation to ACT FAST Training

What Is The Purpose Of ACT FAST Training?

Simply put, the purpose of ACT FAST Training is:

Provide initial emergency treatment

> To prepare you to recognize signs and symptoms, and to provide initial emergency response treatment to patients injured by exposure to nerve and blister agents.

Because of the nature of these agents and the training required to support such a goal, there are other coincidental training needs to which this book may contribute, such as:

> To assist in preparing for hazardous materials emergencies.

Who Is This Book Written For?

This course is designed for all pre-hospital care providers and other pre-hospital emergency medical personnel in initial care and treatment of the sick and injured from a chemical warfare agent accident.

Why Is This Training Important?

First response: immediate

Chemical warfare agents act quickly. As an EMT, the actions you take in the first few minutes can mean the difference between life and death. Treatment must be immediate: there is no time to transport and have a doctor or emergency room staff take the initial actions.

ACT FAST

Because of the requirement for such immediate treatment, the course uses the acronym ACT FAST as its logo. It stands for Agent Characteristics & Toxicology: First Aid & Special Treatment.

How Should This Study Guide Be Used?

Classroom Training

reference guide

This study guide can be used as a reference guide for students attending the ACT FAST Course.

note taking

As you participate in this instructor-led class you can use this study guide to follow along and take notes as necessary. Your instructor will refer to portions of the guide as the class progresses so that you can follow along. The instructor's presentation and this study guide have been designed to coincide so that your note-taking can be minimized.

Self-Study

This guide can also be used for studying on your own because the book has been written to be used by an individual to study independently. For example, you may use the guide . . .

before class

- Before you attend the in-class session to do some pre-study on your own.

during class

- During the in-class session; as a guide for taking notes or to highlight information as the class progresses.

after class

- After you attend the in-class session; to keep as a reference and review resource.

Instead of attending class

- In place of attending the in-class session; as a self-study resource.

Of course, if you use this guide strictly for self-study, you will not have the benefit of the experience obtained through class sessions. For this reason, you should attend the class if at all possible.

How To Use This Guide For Self-Study

Read and study the information in each chapter in the order it is presented. Take extra time in the areas that have been marked on your Training Prescription Worksheet found in Section 3. These are the topics that the representative(s) from your area feel are most pertinent to you. In prescribing these areas, they have considered:

(1) what specific chemical agents are stored at your local storage location
(2) the emergency response resources available
(3) your background knowledge of the subject chemical agents

Relationship Of This Course To Other Training Materials

This course builds on several others that have been developed for CSEPP. Although these other courses contain information that is crucial to your ability to safely treat patients suffering from chemical agent exposure, their contents are not repeated in detail here. We recommend that, before beginning ActFast training, you complete the following CSEPP programmatic training courses:

- Chemical Awareness
- Response Phase Decontamination,
- Personal Protective Equipment, and
- Use of Auto-Injectors by Civilian Emergency Medical Personnel to Treat Civilians Exposed to Nerve Agent.

Your ability to provide the best treatment to chemical agent casualties while protecting yourself from exposure depends on the successful completion of all of these courses.

In addition, your state or local CSEPP offices may have identified other training courses or materials needed to prepare you for participating in the medical response to a chemical agent release. If so, your state or local CSEPP organizations will advise you of these additional training requirements.

How Is The Information In This Guide Organized?

This study guide is divided into six (6) chapters. You will notice that certain chapters have been identified as key chapters. The most important information in this study guide pertains to:

- the agents at the storage facility near you
- symptoms and treatment

Key Chapters

This important information is presented in the "Key Chapters"; they are Chapters 3, 4, 5, and 6.

Chapter 3. Local Response Information and Procedures
Chapter 4. Chemical Agents: Characteristics and Effects
Chapter 5. Signs and Symptoms
Chapter 6. First Aid and Special Treatment (FAST)

Other Chapters

Other chapters (1 and 2) are designed to help you learn the essential information from the Key Chapters:

Chapter 1. An Introduction to the Study Guide
Chapter 2. Background Information

How Can The Guide Help You To Learn ACT FAST?

Keyed Learning

The most significant feature used in this study guide is keyed learning. Its function is to assist you by helping you focus on the main points of the information you are about to learn.

Unlike an involved textbook, this study guide reveals immediately what must be learned in each area. This is done by calling to your attention three specific types of information at the beginning of each chapter and, as needed, at the beginning of each section within the chapter. The specific titles for these three types of information are:

"Objectives"
"Learn This"
"Why is This Important?"

These three titles are repeated throughout the guide. An explanation of each follows.

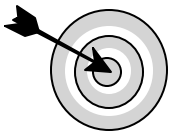
objectives

Objectives are shown on the title page for each chapter. They reveal the learning goal for each chapter; it is what you should expect to accomplish as a result of passing the Self-Check for that chapter. You need not wait until you reach the end of a chapter to ask yourself "Now, what was it I was supposed to learn from this chapter?" By reviewing the objectives for that chapter you will know exactly what to expect.

There are three (3) required objectives for ACT FAST. They are listed at the end of this chapter.

learn this

In addition to laying out your specific learning objectives you are also given the critical information before beginning each new topic. This information is contained under the title "Learn This" — you will notice it throughout the guide. It is accompanied by the bullseye icon shown below.



When designing this study guide the following question was asked of the subject-matter experts who gave advice pertaining to the content for each chapter:

"If a person reading this study guide got nothing else out of this chapter, what is it you want them to completely understand by the time they're finished?"

The answers they provided for each chapter are listed under the title "Learn This". As you can see, this can help you focus your attention on exactly what the experts have deemed is critical for a first responder to ACT FAST.

why is this important?

The last piece of information relating to a key learning feature explains why what you are about to learn is important. Think of it as your motivation key. Found under the title "Why is This Important", you will learn the significance of the material you are about to read. The importance of such material is related directly to the consequences that the information has to the required objective for that chapter. This information is accompanied by the key icon shown below.

The keyed learning feature should help you to keep the information you receive right on target. For efficient learning, we believe you should not have to separate information that is critical-to-know from information that is nice-to-know; it has been done for you in the design of this study guide.

How Will Learning Be Evaluated?

Self-Checks

To help you evaluate your progress, the Key Chapters are followed by a section called "Self-Check". It consists of short answer questions pertaining to the information covered in that chapter. Complete these self-checks after reviewing the material. Then, check your responses with those provided in Appendix E, Self-Check Answers.

Final Quiz

At the end of the class (or study guide if you are using the self-study mode) there is a quiz concerning all of the material in the key chapters. This quiz consists of selection-type questions. Note: The standard for this quiz will be set by the state.

Like the self-checks, this quiz is designed to ensure you have a solid understanding of the essential material. And don't worry—if you do well on the self-checks you'll do great on the final quiz.

What Are The ACT FAST Training Objectives?

The objectives of this training program are for you to be able to respond to an off-post scene involving an accidental release of one or more chemical warfare agents.

Specifically, at the end of this training program you should be able to:

required objectives

- Describe the initial first-aid treatment for victims of nerve agent exposure.
- Describe the initial first-aid treatment for victims of blister agent exposure.

In order to master these two objectives, you must be able to:

supporting objectives

- Describe the potential hazards of nerve agents: what they are, potential route of exposure, and how they work.
- Describe the potential hazards of blister agents: what they are, potential route of exposure, and how they work.
- Identify the signs and symptoms of nerve agent exposure.
- Identify the signs and symptoms of blister agent exposure.

Each objective is repeated at the beginning of each chapter where it is covered.

You should now be familiar with the organization and contents of this study guide.

CHAPTER 2 BACKGROUND INFORMATION

Objectives

The purpose of this chapter is to familiarize you with the background and perspectives of the chemical warfare agents.

Introduction

What Is In This Chapter?

This chapter provides a brief description of the U.S. chemical agent stockpile. A more complete discussion of this topic can be found in the Chemical Awareness course materials.

Why Is This Important?

This chapter is provided for your information only.

If you choose to do so, you may skip over this chapter and resume reading with Chapter 3, Local Response Information and Procedures. There are no questions on the Self-Check or Final Quiz regarding this section. However, in this chapter, you can find the answers to some interesting questions, such as:

"What is the "chemical stockpile?"
"Where is it located?"
"Why are we talking about it now?"

Learn This

- **The name of the agent(s) stored in your local facility.**

  Later, in Section 3.4 , you are asked to name the agent(s) that is (are) stored in your vicinity. This information can be found in Table 2.1, U.S. Army Chemical Stockpile Inventory.

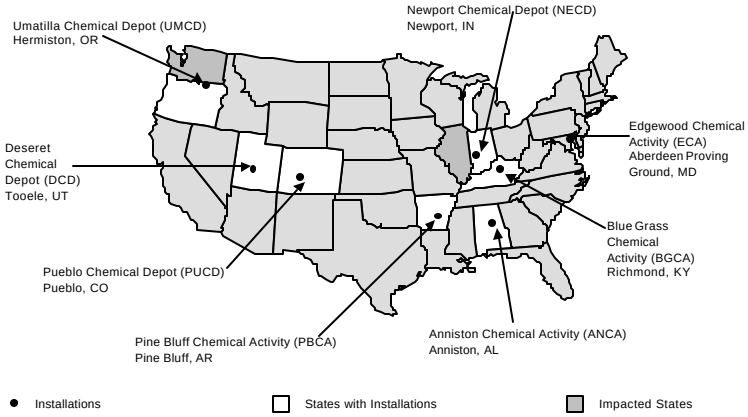
2.1 General Information on the Chemical Stockpile

What Is The "Chemical Stockpile"?

storage of agents

The U.S. Army currently has tons of chemicals stored that were designed and produced for the sole purpose of warfare. This stored material is referred to as the "chemical stockpile". The chemical stockpile is stored at eight locations in the continental U.S.

See Also: Appendix A, "Disposing of the U.S. Chemical Weapons Stockpile, An Approaching Reality, The Journal of the American Medical Association.



LOCATION OF CSEPP SITES

As shown in Table 2.1, the composition of the stockpile varies from location to location. The types of chemicals stored include nerve agents and blister (or vesicant) agents.

Table 2.1. U.S. Army chemical stockpile inventory

	Agent stored				
Installation	GA	GB	VX	Sulfur mustard	Lewisite
Anniston		X	X	X	
Blue Grass		X	X	X	
Deseret	X	X	X	X	X
Edgewood				X	
Newport			X		
Pine Bluff		X	X	X	
Pueblo				X	
Umatilla		X	X	X	

CHAPTER 3 LOCAL RESPONSE INFORMATION AND PROCEDURES

Objectives Identify local procedures and policies.

Introduction

Through this chapter, it is recognized that specific and unique information needs to be addressed at each individual training site. The purpose of this chapter is to provide you with a framework for the portion of the course that will be unique for your particular class.

Community needs and resources vary a great deal from one storage location to the next. Therefore, *your* input on how the emergency care elements in your community could best respond to a release with off-post consequences is important to the success of the program.

3.1 How To Use This Chapter

In Class

If you are attending a class, this chapter will be discussed in detail according to the needs and procedures applicable to your community. All members of your group are knowledgeable of certain local procedures, and will be asked to contribute to the discussion about them.

group discussion

Keep this discussion in mind as the class progresses. As the class discusses issues such as treatment, write down your concerns for how these procedures can be implemented at your location. Your instructor will return to this chapter at the end of the class and will ask for additional feedback pertaining to local procedures.

Your input to this chapter is very important.

Self-Study

If you are using this guide in a self-study mode, read through this chapter and fill in as many of the procedures as you are able for Section 3.3, Local Community Response Procedures. Also, complete Section 3.4, Site-Specific Information.

3.2 What You Should Know That IS NOT In This Study Guide

This study guide does not, and cannot, cover everything you need to know in preparation for your role. In short, you need to find out

- Who the local players are
- The roles and responsibilities of each
- The methods of response
- What supplies and equipment are on hand
- Standard operating procedures
- Memorandum of understanding or agreement

For general hazardous materials emergency planning, much of the information listed above may be included in a City/County Emergency Operations Plan (EOP). Particularly relevant are the section of the EOP dealing with emergency response under CSEPP and the section developed to meet the requirements of the Superfund Amendments and Reauthorization Act of 1986 (SARA), Title III: Emergency Planning and Community Right-to-Know (Public Law 99-499).

Additional guidance on recommended supplies and procedures may be found in *Chemical Accident or Incident Response and Assistance (CAIRA) Operations,* (DA PAM 50-6), a U.S. Army publication developed to help Army installations respond to and recover from a chemical incident.

Space has been provided for you to fill in the appropriate information (Sections 3.3 and 3.4). If you are attending the course, this will be discussed in class. If you are using this study guide for self-study, FEMA will provide additional information, or you may contact your local CSEPP coordinator. Some of the agencies you may also contact within your community are:

- Local emergency services
- Fire department or other emergency responders
- Ambulance service or other rescue services
- Hospital emergency department
- Local health department

3.3 Local Community Response Procedures

If an emergency occurs at the installation that could affect the off-post populations there will be many decisions required of the local community. All of these should be addressed during the planning process. They include but are not limited to:

- Where is the first notification (identification) expected to come from?
- Who, from the facility, is notified?
- Who, from the local community, is notified?
- Who is likely to be the first on the scene?
- What are the duties of the pre-hospital emergency medical personnel?
- What am I expected to do in this situation?
- Am I authorized in my state to administer antidotal medications (atropine, 2-PAM chloride)? Under what circumstances?

For additional information, contact the agencies listed in Section 3.2

3.4 Site-Specific Information

Agents Involved

The agent(s) stored at the local installation is/are:

Nerve Agents	**Blister Agents**
___ VX	___ Mustard
___ GA	___ Lewisite
___ GB	

Drugs Required:

_____
_____
_____
_____
_____
_____
_____
_____

Other Supplies:

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

Important Contacts

Name: _____
Day Phone: _____ Night Phone: _____
Position: _____

Name: _____
Day Phone: _____ Night Phone: _____
Position: _____
Name: _____
Day Phone: _____ Night Phone: _____
Position: _____

Name: _____
Day Phone: _____ Night Phone: _____
Position: _____

Name: _____
Day Phone: _____ Night Phone: _____
Position: _____

Name: _____
Day Phone: _____ Night Phone: _____
Position: _____

Name: _____
Day Phone: _____ Night Phone: _____
Position: _____

Name: _____
Day Phone: _____ Night Phone: _____
Position: _____
Name: _____
Day Phone:_____ Night Phone: _____
Position: _____
Name: _____
Day Phone:_____ Night Phone: _____
Position: _____

CHAPTER 4 CHEMICAL AGENTS: CHARACTERISTICS AND EFFECTS

Objectives

The required learning objectives for Chapter 4 are for you to be able to:

1. Describe the potential hazards of nerve agents: what they are, potential routes of exposure, and how they work.

2. Describe the potential hazards of blister agents: what they are, potential routes of exposure, and how they work.

3. Describe the most likely route of exposure.

Introduction

What Is In This Chapter?

The information presented here is designed to familiarize you with the types of chemical agents that are located in your vicinity. This chapter is divided into two sections which describe general characteristics of nerve and blister agents. The topics covered in this chapter are

4.1 Nerve Agents: A Description
- a. specific names
- b. physical properties
- c. mechanisms of action
- d. routes of exposure

4.2 Blister Agents (Vesicants): A Description
- a. specific names
- b. physical properties
- c. mechanisms of action
- d. routes of exposure

Why Is This Important?

By learning what the chemical agents are, what they look like, and their physical properties, you will be equipped with the knowledge you need to understand how to treat patients and protect yourself.

Before studying how to treat patients, it is necessary to understand a little about the agents themselves. Thus, Chapter 4, Chemical Agents: Characteristics and Effects, centers on (1) what the agents are called, (2) their physical properties, and (3) how they affect the body. Understanding this information will help you learn how to treat patients exposed to blister and nerve agents.

Learn This

The most important points for you to learn from this chapter are:

- Nerve agents:

  a. are stored as liquids (one is oily) that generate extremely toxic vapors
  b. can be absorbed through the skin and spread by direct contact (touch), inhalation (breathing of contaminated air), and ingestion (eating or drinking)

- Blister agents:

  a. are stored as solids or liquids (thick and oily), but can generate toxic vapors
  b. can be absorbed through the skin and spread by direct contact (touch), inhalation (breathing of contaminated air), and ingestion (eating or drinking)

- Most likely route of exposure pre-hospital emergency medical personnel should be prepared for is:

  inhalation of contaminated air

As these points are discussed in this chapter, you may see pieces of information that pertain to treatment. Don't worry about this for now; you are not expected to learn how to protect or treat as part of studying this chapter; this information is described later. For now, concentrate on the points listed on the previous page.

4.1 Nerve Agents: A Description

Toxic chemicals that are classified as “nerve agents” are so called because they are capable of attacking the body's nervous system.

organophosphates

The term “organophosphate” is the scientific classification that describes a group of compounds that inhibit cholinesterase, a naturally occurring enzyme that is important to normal nervous system function.

Specific Names

VX, GB, GA

While the term “nerve agent” refers to a particular form of toxic chemical, there are specific common and chemical names that are associated with this group. They are: VX, GB, and GA. (GA is in the Stockpile only at Deseret).

Abbreviation	Common Name	Referred To As:
VX		VX
GB	Sarin	GB or G-agent
GA	Tabun	GA or G-agent

When the term “nerve agent” is used in this course it refers to all of the agents (VX, GB, GA) unless an agent is specifically mentioned.

See Also: Appendix C, Material Safety Data Sheets

If you are interested in learning more about the different nerve agents, Material Safety Data Sheets (MSDS) are available in Appendix C. They provide technical details on the chemical formulas, structure, names, and physical data. However, this course does not require that you know about nerve agents to that level of detail.

Physical Properties

liquids

In their normal state, nerve agents are liquids. These liquids are volatile —they generate vapors. It is the vapor form of agent that has the greatest potential of being released in the event of an accident. There may also be some potential for agent being released as an aerosol. Once in a vapor or aerosol form and mixed with the outside air, the agent may move from the storage location.

The physical characteristics of nerve agents are described in some detail in the student guide for the Chemical Awareness course. The major physical properties of these agents are summarized in Table 4.1.

Table 4.1 Nerve Agent Comparative Data

Comparative Data	GA	GB	VX
Rate of Action	Very rapid	Very rapid	Rapid
State at 68°F	Colorless to brown liquid	Colorless liquid	Colorless or pale amber liquid
Odor	Faintly fruity; none when pure	Almost none when pure	Odorless when pure
Volatility (mg/m^3 at 77°F)	490	22,000	8.9
LCt_{50} ($mg\text{-}min/m^3$) (human)[a]	135	70	30
Vapor density (x air)	5.59	4.83	9.20
Vapor pressure (mm HG at 77°F)	0.057	2.9	0.00063

[a] LCT_{50} - median lethal inhalation dosage; the calculated inhalation dosage (airborne concentration of the agent multiplied by the time period of exposure) that is lethal to 50% of exposed personnel or animals. The unit used to express LCT_{50} is milligram-minutes per cubic meter ($mg\text{-}min/m^3$). Assumed inhalation rate is 15 L/min.

Source: U.S. Army Soldier Biological and Chemical Command, Material Safety Data Sheet, SBCCOM Online, http://in1.apgea.army.mil:80/RDA/msds/index.htm, Aberdeen Proving Ground, MD (October 1999); U.S. Department of the Army. Chemical Agent Data Sheets, Vol. 1, EO-SR-74001, Edgewood Arsenal Special Report, Defense Technical Information Center, Alexandria, VA (December, 1974); C. J. Dick, Soviet Chemical Warfare Capabilities, Internal Defense Review 1, reprinted as pp. 1 in Selected Readings in Nuclear, Biological and Chemical Operations, U. S. Army Command and General Staff College, Ft. Leavenworth, Kansas (1984).

Mechanisms of Action

Why Is This Important?

In emergency first-aid training emphasis is placed on learning the "why"s in addition to the "how to"s. EMTs and other pre-hospital emergency medical personnel are accustomed to not only learning specific procedures but also (to some degree) how the injury or trauma affects the normal physiological functions of the human body. In most instances, this knowledge is fundamental or prerequisite to the level of understanding required for making critical, life-dependent decisions. It is from this perspective that the following information is presented describing how the nerve agents act on the body.

How Nerve Agents Work

The nervous system controls body functions through the use of chemicals which act as "instructions" to nerves and to the muscles and glands. These "instructions" come in two forms: stimulate (move or work) and relax (stop or rest).

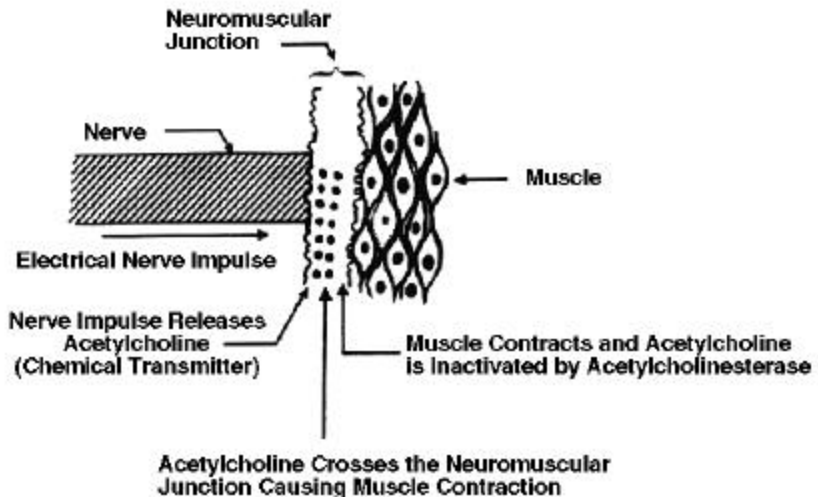
When a nerve agent is present it interferes with the normal chemical instructions that direct the muscle (or gland) to return to an un-stimulated state and relax or rest.

muscles are stimulated continually

By interfering with the normal chemical check and balance, the action of toxic nerve agents overstimulates the nerve endings and central nervous system. Over-stimulation of the nervous system causes muscles and certain glands to over-react and the various body organs to malfunction.

A More Technical Version of How Nerve Agents Work

While the preceding explanation was greatly simplified, the following explanation is slightly more technical. It begins with an explanation of the reaction which normally occurs at a nerve ending and then describes how the nerve agent affects this process.



ACT061B Source: U.S. Army, Navy, and Air Force, Feb. 1990, *Field Manual for Treatment of Chemical Agent Casualties and Conventional Military Chemical Injuries.*

normal nerve ending physiology

Nerves control muscles and organs; the nerve itself is made up of nerve cells that do not directly contact each other. Nerve impulses are relayed between nerve cells at a synapse (gap between the cells) by means of neurotransmitters. This is also how nerve impulses travel between nerves to a muscle or gland.

In normal nervous system function, when the impulse is transmitted between nerve cells, a neurotransmitter (called acetylcholine) is released, which transmits the signal between cells.

nerve agent interference

Once the neurotransmitter acts on the target cell receptor site, the enzyme acetylcholinesterase deactivates the acetylcholine. Stimulation of the target nerve, muscle, or gland cell stops with deactivation of the acetylcholine.

However, nerve agents inactivate acetylcholinesterase, allowing excess acetylcholine neurotransmitter to accumulate and continue to stimulate receptor sites on the target nerve cell, muscle, or gland.

If the affected nerve is stimulating a muscle, the muscle action becomes uncontrolled and a series of twitches or jerks may be seen.

Eventually, if the process is not interrupted, the muscle can go into a prolonged contraction and become fatigued, or even collapse.

If the affected nerve is stimulating a gland, the result could be increased sweating, tearing, or mucus production in the respiratory passages.

(A continuation of this sequence, describing the actions of the antidotes—atropine and 2-PAM chloride—is provided in Chapter 6.)

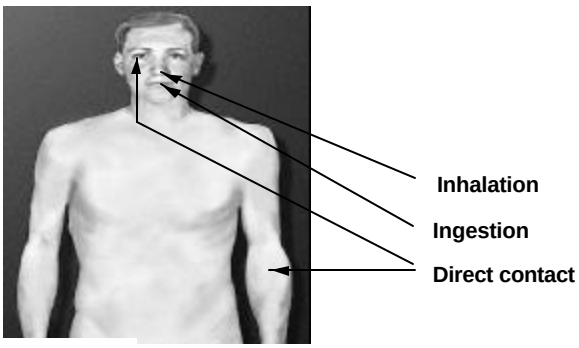
Routes of Exposure

There are three main routes, or ways that a person can be exposed to a nerve agent. They are:

Routes of Exposure:

inhalation	- breathing air that has been contaminated with nerve agent vapors
direct contact	- absorption through the skin or eyes
ingestion	- swallowing contaminated food or drink

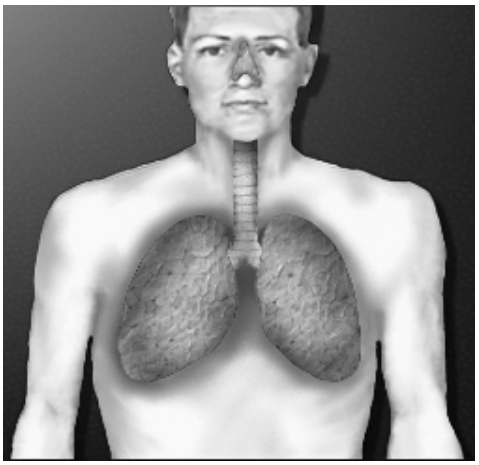
A more descriptive explanation of each follows.



Inhalation

Although the nerve agents begin as a liquid, they are easily changed into vapors. These vapors mix freely with the air. If a person breathes in the contaminated air, the toxic chemical enters the body through the respiratory system.

respiratory system



After the nerve agent has entered the lungs it is generally absorbed rapidly and effectively into the blood stream. This is because of the large surface area of the lung tissue and the number of blood vessels in the lungs. The chief cause of death due to nerve agent exposure, from any route, is respiratory failure.

chief cause of death: respiratory failure

Direct Contact

Direct contact occurs when the skin or eyes come into immediate proximity with agent vapor or liquid. It is through this route that contamination from one patient to another is possible.

Nerve agents have no effect on the skin; rather, the nerve agent is absorbed through the skin. Once penetration has occurred, the nerve agent is circulated to the nervous system. Concentrated vapor, or mist can also penetrate skin tissue in the same way the liquid does.

skin absorbency

All of the nerve agents (VX and G-agents) can be absorbed through the skin; however, agent VX tends to be absorbed much more completely because it does not evaporate as quickly. The persistency of VX causes it to remain on the skin, thus allowing more absorption time. It penetrates slowly compared to GB; thus immediate decontamination is of potentially great importance. This is why, during the decontamination process, the patient's clothing must be removed completely.

VX: absorbs completely

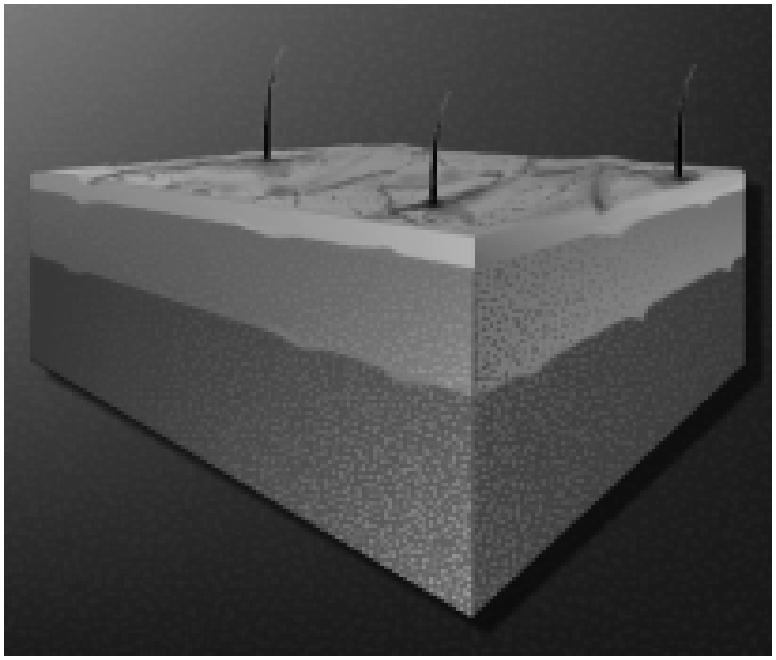
VX is “highly persistent”; it does not volatilize or degrade rapidly. VX persistence is weather-dependent. At 99°F, 90% of a VX droplet will evaporate in approximately 24 hours; at 50°F, the passage of 45 days would be required before 90% of a VX droplet would evaporate.

G-agents: evaporate more quickly

The more watery G-agents, on the other hand, have a tendency to evaporate quickly. Agent GB, in particular, tends to evaporate off the skin quickly rather than penetrate it. Cases of GB poisoning have occurred from skin exposure to liquid agent. Skin exposure to GB vapor can also result in poisoning, but only at concentrations higher than those that produce severe inhalation effects.

skin

Absorbed through the skin, the agent begins to affect the normal chemical neurotransmission process that occurs between the nerves and muscles or glands. This is one reason chemical protective gloves must be worn to protect your hands while treating patients.



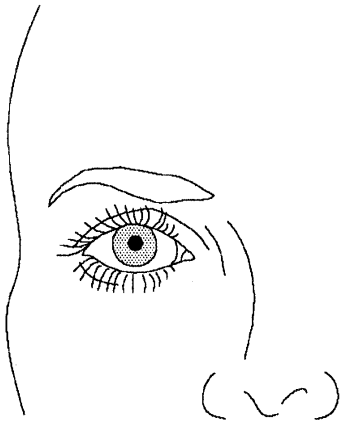
in the presence of other wounds

On normal, intact skin, nerve agent must first pass through a layer of dead cells and the epidermis before reaching the capillaries (bloodstream) and nerve cells found in deeper tissue layers. If a volatile G-agent is involved, evaporation may be complete before a significant dose can be absorbed. However, scrapes or cuts or other damage present immediate entry points for the nerve agent and facilitate direct access to the bloodstream and nervous system.

Increased skin permeability is a concern for skin conditions that are not commonly thought of as "wounds". For example, freshly shaven skin, sunburn, insect bites, and rashes are all examples of immediate entry points for nerve agents.

eyes

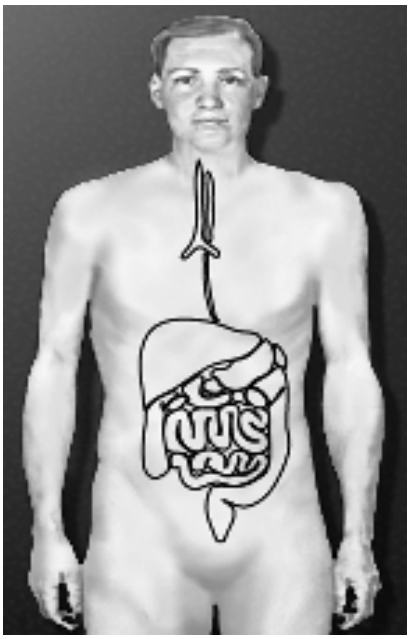
Agent also enters the body very effectively through the eyes. It is important to protect the eyes from exposure to vapors or aerosols. The eye is the most sensitive organ system for nerve agent effects. Threshold dose for miosis is the basis for both VX and GB exposure standards.



Ingestion

If an individual ingests contaminated food or drink, the nerve agent can enter the body through the digestive system. Incidental hand-to-mouth contact, smoking, and swallowing are all examples of potential sources of exposures by this route.

route of entry:
ingestion



Once the nerve agent has entered the body by way of the digestive system, access to the bloodstream can occur. Although the likelihood of the agent contaminating food or drink is extremely slim, you should be aware that it is possible for someone to become exposed through ingestion. Common sense precautions dictate that:

- absolutely no food or beverages should be kept in or around treatment areas, and

- when treating or caring for patients, do not give anything by mouth.

Critical Route of Exposure

A chemical agent release is most likely to affect surrounding communities if agent vapors or aerosols are transported in an airborne plume. For this reason, experts have recommended that you be well prepared to handle exposures that have been caused through atmospheric transport of contamination.

Therefore, you should be most concerned with the routes of exposure that can occur through air, especially inhalation of agent vapors or aerosols. It is much less likely that you will encounter casualties who have ingested chemical agent or come into direct contact with agent in liquid form.

4.2 Blister Agents (Vesicants): A Description

Vesicants are poisons that destroy individual cells in target tissues. The most noticeable effect that these agents have is the "vesicles," or blisters, they cause. For this reason, these types of agents are also referred to as “blister agents”.

Since most people are familiar with the lay term, this study guide uses the term “blister” to describe this category of chemical agent.

Specific Names

While the term “blister agent” refers to a particular action of chemical warfare agents, there are specific common names and abbreviations that are associated with this group.

mustard
Lewisite

Common Name	Abbreviation
Mustard	H, HD, HT
Lewisite	L

Although the Lewisite agent is in the blister agent family, there is very little of this chemical remaining and it is all stored at Deseret Chemical Depot.

See Also: appendix C, Material Safety Data Sheets

If you are interested in learning more technical information about the blister agents, MSDS are available in the appendix. They provide technical details on the chemical formulas, structure, names, and physical data. However, this course does not require that you know about blister agents to that level of detail.

Physical Properties

solid or liquid

In their normal state, mustard blister agents are either solids or liquids. They solidify at fairly high temperatures (13°–15°C or 55°–59°F). If they are heated, these liquids are volatile—they generate vapors. Mustard agent is an oily liquid that burns well once ignited.

The physical characteristics of blister agents are described in some detail in the student guide for the Chemical Awareness course. The major physical properties of these agents are summarized in Table 4.2.

Table 4.2 Blister Agent Comparative Data

Comparative Data	H	HD	HT	L
Rate of Action[a]	Moderately rapid	Moderately rapid	Moderately rapid	Rapid
State of 68°F	Amber to dark brown	Oily, amber to black liquid; water clear if pure	Viscous, clear to pale yellow liquid	Amber to dark brown liquid; colorless oily liquid when pure
Odor	Garlic-like	Garlic-like	Garlic-like	Geranium-like; little odor when pure
Volatility (mg/m^3 at 77°F)	910	910	831	2500 (at 68°F)
LCt_{50} ($mg\text{-}min/m^3$) (human)[b]	Similar to HD	1500	Not established	1200—1500
Vapor density (x air)	5.5	5.5	6.9	7.1
Vapor pressure (mm Hg at 77°F)	0.11	0.11	0.10	0.35

[a]Cellular damage from mustard exposure within minutes; pain, blisters, etc. not manifest for several hours or more (long latent period). Lewisite exhibits little or no latent period.

[b]LCt_{50} - median lethal inhalation dosage; the calculated inhalation dosage (airborne concentration of the agent multiplied by the time period of exposure) that is lethal to 50% of exposed personnel or animals. The unit used to express LCt_{50} is milligram-minutes per cubic meter ($mg\text{-}min/m^3$). Assumed inhalation rate is 15 L/min.

Sources: U.S. Army Soldier Biological and Chemical Command, Material Safety Data Sheet, SBCCOM Online, http://in1.apgea.army.mil:80/RDA/msds/index.htm, Aberdeen Proving Ground, MD (October, 1999); U.S. Department of the Army, Chemical Agent Data Sheets, Vol. 1, EO-SR-74001, Edgewood Arsenal Special Report, Defense Technical Information Center, Alexandria, VA (December, 1974); C. J. Dick, Soviet Chemical Warfare Capabilities, Internal Defense Review 1, reprinted as pp. 1 in Selected Readings in Nuclear, Biological and Chemical Operations, U. S. Army Command and General Staff College, Ft. Leavenworth, Kansas (1984).

Mechanisms of Action

How Blister Agents Work

Blister agents can affect any skin tissue, but are especially harsh to warm, moist surfaces of the body and to delicate tissues such as the soft membranes surrounding the eyes, the eyeball, lung tissue, and tissues of the mouth and throat. Both the liquid itself and the vapors generated from mustard create an extreme hazard. The greater the absorbed dose of either, the greater the damage.

damage to cell membrane

Mustard agent is a cellular poison; cell membranes are damaged within minutes after exposure. Severity of skin and tissue damage is highly dose-dependent.

delayed reaction

See also: Section 5.2, Signs and Symptoms of Blister Agent Exposure

See Also: Section 6.2, Blister Agent Exposure: Initial First Aid Treatment

The delayed reaction is what makes mustard blister agents insidious. There is little or no pain at the time of exposure. The development of clinical signs such as burning, stinging, redness or blisters is usually delayed between 2 and 24 hours, occasionally even up to 36 hours.

Routes of Exposure

Why Is This Important?

A critical step in the treatment of patients of blister agent exposure is to decontaminate. Since mustards are also carcinogenic agents (capable of causing cancer), it is doubly critical that the patient be decontaminated quickly and thoroughly. In order to do this, you must understand how the blister agent is capable of entering the body. By knowing this, you are better able to treat the patient and provide protection for yourself and others.

The warfare function of the blister agents is to decrease the opponent's ability to fight by producing chemical burns on tissues that come into contact with either vapors or liquid droplets/aerosols. Exposed skin surfaces, eyes, the respiratory tract, and upper gastrointestinal tract are all at risk. The moist surfaces of perspiring skin, conjunctiva of the eye, and airway mucous membranes preferentially absorb mustard agent and distribute it over a larger area. The unprotected eye is considered the most sensitive organ to the action of H-agents, and ambient temperature and humidity govern the degree of "casualty effect". Under hot, humid conditions when large areas of skin are likely to be wet with perspiration, much lower mustard concentrations generate debilitating effects.

eye most sensitive

See Also: section 5.2, Signs and Symptoms of Blister Agent Exposure

Section 6.2, Blister Agent Exposure: Initial First Aid treatment.

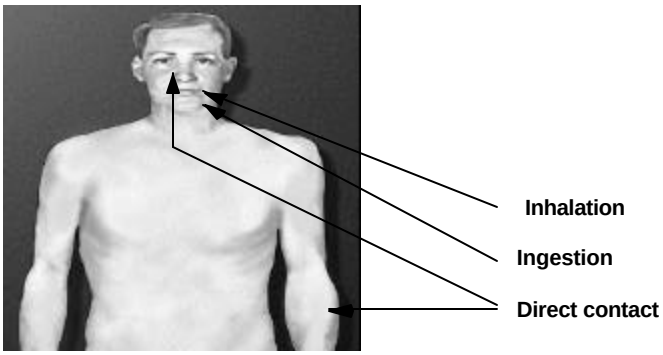
Routes of Exposure:

There are three main routes, or ways that a person can be exposed to a blister agent. They are:

inhalation - breathing air that has been contaminated by vapors or droplets of blister agents

direct contact - agent contact with skin, mucous membranes, or eyes

ingestion - swallowing contaminated food or drink



A more descriptive explanation of each follows.

Inhalation

Although the blister agents may be stored as liquids, they are easily changed into vapors which may be inhaled. These vapors mix freely with the air. If a person inhales the contaminated air the toxic chemical enters the body through the respiratory system.

vesicant effects

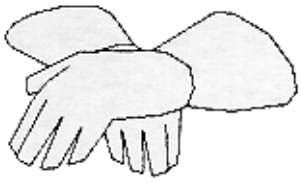
Once inhaled, the blister agents also have direct access to the lining of the nose, the throat, and the bronchial tubes. These warm, moist membranes are particularly vulnerable to the effects of the mustard agent. With prolonged exposure, the mustard agent destroys the mucous membrane lining—just as skin blisters damage the outer layer of skin—causing internal inflammation and hemorrhage and allowing the airways and lungs to become infected. Blister agents do most damage to the upper airways, but with a heavy exposure, the air sacs in the lungs can be injured and filled with fluids.

Direct Contact

Direct contact occurs when any skin surface or the eye touches the liquid agent or touches a surface on which the agent has been deposited. It is through this method that contamination from one patient to another is highly possible unless strict decontamination procedures have been followed.

highly damaging to skin

Unlike nerve agents, blister agents are highly damaging to the skin. This is one reason that chemical protective gloves must be worn to protect your hands while treating patients.



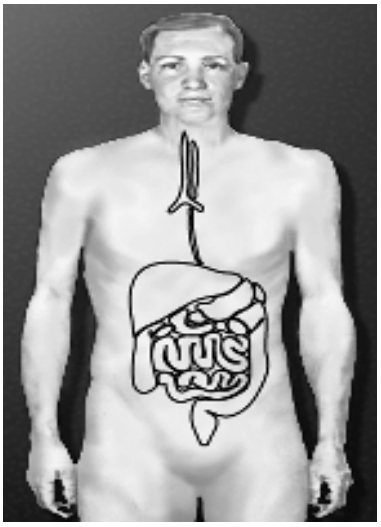
Blister fluid is non-irritating and does not cause vesication upon contact with skin.

warm, moist membranes

Warm, moist membranes are very susceptible to the effects of blister agents. Those membranes include the lining around the eyelids, the inside of the mouth and nose. Since warmth and moisture increase the blister agent's effect, other body areas are particularly susceptible to severe blistering. Examples of these areas are: between the toes, behind the knees, the buttocks, the groin, elbows, the arm pits, folds of the neck, and behind the ears.

Ingestion

If blister agent has been deposited on or in food items, drink, or anything that a person may place in the mouth (e.g., cigarettes), the agent can injure the warm, moist tissues of the mouth, throat, and esophagus. Incidental hand-to-mouth contact, smoking, and swallowing airborne contaminants are examples of this exposure route.



Although the likelihood of the agent contaminating food or drink is small, you should be aware that it is possible for someone to become exposed through ingestion. Common sense dictates that:

- absolutely no food or beverages should be kept in or around treatment areas, and
- when treating or caring for patients, do not give anything by mouth.

Critical Route of Exposure

A chemical agent release is most likely to affect surrounding communities if agent vapors or aerosols are transported in an airborne plume. For this reason, experts have recommended that you be well prepared to handle exposures that have been caused through atmospheric transport of contamination.

Therefore, you should be most concerned with the routes of exposure that can occur through air, especially inhalation of agent vapors or aerosols. It is much less likely that you will encounter casualties who have ingested chemical agent or come into direct contact with agent in liquid form.

Lewisite

Lewisite (L) is a different type of blister agent that exists in the stored chemical stockpile only at Deseret Chemical Depot. It is

chlorovinyldichloroarsine, an organic arsenical, which causes immediate pains upon skin or eye contact. Thus, Lewisite is unlike the mustards that cause little or no pain at the time of exposure.

Lewisite is a suspected carcinogen.

Physical Properties

Lewisite may be an amber to brown liquid; however, it is colorless when pure. It is approximately 10 times more volatile than mustard and often has an irritating, fruity or geranium-like odor. There is little odor when the compound is pure. It is persistent in the environment, and is much more dangerous as liquid than as vapor. Liquid will cause severe burns of the eyes and skin.

Self-Check

Assess your understanding of the material presented in this chapter by completing the following Self-Check.

Multiple Choice

4.1 Toxic chemicals that are categorized as “nerve agents” are so called because

a. they disrupt the body’s nervous system
b. the agent is essential to the nervous system
c. they send “electrical” shooting pains throughout the nervous system
d. the blisters they cause are extremely painful to the nerve endings in the skin tissue

4.2 The specific nerve agents currently in the U.S. Army’s chemical stockpile inventory are:

a. VX and mustard
b. VX, mustard and Lewisite
c. VX, GB, and GA
d. Lewisite and GB

4.3 In their normal state, nerve agents are

a. gas
b. solid
c. vapor
d. liquid

4.4 Nerve agents affect the nervous system by

a. killing off the nerve cells
b. making the central nervous system shut down
c. blocking the messages sent to the nerve, muscle and gland cells
d. inactivating acetylcholinesterase, thus causing the nerve endings to over-stimulate the nerve/muscle/gland

4.5 A person can be exposed to a nerve agent through

a. touching a surface that has the nerve agent on it
b. inhalation of air that has been contaminated by a nerve agent
c. eating or drinking anything that has been contaminated by a nerve agent
d. all of the above routes

4.6 The nerve agent VX is described as "highly persistent". This means that

a. the agent is only very slightly degraded by the environment over a long period of time
b. even if an exposed person is treated immediately the effects never go away
c. it is so watery that it washes away easily with the correct treatment
d. a spill is more potent after several days than the first day

4.7 Which of the following skin descriptions presents the most critical condition for inducing nerve agent effects?

a. hairy chest
b. eyes behind goggles
c. hand wearing a glove
d. forearm with cuts and abrasions

4.8 Toxic chemicals that are categorized as "blister agents" are so called because

a. an inevitable side-effect caused by the drug antidote for this agent has been known to cause blisters in most people
b. the most noticeable effects are blisters and the destruction of cells in target tissues
c. they cause the body to breakout in painless sores that resemble tiny chicken pox-like blisters
d. it was named after the chemist who discovered its potential wartime use

4.9 The specific blister agents currently in the U.S. Army's chemical stockpile inventory are:

a. VX and mustard
b. VX, GA, and GB
c. mustard and Lewisite
d. VX, mustard and Lewisite

4.10 In their normal state, blister agents are

a. liquid or solid
b. aerosols
c. vapor
d. gas

4.11 It is often difficult to detect an exposure to a mustard agent immediately because

a. the signs and symptoms are delayed
b. the blister does not form for several weeks after exposure
c. pain is felt immediately but it is difficult to know what the cause of it is
d. once the blister agent has contacted the skin, the patient no longer has any sensation in that area

4.12 A person can be exposed to a blister agent through all of the following routes EXCEPT:

a. touching a surface that has the blister agent on it
b. inhalation of air that has been contaminated by a blister agent
c. eating or drinking anything that has been contaminated by a blister agent
d. touching the fluid that seeps from a blister of a person who has been exposed to a blister agent

4.13 Although public exposure during the chemical stockpile destruction process is unlikely, the route of spread that EMTs are recommended to be familiar with is

a. ingestion through contaminated food
b. skin exposure through direct contact
c. spill caused by accident while in transportation
d. air contamination, where the plume moves off the storage installation

Check your responses using Appendix D, Self-Check Answers.

Summary

The most important points that you should have learned from this chapter are:

- Nerve agents:

  a. are stored as liquids (one is oily) that generate extremely toxic vapors
  b. can be absorbed through the skin and spread by direct contact (touch), inhalation (breathing of contaminated air), and ingestion (eating or drinking)

- Blister agents:

  a. are stored as solids or liquids (thick and oily), but can generate toxic vapors
  b. can be absorbed through the skin and spread by direct contact (touch), inhalation (breathing of contaminated air), and ingestion (eating or drinking)

- Most likely route of exposure pre-hospital emergency medical personnel should be prepared for is:

  inhalation of contaminated air

CHAPTER 5 SIGNS AND SYMPTOMS

Objectives

The specific learning objectives for Chapter 5 are for you to be able to:

1. Identify the signs and symptoms of nerve agent exposure.
2. Identify the signs and symptoms of blister agent exposure.

Introduction

What Is In This Chapter?

This is a key chapter! It provides important information that pertains directly to the decisions which must be made.

The titles of the sections in this chapter are:

5.1 Signs and Symptoms of Nerve Agent Exposure
5.2 Signs and Symptoms of Blister Agent Exposure

Why Is This Important?

The most important part of medical treatment given to patients of nerve and blister agents is first aid and special treatment. As an EMT, you must be prepared to act fast. The decisions made during the first few seconds, especially in cases of severe nerve agent exposure, are extremely critical and can make the difference between life and death.

In order to make correct decisions, you must have the required knowledge upon which to base those decisions. In the case of patients of agent exposure, where first-responder treatment is so critical, you must be able to size up the situation based on

(1) the known information regarding an accidental release, and

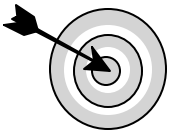
(2) recognition of the event based on signs and symptoms.

While standard procedure allows for full disclosure and wide-spread notification in the event of an accidental release, we must also allow for the possibility of an unknown accidental release or time lags in communicating important information. For this reason, you must be prepared to act based on present indications. This is only possible if you are fully knowledgeable of the signs and symptoms produced by exposure to nerve and blister agents.

In addition, as with any first aid rendered for poisoning, the specific treatment and/or antidote depends on the chemical inflicting the illness or injury. You must be able to identify the agent involved before beginning treatment. This chapter describes the signs and symptoms of nerve agent poisoning and the signs and symptoms of blister agent poisoning.

Learn This

The most important points for you to learn from this key chapter are:



- The specific signs and symptoms of nerve agent vapor/ aerosol exposure

  - miosis (pinpointing of the pupils)
  - increased secretions from mouth, nose and bronchi
  - respiratory difficulty

- The specific signs and symptoms of blister agent vapor/ aerosol exposure

  - irritation, reddening and swelling of eye tissues (conjunctivitis)
  - reddening of the skin (erythema)
  - blisters
  - respiratory irritation and distress

- Fact: Not all signs and symptoms may appear; dose, duration, and route of entry (among other factors) can make a difference.

5.1 Signs and Symptoms of Nerve Agent Exposure

See Also: Appendixes C.1, C.2, and C.6, Nerve Agent MSDS.

The signs and symptoms of nerve agent exposure differ from those that result from blister agent exposure. This section provides information and illustrations for nerve agent exposure only. (See Section 5.2 for signs and symptoms of blister agent exposure.) Signs and symptoms like the ones described may also be caused by health problems other than exposure to a nerve agent; these are discussed in more detail later in this chapter. Appendixes C.1, C.2, and C.6, the MSDSs for nerve agents, contain additional information on nerve agent signs and symptoms. (See "Addendum A" in the MSDSs.)

Specific Signs and Symptoms of Nerve Agent Exposure

Signs are objective evidence of a medical condition or disease (e.g., drooling), while symptoms are subjective evidence of physical disturbance or disease (e.g., headache). The health care worker can see or measure signs, while symptoms usually have to be verbally communicated by the patient.

There are several physical signs to look for in determining if someone has been exposed to a nerve agent. Some signs are caused by local effects of the vapor on the organ (eye or skin) and may or may not correlate with the effects of the agent on the central nervous system. Other signs are the direct result of the chemical effect.

> Note: Not all signs and symptoms may appear. Amount exposed to, duration, and route of entry make a differences.

Miosis

Miosis, or pinpointing of the eye's pupil, is one of the initial effects if the person is exposed to a nerve agent vapor. This sign is a direct effect of nerve agent vapor in the eye.

miosis

Miosis may appear in one eye, but most often appears in both eyes.

Dim Vision

dim vision

If a person has had mild exposure he or she may complain of general eye pain, describing the pain as "somewhere deep in my eye" or "somewhere deep in my head". The patient may complain of dim or blurred vision. He or she may squint often in an attempt to clear up the blurred vision. You may notice that the patient blinks more often than usual; this is a sign that the eyes are affected. The patient may also complain of sensation of pressure in the eyes.

Respiratory Trouble

Watch for these signs and symptoms as indicators that the agent may be contributing to respiratory failure:

- difficulty in breathing
- runny nose
- coughing, frothy secretions, and drooling
- wheezing

labored breathing

The patient shows signs of labored breathing and may complain of a "tight chest" feeling. Remember that the muscles can be severely affected by the nerve agent's ability to overwork the muscle cells to exhaustion. Such an effect on the respiratory muscles makes breathing difficult.

Pay particular attention to this sign. Adequate ventilation must be maintained since respiratory failure is the chief cause of death following severe exposures. Without adequate atropinization, ventilatory support and airway management, a severely exposed person may stop breathing.

drooling/runny nose

Another indication that the agent is interfering with respiratory function is an abundance of mucous secretions from the respiratory passages. The patient drools at the mouth and has a very runny nose.

Localized Sweating

sweating

If the nerve agent has affected nerves that are connected to sweat glands, the patient may sweat profusely. Again, this is due to the over-stimulation caused when nerve agent interferes with the normal function of nerves that control the glands.

Nausea and Vomiting

If exposure was through the skin or by swallowing, gastrointestinal effects of nausea, vomiting and diarrhea may be the first systemic effects to appear. These GI effects can also occur after moderate to severe inhalation exposure.

Abdominal Cramping

Increased activity of the intestines may lead to a cramp or pain in the abdomen.

Involuntary Urination or Defecation

The bladder and bowel, normally controlled through sphincter muscles, may become incontinent. The patient may also exhibit diarrhea.

Heartbeat Irregularities (arrhythmias)

Because the heart is a muscular organ, it too is susceptible to over-stimulation by the nerve agent.

Generalized Weakness

Because the nerve agent also affects the portion of the nervous system that controls the skeletal muscles, the patient may have an overall weak feeling that increases with exertion.

Twitching or Muscle Spasms

unorganized, localized twitching

If the affected nerve is connected to a muscle, the muscle action becomes uncontrollable and repetitive. You may notice this effect as twitching or muscle spasms. Spasms of local muscle groups, usually at the site of exposure, resemble what has been likened to "a bag of worms." The term "fasciculation" is used to describe this

type of motion. Muscle twitching and cramps may become more generalized.

Convulsions and Coma

severe exposure

In severe cases, nerve agent patients may convulse, become comatose, and stop breathing.

mild exposure

Other signs and symptoms, also caused by accumulation of acetylcholine, result from effects on the central nervous system (brain and spinal cord). These are seen with early or mild exposure. The result may be:

- headache
- anxiety
- restlessness
- giddiness
- irritability

summary of signs and symptoms

Table 5.1 lists the signs and symptoms of nerve agent exposure following local exposure and systemic absorption (depending on dose), while Table 5.2 provides a broader summary of effects, routes of absorption, time course, and duration.

Table 5.1 Signs and Symptoms of Nerve Agent Exposure

Site of action	Signs and Symptoms
Following local exposure	
Pupils	Miosis, marked, usually maximal (pinpoint), sometimes unequal
Muscles controlling lens (ciliary)	Frontal headache, eye pain on focusing, blurring of vision
Nasal mucous membranes	Runny nose (rhinorrhea), hyperemia
Bronchial tree	Tightness in chest, bronchoconstriction, increased secretion, cough
Gastrointestinal tract	Occasional nausea and vomiting
Following systemic absorption (Depending on dose)	
Bronchial tree	Tightness in chest, with prolonged wheezing expiration suggestive of bronchoconstriction or increased secretion, labored breathing (dyspnea), pain in chest, increased bronchial secretion, cough, bluish discoloration of skin (cyanosis), pulmonary edema
Gastrointestinal tract	Anorexia, nausea, vomiting, abdominal cramps, upper stomach and substernal tightness (cardiospasm) with "heartburn" and belching, diarrhea, involuntary defecation
Sweat glands	Increasing sweating
Salivary glands	Increased salivation
Lacrimal glands	Increased tearing (lacrimation)
Heart	Heart rate less than 50 (bradycardia)
Pupils	Miosis, occasionally unequal, later maximal miosis (pinpoint)
Muscles controlling lens	Blurring of vision, headache
Bladder	Frequent, involuntary urination
Striated muscle	Easy fatigue, mild weakness, muscular twitching, fasciculations, cramps, generalized weakness/flaccid paralysis (including muscles of respiration) with labored breathing and bluish discoloration of skin
Sympathetic ganglia	Pallor, transitory elevation of blood pressure followed by low blood pressure (hypotension)
Central Nervous System	Immediate (acute) effects: generalized weakness, depression of respiratory and circulatory centers with labored breathing, skin discoloration, and low blood pressure with the vascular system; convulsions, loss of consciousness, and coma.
	Delayed (chronic) effects: giddiness, tension, anxiety, jitteriness, restlessness, emotional instability, excessive dreaming, insomnia, nightmares, headaches, tremor, withdrawal and depression, bursts of slow waves of elevated voltage in EEG (especially on hyperventilation), drowsiness, difficulty concentrating, slowness of recall, slurred speech, staggering or muscular discoordination (ataxia)

Adapted from the *Field Manual for Treatment of Chemical Agent Casualties and Convential Military Chemical Injuries*, Department of the Army, the Navy, and the Air Force, ARMY FM8-285, NAVY NAVMED P-5041, AIR FORCE AFM 160-11 (February 1990).

Table 5.2 Time Course and Summary of Nerve Agent EffectsÓ

Types of Effects	Routes of Absorption	Description of Effects	When Effects Appear After Exposure	Duration of Effects: Mild Exposure	Duration of Effects: Severe Exposure
			Vapor		
Local	Lungs	Runny nose, nasal redness, tightness in chest, wheezing	One to several minutes	A few hours	1 to 2 days
Local	Eyes	Miosis, cunjunctival hyperemia, eye pain, frontal headache	One to several minutes	Miosis – 24 hours	2 to 3 days
Systemic	Lungs or eyes	Muscarinic, nicotinic, and central nervous system effects (see Table 5.1)	Less than 1 minute to a few minutes after moderate or severe exposure; about 30 minutes after mild exposure	Several hours to a day	Acute effects: 2 to 3 days; CNS effects: days to weeks
			Liquid Agent		
Local	Eyes	Same as vapor effects	Instantly	Similar to effects of vapor	
Local	Ingestion	Gastrointestinal	About 30 minutes after ingestion	Several hours to a day	2 to 5 days
Local	Skins	Local sweating and muscular twitching	3 minutes to 2 hours	3 days	5 days
Systemic	Lungs	See Table 5.1	Several minutes		1 to 5 days
Systemic	Eyes	Same as for vapor	Several minutes		2 to 4 days
Systemic	Skin	Generalized sweating	15 minutes to 2 hours		2 to 5 days
Systemic	Ingestion	Gastrointestinal (see Table 5.1)	15 minutes to 2 hours		3 to 5 days

After lethal or near lethal exposures to nerve agents, the time to onset of symptoms and to maximal severity of symptoms is shorter; it may be extremely brief after overwhelming exposure. Following exposure to lethal concentrations, the time interval to death depends upon the degree, the route of exposure, and the agent. If untreated, exposure to lethal concentrations of nerve agents can result in death 5 minutes after appearance of symptoms.

Adapted from the *Field Manual for Treatment of Chemical Agent Casualties and Convential Military Chemical Injuries*, Department of the Army, the Navy, and the Air Force, ARMY FM8-285, NAVY NAVMED P-5041, AIR FORCE AFM 160-11 (February 1990).

Factors That Affect Nerve Agent Exposure Signs And Symptoms

Time Factor (onset)

onset

While the signs and symptoms of nerve agent exposure often begin immediately, they may also be delayed. In addition, some particular signs may appear much sooner than others. Onset time, and whether or not the sign or symptom shows up at all, depend on several factors:

- type of agent
- amount of agent to which the patient has been exposed
- dose (how much patient has absorbed)
- duration of the exposure
- route of exposure (inhalation, direct contact, ingestion)
- sensitivity of the patient's system (depends on general state of health, age, gender, etc.)

reaction time

However, as a general rule, the reaction time to a nerve agent is:

IMMEDIATE	if	moderate to large amounts (relative to LD_{50}) are inhaled
		moderate to large amounts (relative to LD_{50}) are spilled onto the skin
DELAYED	if	small amounts (relative to LD_{50}) are involved
		agent has been absorbed through the skin in a small localized area (takes time to absorb and take action)

Peak Effect

exposure through inhalation

peaks at 15-20 minutes

If the exposure route is inhalation of air with a high concentration of agent, effects can occur after a single breath. This "immediate" response occurs within seconds. After the patient has been removed from the exposure, look for the effects to peak within 15-20 minutes. Generally, you can be reasonably certain that if the exposure was through air (only) and the time lapse has been 15 minutes or more, the effects have maximized —they will not worsen after this time.

Exposure through skin/absorption

If the exposure route is dermal (droplet or liquid or vapor that touches the skin), absorption may continue for hours. This is likely to continue even after decontamination is completed since

1-18 hours

the absorption occurs within the skin layers and from fatty deposits. In contrast to the air route (where the worst can be expected within 15-20 minutes), the effects of direct skin contact may not occur for hours after exposure (range from 1-18 hours). On the plus side, however, effects that occur many hours after exposure are usually non-lethal.

Toxicity

The median lethal dose (LD_{50}) of liquid nerve agent VX is 10 milligrams on the skin of a 70-kg man. This is approximately equivalent to a small droplet being absorbed through the skin of a 155-pound person. By the inhalation route, VX vapor (considered the most potent nerve agent) is at least 50 times more toxic than cyanide gas (LCt_{50} of 30 mg-min/m^3). The LD_{50} of GB agent is approximately 1.7g on the skin on a 70-kg man. The median lethal dose (LCt_{50}) from inhalation of GB vapor is 70 mg-min/m^3.

Lethality

respiratory failure: the chief cause of death

The chief cause of death due to nerve agent exposure is respiratory failure. The contributing biological effects are bronchoconstriction and secretions in the airways, weakness of the muscles that force the lungs to expand and contract, and inhibition of the respiratory center in the brain.

Will A Person Exhibit All Of The Signs & Symptoms Of Nerve Agent Poisoning After Being Exposed?

No. Some of the signs and symptoms depend on several different factors. Some patients may exhibit only one or two signs; others may experience several symptoms at the same time. In addition, the time factor for when these signs and symptoms begin to appear may differ from person to person. Remember, there are large differences in sensitivity between persons.

Nerve Agent Signs and Symptoms By Degree of Severity

Although any and all of the signs and symptoms mentioned previously may appear, they are more likely to appear according to the severity of the exposure. While Tables 5.1 and 5.2 are general summaries of the signs and symptoms of nerve agent exposure, Tables 5.3 and 5.4 present the signs and symptoms according to type of effect, routes of absorption, time courses of effects, and severity of exposure. Effects are segregated by route of exposure because target organs vary significantly in the ability to absorb agent.

Table 5.3 Eye and Inhalation Exposure to Nerve Agent Vapor by Degree of Severity

Degree of Severity	Body Part Affected	Symptom(s)
Mild: (May also be effects of an initial reaction leading to a more serious reaction.)		
	eyes	miosis, pain (deep in eye or head); dim or blurred vision
	nose	runny
	lungs	"tightness in chest", bronchoconstriction, secretions in airways, cough, moderate difficulty in breathing
Moderate: (May also include symptoms under "Mild".)		
	eyes	miosis, pain, dim or blurred vision
	nose	runny (severe), nasal congestion
	lungs	"tightness in chest", breathing is more difficult, secretions more abundant
	muscles	feeling of generalized weakness, generalized twitching of large muscle groups
	GI	nausea, vomiting, diarrhea, cramps
Severe: (May develop from symptoms under "Mild" and "Moderate" or go directly to these symptoms.)		
	muscles	convulsions, weakness with eventual flaccid paralysis
	lungs	cessation of respiration
	(all)	loss of consciousness, coma, death

TIME COURSE:

Onset time: seconds to several minutes. Symptoms may occur after little more than one breath of nerve agent vapor; large amounts may cause reactions within seconds. Effects do not worsen appreciably after 15-20 minutes following cessation of agent exposure.

Adapted from F. R. Sidell, "Clinical Notes on Chemical Casualty Care," USAMRICD Technical Memorandum, 90-1 (1990).

Table 5.4 Skin Exposure to Nerve Agent By Degree of Severity

Degree of Severity	Body Part Affected	Symptom(s)
Mild:		
(May also be effects of an initial reaction leading to a more serious reaction.)		
	skin	sweating at exposure site
	muscle	localized, unorganized fasciculation at exposure site ("bag of worms")
Moderate:		
(May also include symptoms under "Mild".)		
	muscle	generalized (at random, all over) fasciculation and twitching; generalized weakness that increases with any form of activity
	GI	nausea, vomiting, diarrhea
Severe:		
(May develop from symptoms under "Mild" and "Moderate" or go directly to these symptoms.)		
	muscles	extremely weak; convulsions (seizures) with eventual flaccid paralysis
	lungs	cessation of respiration
	(all)	sudden loss of consciousness and collapse, death
TIME COURSE:		
Onset time: minutes to several hours. The larger the exposure the shorter the onset time. After a large exposure (lethal amount or greater) the effects may occur within minutes; after an asymptomatic period, the first effect may be loss of consciousness. Onset time may be as long as 18 hours after exposure; however, in such cases the effects are usually not lethal.		

Adapted from F. R. Sidell, "Clinical Notes on Chemical Casualty Care," USAMRICD Technical Memorandum, 90-1 (1990).

See Also: Section 7.1 Nerve Agent Exposure: Initial First Aid Treatment

Differential Diagnosis - Nerve Agent

The symptoms described above may be caused by health problems other than exposure to a nerve agent. As you will learn later, it is important to determine whether or not a person is suffering from actual nerve agent exposure before any nerve agent antidote is given.

What is "Differential Diagnosis"?

Differential diagnosis refers to distinguishing one disease from another when two or more diseases produce the same or similar effect. One of the first steps in providing treatment to patients of any agent exposure is the verification of the type of agent that is involved.

In some cases, you will know what agent is involved before arriving at the scene. If an accidental release occurs at the storage location, authorities are notified. In such a situation, agent identification is through a "known release".

Other Possible Causes of Nerve Agent Symptoms

The same signs and symptoms described as nerve agent effects (taken in isolation) may also be attributed to:

- epilepsy
- gastroenteritis
- exposure to agricultural insecticides (organophosphates and carbamates)
- emphysema
- stroke
- head trauma
- drug overdose
- heat illnesses

Examine and question the patient closely for other signs and symptoms of what may or may not be nerve agent poisoning. Gaining medical history from the patient or, if patient is unconscious, looking for medic-alert bracelets or cards may assist in making the correct diagnosis.

5.2 Signs and Symptoms of Blister Agent Exposure

The signs and symptoms of blister agent exposure are different from those that are produced as a result of exposure to a nerve agent. This section provides information and illustrations for sulfur mustard blister agent exposure only; Lewisite is present at only one site and is addressed separately at the end of the section. Appendixes C.3, C.4, and C.5 the MSDSs for blister agents, contain additional information on blister agent signs and symptoms. (See “Addendum A” in the MSDS.)

> While liquid deposition of agent or high concentrations of vapor are not expected off-post, it is important to recognize the signs and symptoms of more severe exposure.

Specific Signs and Symptoms of Mustard Agent Exposure

influence of weather

The severity of the symptoms and the rapidity with which they develop are greatly influenced by weather conditions as well as degree of exposure. Hot, humid weather significantly increases the action of mustard.

Following mustard exposure, the onset of clinical signs and symptoms is characteristically delayed for a period of hours. However, there are several physical signs to look for when determining if someone has been exposed to mustard.

Eye Irritation/Inflammation

eye most sensitive indicator

The eyes are extremely susceptible to mustard agent vapors due to the sensitivity of the mucous membranes of the eyelid and surrounding tissue. Effects include tearing, itching, blinking, reddening of eye tissue and a sensation of "grit" in the eye. These effects occur at lower doses more often than any other effect. **For this reason, this particular set of signs is the most sensitive indicator of a mustard agent exposure.**

The eyelids may swell to the extent that the eyes are completely closed. Burning pain can be severe. In severe cases, the cornea

can become ulcerated. Patients may be alarmed and think they are blind. However it is only the swelling that obstructs vision.

Photophobia

If the eyes are exposed to mustard agent vapors the person may experience photophobia, or pain caused by light. Light may also cause general discomfort, and not necessarily pain.

Erythema (reddening of exposed skin)

skin rash

One of the earliest signs of dermal exposure is a skin rash or reddening (erythema) that resembles sunburn. Itching and/or burning pain often accompany erythema. With mustard, erythema typically occurs between 4 and 6 hours after exposure; the range of onset time is 2 to 24 hours.

Because the mustard agents are absorbed faster in warm, moist areas of the body, certain areas are more likely to be affected much quicker. Such body areas include the armpits, anal-genital area, between fingers and toes, membranes surrounding the eyes, lungs, skin folds of the neck, and creases of elbows and knees.

Blisters

blisters less likely in vapor exposures

If not immediately decontaminated, or if exposure has been severe, the reddened skin develops fluid-filled blisters. These blisters, if crudely broken, could become infected.

The blisters, like serious chemical burns, may not be painful initially. However, pain and itching may occur not long after blisters develop, then subside, then reoccur a few days later as healing progresses.

Care must be taken to avoid introducing infection into the blister wounds. Because of the damage to the skin tissue and the immunosuppressive action of sulfur mustard, the person's ability to fight infection has been diminished. This same precaution is used for any type of massive surface injury (such as thermal burns).

Blisters may appear 2 hours after exposure; however, they often do not appear for at least 6 hours. In some cases, blisters may not appear for as long as 36 hours after exposure.

Inflammation of the Respiratory Tract

If inhaled, the mustard agent can be extremely devastating, although not necessarily fatal. It causes edema (swelling) and necrosis of the mucous membrane of the airways, resulting in internal inflammation and blistering of the throat and lungs. Tracheobronchitis in the first 12 hours after mustard exposure is characteristic; and can be identified by hoarseness, hacking non-productive cough, chest tightness, and increased respiratory rate.

Depending on the severity of the exposure, the inflammation can cause a substantial amount of fluid to build up in the lungs. The combined effect of fluids and inflammation can obstruct the respiratory tract. Mustard agents do most damage to the upper airways, but with a heavy exposure, the air sacs in the lungs can be injured.

First signs of respiratory tract damage from mustard usually appear within 2 hours after exposure; severity of response may increase for up to 24-48 hours later. For low-dose cases, initial symptom onset may be delayed for up to 36 hours after exposure.

irritation of the lining in nose and mouth

A mild exposure to mustard agent can cause slight to moderate irritation of the lining of the nose and mouth. It has been likened to a "very sore throat feeling, even without swallowing" that extends from the mouth, nose, and all the way down the back of the throat.

Systemic and Gastrointestinal Effects of Mustard

Ingestion of food or water contaminated by liquid mustard produces nausea and vomiting, pain, and, sometimes diarrhea or constipation. Mustard vapor does not significantly contaminate food or water. Exposure of only the skin to mustard may cause systemic symptoms such as malaise, nausea, vomiting, and fever—at about the time the skin reddens. Exceptional cases of severe systemic mustard poisoning may also present central nervous system symptoms such as cerebral depression and other effects such as cardiac irregularities. Shock may occur. Severe systemic effects do not occur with lesser mustard exposures.

severe exposure effects

With lesser skin or respiratory exposures to mustard, no apparent systemic lesions develop. However, with amounts approaching a lethal dose, injury to the blood-forming tissues (bone marrow, lymph nodes, and spleen) may result.

Table 5.5 summarizes the signs and symptoms of mustard agent exposure.

Factors that Affect Mustard Agent Signs and Symptoms

Time Factor (onset)

delayed onset

Although the signs and symptoms of mustard agent exposure are characteristically delayed, they may appear quickly if the person has been exposed to a large quantity. Depending on these factors, some signs may appear much sooner than others. Just as with nerve agent exposure, the onset of symptoms depends on:

- type of agent
- amount of agent to which the patient has been exposed
- dose (how much patient has absorbed)
- duration of exposure
- route of exposure (inhalation, contact, ingestion)
- sensitivity of the patient's system (depends on general state of health, age, gender, etc.)

If the mustard agent has been inhaled it causes a much quicker reaction than exposure through skin contact. This is because the agent is absorbed much faster in warm, moist areas (in this case, the respiratory tract) and is not as easily removed once inhaled. The soft membranes inside the nose, mouth, throat, and bronchial tubes are extremely susceptible to the harsh effects of the mustard agent vapor.

Peak Effect

exposure through inhalation

If the exposure route is inhalation, the effects can occur after a few hours of latency. The onset is usually accompanied by sneezing, coughing, and tracheobronchitis.

exposure through skin/absorption

If the exposure route is dermal (droplet or liquid or vapor that touches the skin), the effects are usually delayed and absorption may continue for hours. This is likely to continue even after decontamination since the absorption may continue deep within the skin layer.

Table 5.5 Summary of Mustard Blister Agent ExposureÓ

Types of Effects	Route of Absorption	Description of Effects	When Effects Appear After Exposure
		Vapor	
	Skin	No immediate clinical effects (no burning, stinging, or redness)	Becomes "fixed" to tissues within minutes
		Reddening of skin	2 to 36 hours
	Eyes	Itching, tearing, conjunctiva reddening; gritty pain	4 to 12 hours if mild; 3 to 6 hours if moderate
		Sensitivity to light (photophobia)	4 to 12 hours if mild; 3 to 6 hours if moderate
		Swelling of eyelids	Some after 4 to 12 hours if mild; to point of near closure within 3 to 6 hours if moderate; to point of closure if severe
		Severe inflammation of conjunctiva and cornea; ulceration, perforation possible if severe	3 to 6 hours if moderate; 1 to 3 hours if severe
	Nose, throat, and windpipe	Burning sensation, sinus pain, cough	2 to 36 hours; 2 to 4 hours if moderate
		Severe burning	24 to 48 hours if severe
	Lungs	Chest tightness, hacking cough, hoarseness, sneezing	2 to 36 hours if mild; 2 to 4 hours if moderate
		Increased respiration rate	4 to 16 hours if moderate
		Very rapid breathing; lung tissues hemorrhage, bronchopneumonia	24 to 48 hours if severe
		Severe cough; unable to speak	16 to 48 hours if severe

Table 5.5 Summary of Mustard Blister Agent Exposure (continued)Ó

Types of Effects	Route of Absorption	Description of Effects	When Effects Appear After Exposure
		Liquid Agent	
	Skin	Same as vapor effect but more likely to result in moderate to severe damage	Becomes "fixed" to tissues within minutes
		Reddening of skin; blisters	2 to 24 hours (typically 4 to 6 hours); 2 to 36 hours if mild; sooner and more severe if moderate; sooner and large if severe
		Death of epidermal tissues (necrosis)	Several days
	Eyes	Same as vapor effect but more likely to result in moderate to severe damage	Becomes "fixed" to tissues within minutes
	Lungs	Same as vapor effect but more likely to result in moderate to severe damage	Becomes "fixed" to tissues within minutes
Systemic	GI tract (ingestion)	Nausea and vomiting (mild and moderate)	
Systemic	Skin	Malaise, vomiting, fever (moderate), prostration (severe), injury to bone marrow, lymph nodes, and spleen (only if approaching lethal dose)	
Systemic	Cardiovascular system	Shock after severe; late depression of bone marrow	
	Central nervous system	Cerebral depression (severe)	

Adapted from the *Field Manual for Treatment of Chemical Agent Casualties and Convential Military Chemical Injuries*, Department of the Army, the Navy, and the Air Force, ARMY FM8-285, NAVY NAVMED P-5041, AIR FORCE AFM 160-11 (February 1990).

Toxicity

The median lethal skin dose (LD_{50}) of mustard agent is 7 g/70-kg man (liquid on skin). This is equivalent to about 1 teaspoon. Between 4 and 32 micrograms are enough to cause skin erythema and blistering.

By the inhalation route, mustard vapor is three times more toxic than cyanide gas.

Lethality

chief causes of death

The chief causes of death from blister agent exposure are usually

- respiratory failure due to damage caused to lungs and airways
- infections due to the combination of airway damage and suppressed immune response mechanisms (e.g., pneumonia, etc.).

However, mustard exposures are rarely lethal; with the massive numbers of soldiers exposed in World War I, approximately 3% died.

Will a Person Exhibit All of the Signs and Symptoms of Mustard Agent Poisoning After Being Exposed?

No. Some of the signs and symptoms described are very dependent on the dose received, the sensitivity of that individual, and the route of exposure.

Mustard Agent Signs and Symptoms By Degree of Severity

Although any and all of the signs and symptoms mentioned previously may appear, they are more likely to appear according to the severity of the exposure by route. While Table 5.5 is a general summary of the signs and symptoms of mustard agent exposure, Tables 5.6 and 5.7 summarize mustard blister effects by severity of effects.

Table 5.6 Exposure Through Direct Contact with Mustard Agent By Degree of Severity

Degree of Severity	Body Part Affected	Symptom(s)
Mild:		
	skin	no immediate clinical effects (no burning, stinging, or redness); becomes "fixed" to the tissue within minutes, blisters appear about 2 to 36 hours later.
	eyes	in 4-12 hours after exposure, itching, tearing, conjunctivitis (reddening of tissues surrounding the eyeball), sensation of grit in the eye, burning and photophobia (sensitivity to light), some swelling of eyelids.
Moderate:		
	skin	no immediate clinical effects; blisters appear sooner and are more severe than in cases of "mild" dose.
	eyes	in 3-6 hours after exposure, increased intensity from "Mild" symptoms, edema (swelling) of lids to the point of near closure; spasms of the muscles surrounding the eye; increased photophobia; blurred vision; possible discharge; miosis may also occur; severe inflammation of conjunctiva and cornea.
Severe:		
	skin	no immediate clinical effects; blisters appear sooner and are large; necrosis; skin charring may be evident later.
	eyes	severe pain, increased swelling of lids to point of closure, discharge; possible damage to cornea (e.g., ulceration, perforation, etc.).
	muscles	large amounts may affect nerve endings (NOTE: This is a systemic effect that may occur after large dose through skin or inhalation or combination.)

Adapted from F. R. Sidell, "Clinical Notes on Chemical Casualty Care," USAMRICD Technical Memorandum, 90-1 (1990).

Table 5.7 Exposure Through Inhalation/Ingestion of Mustard Agent By Degree of Severity

Degree of Severity	Body Part Affected	Symptom(s)
Mild:		
	nose, throat and windpipe	burning sensation, sinus pain, cough
	GI	nausea and vomiting
Moderate:		
	nose, throat and windpipe	burning sensation
	lungs	chest tightness, severe cough
	GI	nausea and vomiting, stomach pains
Severe:		
	nose, throat and windpipe	severe burning
	lungs	difficulty breathing due to airway damage
	GI	nausea, vomiting, bloody diarrhea, stomach pains
	muscles	large amounts may affect nerve endings (NOTE: This is a systemic effect that may occur after large dose through skin or inhalation or combination.)

TIME COURSE:

Onset of symptoms may be delayed 2 to 36 hours; initial signs/symptoms are those of acute tracheobronchitis. Approximate time course for moderate exposure: 2-4hrs, chest tightness, hacking cough, hoarseness, sneezing; 4-16 hrs, sinus pain, increased respiration rate; 16-48 hrs, severe cough, unable to speak, very rapid breathing; 24-48 hrs, severe dyspnea, lung tissue hemorrhage, bronchopneumonia.

Adapted from F. R. Sidell, "Clinical Notes on Chemical Casualty Care," USAMRICD Technical Memorandum, 90-1 (1990).

Lewisite Signs and Symptoms

Although Lewisite differs from the mustard agents in its chemical composition and method of action, it too destroys individual cells in target tissues. When inhaled, Lewisite vapor may produce mild to moderate irritation of the upper respiratory tract. It may also cause sneezing. These are similar to mustard effects, except in the most severe cases when excess fluid may accumulate in the lungs and fluid may ooze into spaces between the pleural membranes lining in the chest cavity.

Lewisite does not exhibit the latency period of mustard; liquid Lewisite causes immediate severe pain upon contact with the eyes and skin. The eye can be severely damaged, with immediate stinging pain and twitching of the muscles around the eyes; swelling of the conjunctivae and lids that may close the eye within 1 hour; inflammation of the iris and corneal damage. Within hours, the swelling subsides. Mild conjunctivitis may heal in a few days without specific treatment, but severe exposure may cause permanent injury or blindness.

Contact with liquid Lewisite produces more severe skin lesions than does mustard. Erythema is followed by blistering over the entire area of erythema. There is also deeper injury to connective tissue and muscle, greater vascular damage, and more inflammation. The pain is immediate and becomes deep and aching. Itching and irritation persist for a day, and blisters develop fully in one-half of that time.

Lewisite is also known to be a systemic poison (liver and kidneys) at sufficiently large doses and has induced Bowen's disease, a relatively slow-growing and usually nonfatal form of skin cancer, among exposed soldiers and poison gas factory workers.

Table 5.8 Signs and Symptoms of Lewisite Exposure

Site of Action	Signs and Symptoms
Eye	Prompt redness, swelling, irritation, immediate burning sensation, may cause inflammation of iris, corneal injury
Nose	Prompt irritation
Respiratory tract	Rapid irritation, hoarseness, loss of voice, cough. Pneumonia, fever, accumulation of fluid in lungs (in severe cases), fluid between pleural membranes
Skin	Prompt burning redness within 30 min, blisters on 1st or 2nd day. Pain more severe and necrosis deeper than mustard
GI Tract	Diarrhea, nausea, vomiting, liver failure
Cardiovascular system	Shock after severe symptoms, anemia due to destruction of red blood cells, concentration of blood due to loss of body fluid or plasma
Bladder	Kidney failure
Central Nervous System	Malaise, prostration, depression after severe symptoms

Adapted from the *Field Manual for Treatment of Chemical Agent Casualties and Convential Military Chemical Injuries*, Department of the Army, the Navy, and the Air Force, ARMY FM8-285, NAVY NAVMED P-5041, AIR FORCE AFM 160-11 (February 1990); *U.S. Department of the Army May 1991. Chemical Accident or Incident Response and Assistance (CAIRA) Operations*, Pamphlet 50-6.

Differential Diagnosis - Blister Agents

The signs and symptoms described may be caused by health problems other than exposure to a blister agent. As you will learn later, it is important to determine whether or not a person is suffering blister agent exposure in order to take decontamination precautions.

What is "Differential Diagnosis"?

As mentioned earlier, differential diagnosis refers to distinguishing one disease from another when two or more diseases produce the same or similar effect. One of the first steps in providing treatment to patients of any agent exposure is the verification of the type of agent that is involved.

In some cases, you will know what agent is involved before arriving at the scene. If an accidental release occurs at the storage location authorities are notified. In such a situation, the agent identification is through a "known release". In other cases the release is, for some reason, not discovered until after the fact, and the identification of the agent must be done according to the patient's signs and symptoms.

Other Possible Causes of Blister Agent Signs and Symptoms

The signs and symptoms described as blister agent effects may also be attributed to:

- hay fever (red eyes)
- burns—thermal, sun, or other chemicals (erythema and/or blisters)
- large amounts of tear gas exposure (all signs/symptoms)
- poison ivy, poison oak, other contact allergies

As with potential nerve agent exposure, examine and question the patient closely for other signs and symptoms of what may or may not be blister agent poisoning. Gaining medical history from the patient may assist in making the correct diagnosis.

Self-Check

Assess your understanding of the material presented in this chapter by completing the following Self-Check.

Matching

Identify the probable cause of the following signs and symptoms by matching the Sign/Symptom in Column A with the correct Cause in Column B. Notice that your choices in Column B also include: either and neither.

Column A Signs/Symptoms	**Column B** Cause
___ **5-1.** miosis	a. nerve agent
___ **5-2.** difficulty in breathing	
___ **5-3.** increased oral nasal secretions	b. blister agent
___ **5-4.** sudden hair loss	
___ **5-5.** twitching spasms	c. either; may be caused by both nerve and blister agents
___ **5-6.** blisters	
___ **5-7.** fever	
___ **5-8.** a delayed, severe rash	
___ **5-9.** localized sweating	
___ **5-10.** overall weakness	d. neither; is not a sign/symptom of nerve nor blister agent
___ **5-11.** intense itching in body crevices	
___ **5-12.** extreme sore throat, irritated eyes, nose and mouth	
___ **5-13.** convulsions	
___ **5-14.** temporary hearing loss	
___ **5-15.** burning sensation in mucous membranes around eyes, in nose and mouth	
___ **5-16.** giddiness	
___ **5-17.** high blood pressure	
___ **5-18.** extremely dilated pupils	
___ **5-19.** severe burn-like, blisters	
___ **5-20.** irregular heart beat	

Multiple Choice

5-21. As a general rule, the reaction time (symptom onset) to a nerve agent is immediate if

a. very small amounts are involved.
b. moderate to large amounts are inhaled.
c. a minute amount is absorbed through the skin in a localized area.
d. if moderate to large amounts are combined with a blister agent.

5-22. As a general rule, the reaction time (symptom onset) to a mustard agent is

a. delayed for severe cases
b. delayed for mild to moderate cases
c. immediate for mild to moderate cases
d. immediate regardless of the severity

5-23. Reaction to a nerve or blister agent, and whether or not a particular sign/symptom shows up at all, depends on several factors which include:

a. route of exposure; dosage concentration
b. the duration of the exposure; the common name of the agent
c. common name of the agent; altitude of the terrain at the time of exposure
d. the duration of the exposure; whether the agent is classified as unitary or binary

5-24. The chief cause of death due to nerve agent exposure is

a. cerebral hemorrhage
b. respiratory failure
c. severe bilateral miosis
d. severe gastroenteritis

5-25. "Differential diagnosis" means

a. a different care giver arriving at the same diagnosis
b. diagnosing multiple causes in order to give different treatments at the same time
c. arriving at the same diagnosis for different patients who display the same or similar effects
d. distinguishing one disease from another when two or more diseases produce the same or similar effects

True/False

5-26. After being exposed to a nerve agent, a patient will not necessarily display all of the signs/symptoms described in this study guide.

a. true
b. false

Explain:
_____
_____
_____

5-27. After being exposed to a blister agent, a patient will not necessarily display all of the signs/symptoms described in this study guide.

a. true
b. false

Explain:
_____
_____
_____

Short Answer

5-28. List at least two factors that affect the onset of symptoms for a victim of nerve or blister agent exposure.

a. _____

b. _____

5-29. List at least two other causes that produce the same effects as exposure to nerve agents.

a. _____

b. _____

5-30. List at least two other causes that produce the same effects as exposure to blister agents.

a. _____

b. _____

Check your responses using Appendix D, Self-Check Answers.

Summary

The most important points that you should have learned from this chapter are:

- The specific signs and symptoms of nerve agent vapor/aerosol exposure
  - miosis (pinpointing of the pupils)
  - increased secretions
  - respiratory difficulty
- The specific signs and symptoms of blister agent vapor/aerosol exposure
  - eye irritation and inflammation
  - erythema (reddening of the skin)
  - blisters
  - respiratory irritation and distress
- Fact: Not all signs and symptoms may appear; dose, duration, and route of entry (among other factors) can make a difference.

CHAPTER 6 FIRST AID AND SPECIAL TREATMENT (FAST)

Objectives

The specific learning objectives for Chapter 6 are for you to be able to:

1. Describe the need for self protection when providing treatment for nerve/blister agent exposure.

2. Describe the initial first-aid treatment for patients of nerve agents.

3. Describe the initial first-aid treatment for patients of blister agents.

Introduction

What Is In This Chapter?

This is a key chapter! It provides important information that pertains directly to the decisions which must be made.

The titles of this chapter's sections are:

6.1 Protecting Yourself: Zones, PPE, and Decontamination
6.2 Nerve Agent Exposure: Initial First Aid Treatment
6.3 Blister Agent Exposure: Initial First Aid Treatment

Why Is This Important?

The most important part of medical treatment given to patients of nerve and blister agents is the first aid and special treatment. As a first responder, you must be prepared to act fast. The actions taken during the first few minutes, especially in cases of severe nerve agent exposure, are extremely critical and can make the difference between life and death.

Perhaps when you received your basic EMT training, you were taught the "ABCs of emergency care":

Airway (establish airway),
Breathing (artificial respiration),
Circulation.

The initial treatment for patients exposed to nerve and blister agent ranks just as high on this priority list. Just like the ABCs, there is no time to transport or wait for help. You must be prepared to act decisively and immediately.

Learn This

The most important points for you to learn from this key chapter are:

- The Number 1 Rule in providing treatment for nerve or blister agent exposure is: PROTECT YOURSELF.

  It is assumed that patients will have been decontaminated before being brought to EMS personnel in the cold zone. Information regarding decontamination or removal from contaminated areas should not be interpreted as encouraging EMS personnel to go into the hot zone. Only persons who are properly equipped and trained in accordance with applicable OSHA regulations should conduct rescue or decontamination operations in contaminated areas.

  You can protect yourself by:

  1. recognizing the area with exposure potential and the zones set up to operate safely during the emergency, and
  2. ensuring the exposed person is completely decontaminated.

- The initial treatment (first-aid) for nerve agent patients is:

  - Give atropine, followed by 2-PAM chloride (administration of antidote compounds by non-physicians varies among states)
  - As necessary, support airway management

- The initial treatment (first-aid) for blister agent patients is:

  - Ensure that patient is decontaminated
  - If necessary, take precautions for sterile technique and support airway management as necessary.

- Atropine overdose can occur if given when there has been no exposure to nerve agent.

6.1 Protecting Yourself: Zones, PPE, and Decontamination

The first rule in treating of any patient of a toxic agent is to protect yourself. Do not become a patient. This rule may seem too obvious to even mention, but a short discussion is definitely warranted. For some individuals, especially those who have been in life-saving situations where, with the welfare of the patient foremost in mind and the adrenaline level high, the welfare of "self" is temporarily put aside.

The Number 1 Rule: PROTECT YOURSELF

cause of injury: the chemical agent

However, when treating patients of toxic agent exposure, never forget the cause of the injury you are treating: the chemical agent. It was designed to spread and cause multiple injuries. All of your skill and training are useless to the patient if you are exposed to the agent, not to mention the unnecessary trauma you face as a patient yourself.

You can protect yourself by:

1. recognizing the area with exposure potential and the zones set up to operate safely during the emergency,
2. ensuring the exposed person is completely decontaminated.

If a chemical accident with potential off-post consequences should occur at one of the disposal locations, the general public and all local authorities would immediately be notified. Emergency response and medical treatment would be established at one or more central locations, where people with agent symptoms could be screened and treated.

initial hazard prediction

Once a chemical plume from an accident is expected to cross the borders of the installation, an initial hazard prediction will be given that identifies the expected pattern and path of off-post exposure. Emergency response and treatment teams will be established to assist with the treatment of persons exposed. The area expected to be affected by the plume will be restricted, as in other hazardous materials emergency response situations.

It may be necessary for civilian responders, including EMTs, to wear protective clothing and breathing devices to ensure that they are not exposed to chemical agent. The CSEPP training course, *Personal Protective Equipment* (revised in year 2000), identifies the specific clothing and breathing equipment that is approved for use in the program along with associated training, medical, and maintenance policies. The CSEPP policies meet, and in some cases exceed, OSHA regulations.

Decontamination: An Essential Part of Treatment

prevents agent from spreading; doing further damage

An essential part of any treatment provided for a patient of a nerve or blister agent is the decontamination, or removal of the agent, which should have been accomplished before the patient is brought to the treatment area. This crucial process not only prevents the agent from doing any further damage, but also, if done correctly, prevents the agent from spreading to others and thereby producing other patients.

Specific instructions for step-by-step contamination reduction procedures, such as what materials to use and how to use them, are covered in the training course *Response Phase Decontamination for CSEPP*. Decontamination is mentioned here, along with treatment procedures, to emphasize how important decontamination is to effective treatment.

Drug Administration

check the laws of your state

The laws concerning drug administration differ from state to state. Some states require that any administration of atropine and/or 2-PAM chloride be under the orders of a physician. You should be familiar with the laws of your state governing drug administration in emergency situations.

When you learn the specific provisions of your state regarding emergency drug administration, be sure to complete Section 3.4.

6.2 Nerve Agent Exposure: Initial First Aid Treatment

Treatment for a severe nerve agent exposure must be immediate. Depending on the severity of the exposure, seconds can make the difference between life and death. Patients should be treated only if they have at least two signs and symptoms of nerve agent poisoning.

nerve agent Rx

The first aid treatment for symptomatic patients of nerve agents includes three steps:

- antidote administration,
- airway management , and
- decontamination.

Treatment Details

This section provides pertinent details on the first two of these steps in nerve agent initial emergency treatment. Decontamination is addressed in the course *Response Phase Decontamination for CSEPP*.

The Antidote: A Combination

atropine
2-PAM chloride

The initial treatment for nerve agent exposure comes as a two-part antidote: (1) atropine to counteract the cholinergic effect of the nerve agent, and (2) 2-PAM chloride which acts by removing agent from cholinesterase and restoring normal control of skeletal muscles.

atropine blocks over-stimulation

Atropine is the first drug used for treating nerve agent exposure. It stops the effect of the nerve agent by blocking the effects of over-stimulation. This antidote relieves the smooth muscle constriction in the lungs and GI tract and dries up respiratory tract secretions. It cannot reverse respiratory muscle paralysis. Atropine is a drug that has long been used in medicine as a pre-anesthetizing agent.

After the initial dose, the need for additional atropine is re-evaluated every few minutes as indicated in Tables 6.1, 6.2, and 6.3. In cases of severe exposure, additional doses of atropine may be required during the entire trip to the emergency room.

CAUTION: Atropine should not be administered without clear indications of nerve agent poisoning.

The follow-up drug to atropine is 2-PAM chloride (also called Pralidoxime). 2-PAM chloride complements, or completes, the action of atropine by restoring normal functions at the nerve synapse by removing organophosphate from cholinesterase. This antidote is effective at re-establishing normal skeletal muscle contraction (relieves twitching and paralysis of respiratory muscles). The drug 2-PAM chloride has side effects if administered too much too rapidly. It should be administered slowly and carefully. Side effects include hypertension, blurred vision, and vomiting.

2-PAM Chloride (Pralidoxime, U.S.P.) restores nerve function

How the Nerve Agent Antidote Works

See Also: Under Section 5.1, Nerve Agents: A Description

In a patient suffering from nerve agent exposure, the target muscle is overstimulated because of the agent's interference with the normal chemical "stop and go" process between the nerve cell and the muscle cell.

If the over-stimulation is not interrupted, the muscle can eventually go into a prolonged contraction and become fatigued, or go limp.

When atropine is administered, it blocks the action of the accumulated acetylcholine from stimulating the adjacent muscle cell.

Note that the atropine prevents part of the nerve agent action that had over-stimulated the muscle cell.

What atropine does not do is free up acetylcholinesterase to restore normal control of target muscle cells.

That is why 2-PAM chloride is given in addition to atropine—it restores the activity of the inhibiting enzyme, acetylcholinesterase.

2-PAM chloride also reduces the need for assisted ventilation since it restores normal control of respiratory muscles.

Recommended Dosages of Atropine and 2-PAM Chloride:

The appropriate dosages of atropine and 2-PAM Chloride to administer after an exposure to nerve agent vary depending on the age and body weight of the patient and the severity of the signs and symptoms. Because of the extreme toxicity of nerve agents, the required doses are much higher than those normally administered following exposure to pesticides that are chemically similar to nerve agents.

The recommended doses listed in this section may be repeated as clinically indicated. Atropine treatment should be repeated until the patient is "atropinized" (discussed later in this chapter). Incremental 2-PAM Chloride dosages may be repeated until the maximum dose based on body weight has been given. The treatment lists in this chapter sometimes indicate that 2-PAM Chloride should be given by a "slow IV." This means that the recommended dosage should be administered over a 20- to 30-minute period in 250 ml of normal saline or 250 ml of 5% dextrose/water solution.

Experience has revealed two common problems with the administration of nerve agent antidotes. The most common problem is underdosage, when too little antidote is administered to relieve the effects of the nerve agent. The second most common problem is the administration of antidotes to patients who have not actually been exposed to nerve agent. Atropine, one of the key antidotes, can produce adverse effects when administered to someone who has not been exposed to organophosphates. The most serious problem would be failing to administer atropine when it was needed.

Nerve agent antidotes may be administered intramuscularly (IM), intravenously (IV), or with a MARK I Chemical Agent Treatment kit. The MARK I kit is an Army product that includes two auto-injectors, one containing 2 mg of atropine, and the other containing 600 mg of 2-PAM Chloride. Auto-injectors containing the two vaccine components are also available commercially. The qualifications of emergency workers and state and local regulations will determine how the drugs are administered in a specific event.

In addition to the two–drug antidote, diazepam should be administered as an anticonvulsant to patients who are experiencing convulsions and considered for other patients who display signs of

severe exposure. The recommended dosages of diazepam vary depending on the patient's age.

Adult Dosages

Adults who have been exposed only to nerve agent vapors and are exhibiting mild signs and symptoms, such as pinpoint pupils and runny nose, should be observed only. For adults experiencing stronger effects, dosages of nerve agent antidotes are based on route of exposure and the severity of signs and symptoms. Table 6.1 lists the recommended antidote treatment for adults suffering from exposure to nerve agent vapor. Table 6.2 presents similar information for adults who have come into direct contact with liquid nerve agent.

Table 6.1. Treatment of Adults Exposed to Nerve Agent Vapor

Mild Signs and Symptoms:

Atropine:
- 2 mg IV or IM (1 auto-injector)
- Repeat doses at 5 to 10 minute intervals until patient is atropinized.

2-PAM Chloride:
- 1 g by slow IV or 600 mg IM (1 auto-injector)

Moderate Signs and Symptoms:

Atropine:
- 4 mg IV or IM (2 auto-injectors)
- Repeat doses at 5 to 10 minute intervals until patient is atropinized.

2-PAM Chloride:
- 1 g by slow IV (repeat hourly as needed for up to a total of 3 g in 3 hours) or 1200 mg IM (2 auto-injectors)

Severe Signs and Symptoms:

Atropine:
- 6 mg IV or IM (3 auto-injectors)
- Once hypoxemia is reversed, an additional 2 mg IV at 3 to 5 minute intervals may be required to support airways.

2-PAM Chloride:
- 1 to 2 g by slow IV (repeat hourly as needed for up to a total of 3 g in 3 hours) or 1800 mg IM (3 auto-injector)

Diazepam:
- 10 mg IM or 5 mg IV (repeat doses as required)

Table 6.2. Treatment for Adults Exposed to Nerve Agent Via Direct Contact

A person exposed to liquid nerve agent should be treated according to the signs and symptoms as a person exposed to nerve agent vapor. Due to the slower uptake, however, onset of symptoms may be delayed for 1 to 2 hours and some symptoms may not appear until after 6 hours.

Mild signs and symptoms: Onset of sweating and muscle fasciculation at site of exposure 1 to 2 hours after exposure should be treated with:

Atropine:

2 mg IM (1 auto-injector)

2-PAM Chloride:

600 mg IM (1 auto-injector) or 1 g slow IV

Moderate signs and symptoms: Onset of GI symptoms more than 6 hours after exposure should be treated with:

Atropine:

2 mg IM (1 auto-injector)

2-PAM Chloride:

600 mg IM (1 auto-injector)

Severe signs and symptoms Same as for vapor exposure.

Atropine:

6 mg IM (3 auto-injector)

2-PAM Chloride:

1 to 2g by slow IV (repeat hourly as necessary for up to 3 g in 3 hours).

Dosages for Adolescents, Children, and Infants

A different antidote treatment regimen is recommended for non-adults suffering from nerve agent intoxication. The prescribed dosages of atropine for these people are based on age, while dosages of 2-PAM Chloride are based on body weight. Table 6.3 lists the recommended dosages for non-adult patients.

Table 6.3. Treatment of Adolescents, Children, and Infants

Treatment varies depending on age and body weight of child or adolescent. The adult-size atropine and 2-PAM Chloride auto-injectors should never be given to infants.

Atropine: (depends on age)

Repeat doses for all age groups as clinically indicated until patient is atropinized.

Less than 2 years:	0.5 mg IV or IM
2 to 10 years:	1 mg IV or IM
Over 10 years or adolescent:	2 mg IV or IM (1 auto-injector)

2-PAM Chloride: (depends on body weight)

Less than 50 lbs. (22.7 kg):	15 mg per kg of body weight by slow IV
Over 50 lbs.:	600 mg IM (1 auto-injector) Repeat doses at hourly intervals as clinically indicated (no more than twice).

Diazepam: (depends on age)

Infants over 30 days to children age 5 years:
0.2 mg to 0.5 mg per kg of body weight slowly every 2 to 5 minutes, up to a maximum total dose of 5 mg IV or IM

Children over 5 years:
1 mg every 2 to 5 minutes, up to maximum total dose of 10 mg

How Much Atropine is Enough?

most patients are underdosed

Frequently mentioned in this study guide is the fact that atropine treatment tends to be **underdosed** rather than overdosed. While there is an optimum dosage, that exact amount is often difficult to determine because the exact amount of nerve agent exposure is often impossible, or difficult at best, to determine. To help answer the question, "How much atropine is enough?", use the following guidelines for atropine administration:

Guidelines For Atropine/2-PAM Administration:

1. Make sure atropine is warranted before it is given. The second most common error is giving atropine when the only sign is miosis.

2. Administer the dosage of atropine recommended in Table 6.1, 6.2, or 6.3. Follow up with the recommended dosage of 2-PAM chloride.

3. Continue administering the prescribed dosages of atropine as recommended in Tables 6.1, 6.2, and 6.3 until signs of "atropinization" appear.

4. If needed, repeat dosage of 2-PAM chloride, as recommended in Tables 6.1, 6.2, and 6.3, until maximum total dose has been given.

"atropinization"

"Atropinization" is the term used to describe the noticeable signs that a nerve agent patient has received ample amounts of atropine—the effect of treating with sufficient atropine to decrease respiratory symptoms, relieve bronchospasm, stop sweating, and relieve diarrhea and abdominal cramping under the influence of atropine. Recognition of "atropinization" helps to determine that the patient is not underdosed (a common mistake made by care providers when treating nerve agent patients).

Watch for these signs and symptoms to determine that enough atropine has been given:

atropinization:

- secretions are dry (eyes, nose, bronchi, and mouth are no longer runny)
- breathing is easy

supplies of Atropine

A severely affected patient may need up to 20 mg of atropine the first day. A single patient may require up to four injections, if symptoms dictate, on the way to the hospital.

Atropine Overdose

better to overdose

Adverse side effects can result if atropine is given to a person who has not been exposed to a nerve agent. Although the most common mistake in providing atropine treatment (when nerve agent exposure is positive) is to underdose rather than overdose, an overdose of atropine can result in undesirable effects. Most likely, however, atropine poisoning is caused when it is given but was not needed at all. In comparing the consequences of both mistakes regarding atropine administration, overdosing is far less serious. Atropine overdose is not usually life-threatening.

Signs and Symptoms of Atropine Overdose

The following signs and symptoms help to identify atropine effects.

Dilated (large) Pupils

eyes

The patient's pupils are dilated. Notice that this effect is directly the opposite effect of the nerve agent. The nerve agent causes miosis, or pinpointing of the pupils. When too much atropine is introduced the pupils are opened almost completely.

Dry Mouth and Skin

The patient's mouth and skin are dry. Notice that this effect is also the direct opposite of the nerve agent effect. While the nerve agent induces sweating and copious salivation, atropine overdose causes dryness, and:

atropine overdose effects

- Rapid pulse
- Red (flushed) skin
- Difficulty urinating
- Confusion; visual hallucinations; delirium

- Temperature control is diminished, resulting in high fever and hot skin
- Intense thirst
- Restlessness

Differential Diagnosis of Atropine Overdose

Other causes have been known to produce similar signs:

- Heat stroke
- Locoweed
- Atropine-like medicines used in treating ulcers or other conditions

Treatment for Atropine Overdose

- Keep cool.
- Protect from irrational actions.
- Transport to hospital as soon as possible.

Alternate Method of Administration of Antidotes

auto-injectors

Pre-measured amounts of atropine (2 mg) and 2-PAM Chloride (2-PAM Cl; 600 mg) antidotes are available in commercially available auto-injectors. Auto-injectors have been approved for civilian use by the Food and Drug Administration in instances involving nerve agents and organophosphorus (OP) insecticides. Auto-injectors are simple, compact injection systems that come equipped with a pre-measured amount (dose) of antidote. Atropine auto-injectors are approved for adults and children, but not for infants; 2-PAM Cl auto-injectors have only been approved for adults. The shelf life of atropine and 2-PAM Cl in auto-injectors is approximately 5 years. Detailed and practical information on the administration of antidotes via autoinjectors is available in the CSEPP training course, *Use of Autoinjectors by Civilian Emergency Medical Personnel to Treat Civilians Exposed to Nerve Agent.*

It has been standard medical policy that age, sex, weight and health of all patients must first be considered when determining the amount of atropine and 2-PAM Cl to administer.

check your state laws

Each state has its own laws and regulations governing the services extended by medical personnel, and can make its own determinations regarding method of administration.

Respiratory Support

anticipate respiratory support only if exposure severe

Respiratory support may be required and should be anticipated as part of treatment for nerve agent exposure if exposures are severe. Remember, the chief cause of death due to severe nerve agent exposure is respiratory failure. Difficulty in breathing is also one of the major symptoms of nerve agent poisoning.

If the patient has been exposed to a moderate to heavy dose of nerve agent, it is quite likely that respiratory support will be necessary. This support may range from administering oxygen (if breathing is difficult) to providing ventilation, airway management and suctioning secretions as needed.

In severe nerve agent poisonings, it may not be possible to correct respiratory trouble until enough atropine is given. This is because of the intense bronchoconstriction and heavy secretions that are characteristic of severe poisoning.

Ventilation

higher pressure

In some cases, ventilation may be required. If the patient must be ventilated, the insertion of an endotracheal tube by a qualified person is recommended. High pressure is required to overcome the resistance of the narrowed airways and increased secretions.

check ventilator limitation

up to 70^+ CMH_2O pressure may be needed

Some respirating devices, including some that are common on ambulances "pop-off" at about 40–45 cm H_2O and will not deliver the pressure needed. If this is true of your equipment, and if you are treating a severely poisoned adult who is "un-atropinized", this will not be enough pressure to ventilate. Check the pressure relief rating of your manual or powered respirator. Up to 70^+ cm H_2O pressure may be needed to ventilate severely poisoned patients.

Resuscitation

If breathing has stopped, give artificial respiration using an approved mask-bag oxygen delivery system.

6.3 Blister Agent Exposure: Initial First Aid Treatment

Treatment for a blister agent exposure must be immediate. There is no available antidote for blister agent poisoning. The best first aid treatment that can be offered consists of immediate removal and decontamination, use of sterile technique, and airway management as necessary.

Treatment Details

This section provides pertinent details on each of the critical steps of blister agent initial emergency treatment.

Sterile Technique

protect skin from infection

If the blister agent patient is suffering from severe blistering, take precaution after decontamination is complete to protect the injured skin area from infection.

Treatment for Eye Contact

If the agent has gotten to the eyes, speed in decontamination is especially critical. Irreversible damage may be done to the eyes and skin very quickly, even though the effects of this damage may not begin to appear for several hours.

flush eyes immediately

To the patient, the effects of blister agent are first evident in the eyes, though onset may take 1–3 hours. Flush the eyes immediately with water 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. Make sure that hands and fingers used in this procedure are not contaminated with agent.

photophobia

If the eyes have been exposed to a blister agent the person may experience photophobia (sensitivity to light). Dark or opaque glasses help shield the eyes from the light and provide relief from photophobia.

Treatment for Skin Contact

blister gent is more likely to "burn" in body crevices

When performing decontamination procedures for blister agents, pay special attention to skin creases (groin, armpits, behind ears, between fingers, etc.). These are the areas where the agent is most likely to cause severe blistering.

Once at the hospital, additional treatment for the blisters may be given, as determined by the attending physician. This may include, administration of antibiotics (including application of topical antibiotics) and other treatments common for burn injuries. Calamine or other soothing lotions to relieve burning may be all that is needed if the only effect is a rash.

Treatment for Inhalation

respiratory support

Respiratory support may be required if the patient has inhaled significant amounts of blister agent. If blisters have formed in the respiratory tract, breathing may be difficult. Administer oxygen as needed.

If breathing has stopped, resuscitate the person. Additional intravenous fluids may be needed, but fluid replacement is not as serious a problem as it would be for thermal burns affecting the same area. Do not overload with intravenous fluids.

Initial First Aid Treatment for Lewisite

Decontamination of the exposed person should occur immediately, particularly in cases of liquid exposure, in order to avoid deep burns.

British Anti-Lewisite (BAL) ointment (dimercaprol), was developed by British toxicologists prior to World War II to be used as an antidote for Lewisite and arsenical poisoning. However, the antidote is not manufactured at this time.

Self-Check

Assess your understanding of the material presented in this chapter by completing the following Self-Check.

Multiple Choice

6-1. The FIRST step in providing treatment to a patient of nerve or blister agent exposure is

a. protect yourself
b. stop the bleeding
c. decontaminate the patient
d. transport to the hospital

6-2. The FAST steps for nerve agent exposure patients must be done

a. immediately
b. within 48 hours of the time of exposure
c. by licensed EMTs under official supervision of the U.S. Army

6-3. The authority to administer atropine/2-PAM chloride under emergency conditions is granted by

a. FEMA
b. the U.S. Army
c. the CSEPP Program
d. local or state statutes

6-4. The antidote for patients of nerve agent exposure consists of the following drug or drug combination

a. atropine only
b. 2-PAM chloride only
c. both atropine and 2-PAM chloride
d. either atropine or 2-PAM chloride

6-5. Nerve agent antidotes may be administered

a. intramuscularly (IM)
b. intravenously (IV)
c. with a MARK I Chemical Agent Treatment kit
d. any of the above

6-6. The best indicator used to ensure that adequate amounts of atropine are given is

a. signs of atropinization
b. the disappearance of miosis
c. blood pressure of 110/90 or lower
d. the disappearance of the skin rash

6-7. The most common mistake made when administering atropine is

a. overdosing
b. underdosing

6-8. Atropine overdose may occur by administering atropine

a. in doses that are too small
b. without administering 2-PAM chloride
c. when the person has not been exposed to a nerve agent
d. when the person has not been exposed to a blister agent

6-9. By far, the MOST serious of the conditions listed below is

a. atropine underdosing
b. atropine overdosing
c. not giving atropine when it is needed
d. giving atropine without giving 2-PAM chloride

6-10. In order to determine if additional atropine is needed after the initial dose, an adult patient with severe signs and symptoms of nerve agent exposure should be re-evaluated

a. continually, every 30 minutes
b. continually, every 3-5 minutes
c. at the scene, before transport, at the receiving hospital
d. once at the scene and then again, if necessary, at the receiving hospital

6-11. When treating a blister agent exposure patient, sterile precautions may be necessary because

a. the fluid in the blisters can spread the agent
b. sterile technique accomplishes the same results as decontamination
c. damage done to the skin can permit infection if the blisters are severe
d. treatment provided later, at the hospital, requires that the blisters be as sterile as possible for testing

Short Answer

6-12. List 2 main FAST (first aid & special treatment) steps required for nerve agent exposure patients.

a. _____
b. _____

6-13. List 2 main FAST (first aid & special treatment) steps that may be necessary for blister agent exposure patients.

a. _____
b. _____

6-14. List 2 specific signs that signify that sufficient atropine has been administered

a. _____
b. _____

Summary

The most important points that you should have learned from this key chapter are:

- The Number 1 Rule in providing treatment for nerve or blister agent exposure is: PROTECT YOURSELF.

  It is assumed that patients will have been decontaminated before being brought to EMS personnel in the cold zone. Information regarding decontamination or removal from contaminated areas should not be interpreted as encouraging EMS personnel to go into the hot zone. Only persons who are properly equipped and trained in accordance with applicable OSHA regulations should conduct rescue or decontamination operations in contaminated areas.

  You can protect yourself by:

  1. recognizing the area with exposure potential and the zones set up to operate safely during the emergency, and
  2. ensuring the exposed person is completely decontaminated.

- The initial treatment (first-aid) for nerve agent patients is:

  - Give atropine, followed by 2-PAM chloride (administration of antidote compounds by non-physicians varies among states)
  - As necessary, support airway management

- The initial treatment (first-aid) for blister agent patients:

  - Ensure that patient is decontaminated
  - If necessary, take precautions for sterile technique and support airway management as necessary.

- Atropine overdose can occur if given when there has been no exposure to nerve agent.

APPENDIX A SOURCE DOCUMENTS AND REVIEW PUBLICATIONS)

Many publications were reviewed in the development of this Study Guide, but the major sources are from the course materials used by the Army in the Medical Management of Chemical Exposures Course (Dr. Frederick Sidell), the Centers for Disease Control Medical Management of Chemical Exposures Course (Dr. Sanford Leffingwell), and other publications recommended to us by our reviewers.

Blewett, William K. June 1986. " Tactical Weapons: Is Mustard Still King?", in *NBC Defense and Technology International* **1**(3), pp. 64–66.

Carnes, S.A. 1989. *Site-Specific Emergency Response Concept Plans For the Chemical Stockpile Disposal Program: A Comparative Summary***,** ORNL/TM-11357, Oak Ridge National Laboratory, Oak Ridge, TN.

Carnes, S.A. and A.P. Watson 1989. "Disposing of the U.S. Chemical Weapons Stockpile: An Approaching Reality*," J. of the American Medical Association* **,** Vol. 262, No. 5, 653–659.

Chemical Stockpile Disposal Program Final Programmatic Environmental Impact Statement, Vols. 1, 2 and 3, December 1987. U.S. Department of the Army.

Clement Associates, Inc., September 1992. *Toxicological Profile for Mustard "Gas"* TP-91/92, Agency for Toxic Substances and Disease Registry, Public Health Service, U.S. Department of Health and Human Services.

D'Halluin, F. and H. Roels, May 21–23, 1984. "Autopsy Observations in an Iranian Soldier Exposed to War Gas," in *Proceedings of the First World Congress on New Compounds in Biological and Chemical Warfare: Toxicological Evaluation*, State University of Ghent and the National Science Foundation of Belgium, Ghent, pp. 284–290.

Dunn, P. April 1986. " The Chemical War: Journey to Iran," in *NBC Defense and Technology International 1*, pp. 29–37.

Dunn, P. June 1986. " The Chemical War: Iran Revisited—1986," in *NBC Defense and Technology International* **1**(3), pp. 32–37.

Emergency Management Institute April 1992. *Hazardous Materials Workshop for EMS Providers, Student Manual*.

Gosselin, R.E., R.P. Smith, H.C. Hodge, and J.E. Braddock 1984. *Clinical Toxicology of Commercial Products*, Fifth Edition, Williams and Wilkins, Baltimore, MD.

Hafen, B.Q. and K.J. Karren 1989. *Prehospital Emergency Care and Crisis Intervention,* Third Edition, Morton Publishing Company, Englewood, CO.

Heyndrickx, A. and B. Heyndrickx May 21–23, 1984. "Comparison of the Toxicological Investigations in Man in Southeast Asia, Afghanistan and Iran, Concerning Gas Warfare," in *Proceedings of the First World Congress on New Compounds in Biological and Chemical Warfare: Toxicological Evaluation*, State University of Ghent and the National Science Foundation of Belgium, Ghent, pp. 426–434.

Leffingwell, S.S. *Medical Management of Chemical Exposures Course*, U.S. Public Health Service, Centers for Disease Control, Atlanta, GA.

Mandl, H. and G. Freilinger May 21–23, 1984. "First Report on Victims of Chemical warfare in the Gulf-war Treated in Vienna," in *Proceedings of the First World Congress on New Compounds in Biological and Chemical Warfare: Toxicological Evaluation*, State University of Ghent and the National Science Foundation of Belgium, Ghent, pp. 330–340.

Munro, N., A. Watson, K. Ambrose, and G. Griffin 1990. "Treating Exposure to Chemical Warfare Agents: Implications for Health Care Providers and Community Emergency Planning," *Environmental Health Perspectives*, Vol. 89, pp. 205–215.

National Defence Research Institute June 1983. *Chemical Warfare Agents*, Stockholm, Sweden.

Rogers, G.O., A.P. Watson, J.H. Sorensen, R. Sharp, and S.A. Carnes 1990. *Evaluating Protective Actions for Chemical Agent Emergencies*, ORNL/TM-6615, Oak Ridge National Laboratory, Oak Ridge, TN.

Science Applications International Corporation 1999. *Toxic Chemical Training for Medical Support Personnel,* Edgewood, MD.

Sidell, F.R., et. al. 1990. *Medical Management of Chemical Exposures Course*, U.S. Army Medical Research Institute of Chemical Defense, Aberdeen Proving Ground, MD.

Sidell, F.R. 1990. *Clinical Notes on Chemical Casualty Care*, USAMRICD Technical Memorandum 90-2, U.S. Army Medical Research Institute of Chemical Defense, Aberdeen Proving Ground, MD.

Sidell, F.R. August 14, 1990. *Clinical Notes on Chemical Casualty Care*, USAMRICD Technical Memorandum 90-1, U.S. Army Medical Research Institute of Chemical Defense, Aberdeen Proving Ground, MD.

Stewart, C. MD, FACEP March 1991. "Chemical Weapons", *Emergency Medical Services* 20(3), pp. 38–69.

U.S. Army Chemical Research, Development and Engineering Center December 3, 1990. *Material Safety Data Sheets for GB, GA, VX, HT, HD, and L*, Aberdeen Proving Ground, MD.

U.S. Department of the Army May 1991. *Chemical Accident or Incident Response and Assistance (CAIRA) Operations*, Pamphlet 50-6.

U.S. Department of the Army December 1974. *Chemical Agent Data Sheets, Volume 1*, Edgewood Arsenal Special Report, EO-SR-74001, Edgewood Arsenal, Aberdeen Proving Ground, MD.

U.S. Department of the Army, Navy, and Air Force February 1990. *Field Manual for Treatment of Chemical Agent Casualties and Conventional Military Chemical Injuries*, ARMY FM 8-285, NAVY NAVMED P-5041, AIR FORCE AFM 160-11.

U.S. Department of Health and Human Services. *Results of a Workshop Meeting to Discuss Protection of Public Health and Safety During Reentry into Areas Potentially Contaminated with a Lethal Chemical Agent (GB, VX, or Mustard Agent),* availability announced in *55Federal Register 28940*.

U.S. Department of Transportation, National Highway Traffic Safety Administration August 1986. *Emergency Medical Technician—Paramedic: National Standard Curriculum, Course Guide,* DOT HS 900 088.

U.S. Department of Transportation, National Highway Traffic Safety Administration August 1986*. Emergency Medical Technician—Intermediate: National Standard Curriculum, Course Guide*, DOT HS 900 090.

U.S. Department of Transportation, National Highway Traffic Safety Administration January 1983. *Emergency Medical Care, A Manual for the Paramedic in the Field*, DOT HS 805 548.

U.S. Department of Transportation, National Highway Traffic Safety Administration August 1986*. Emergency Medical Technician—Intermediate: National Standard Curriculum, Course Guide*, DOT HS 900 090.

U.S. Department of Transportation, National Highway Traffic Safety Administration March 1979. *Emergency Medical Services: First Responder Training Course Guide*, DOT HS 900 025; *Student Study Guide*, DOT HS 900 027.

Watson, A.P., F.R. Sidell, S.S. Leffingwell, and N.B. Munro January 1992. *General Guidelines for Medically Screening Mixed Population Groups Potentially Exposed to Nerve or Vesicant Agents*, ORNL-TM-12034, Oak Ridge National Laboratory, Oak Ridge, TN.

Watson, A., K. Ambrose, G. Griffin, S. Leffingwell, N. Munro, and L. Waters 1988. "Health Effects of Warfare Agent Exposure: Implications for Stockpile Disposal*," Environmental Professional***,** Vol.10, pp. 335–353.

APPENDIX B GLOSSARY

Acetylcholine	A chemical compound formed from an acid and an alcohol which causes muscles to contract. It is found in various organs and tissues of the body. It is rapidly broken down by an enzyme, cholinesterase. Excessive production of acetylcholine at the motor endplates (such as found in nerve agent poisoning) may block the transmission of impulses between nerve cells and muscles.
Acetylcholinesterase	An enzyme which normally stops the action of acetylcholine. This occurs as soon as acetylcholine has produced a muscle contraction. Nerve agents combine with acetylcholinesterase to prevent it from inactivating acetylcholine.
Antidotes	A substance used to counteract adverse effects resulting from toxic agent exposure. Nerve agent antidotes (atropine and 2-PAM Chloride) block the effects of agent-induced skeletal and smooth muscle contraction (relieve convulsions and loss of breathing control) and reduce glandular paralysis (dry up the excess respiratory secretions that make normal breathing difficult). There are no specific antidotes for mustard agent poisoning because the agent reacts too quickly with body tissue.
Atropine	A medication used as an antidote to organophosphate poisoning such as might result from exposure to nerve agents or some insecticides. Atropine counteracts the excess acetylcholine that accumulates at nerve endings thus relieving the bronchoconstriction and bronchosecretions that interfere with breathing. Atropine cannot reverse respiratory muscle paralysis. It is best to use 2-PAM Cl with atropine.
Atropinization	The presence of noticeable signs that a nerve agent patient has received ample amounts of atropine. Secretions will be dry and ventilation easy; conscious patients will be breathing comfortably.

Blister (vesicant) agent	A chemical warfare agent which produces local irritation and damage to the skin and mucous membranes, pain and injury to the eyes, reddening and blistering of the skin, and, when inhaled, damage to the respiratory tract. Blister agents include mustards (HD, H and HT), and arsenicals (L).
Bradycardia	Heart rate less than 50.
Bronchitis	Inflammation of either of the two primary divisions of the trachea that head to the lungs; produces chronic cough.
Bronchoconstriction	Constriction of the bronchial tubes which tends to trap air in the lungs.
Bronchopneumonia	Pneumonia involving many relatively small areas of lung tissue; usually affects both lungs.
Carcinogen	Any cancer-causing substance.
Chemical event	A term used by the military that includes (1) chemical accidents and leaks resulting from nondeliberate events where safety is of primary concern, or (2) chemical incidents resulting from deliberate acts or chemical acts where security is a concern.
Chemical warfare agent	A chemical substance which, because of its physiological, psychological, or pharmacological effects, is intended for use in military operations to kill, seriously injure, or incapacitate humans (or animals) through its toxicological effects.
Cholinergic	Referring to acetylcholine or nerve endings which liberate acetylcholine. Acetylcholine transmits the nerve impulse across the neuromuscular junction.
Ciliary muscles	The muscles which dilate and contract the pupil of the eye.

Ciliary spasm	Spasm of the muscles of the eyelids which are usually painful and may interfere with functioning of the eyelid.
Conjunctiva	The delicate membrane that lines the eyelids and covers the exposed surface of the white of the eye.
Conjunctivitis	Inflammation of the conjunctiva.
Contamination	The deposition of chemical agents on personnel, clothing, equipment, structures, or areas. Chemical contamination consists of liquid, solid particles, and vapor hazards. Vapor hazards are probably the most prevalent means of contaminating the environment, although they are not necessarily a contact hazard.
Cornea	The clear, transparent front portion of the eye, comprising about one-sixth of its surface through which light passes to transmit images to the retina.
Cutaneous	Pertaining to the skin
Chemical Stockpile Disposal Program (CSDP)	The Congressionally mandated program that requires the Army to dispose of all its unitary chemical agents.
Chemical Stockpile Emergency Preparedness Program (CSEPP)	A joint DA/FEMA program to oversee and assist in the development of emergency response plans and capabilities for all jurisdictions that might be affected by a chemical agent release associated with stockpile storage or CSDP activities.
Cholinesterase (Ache)	Acetylcholinesterase is the enzyme which normally breaks down the neurotransmitter acetylcholine after it has transmitted a signal from a nerve ending to another nerve, muscle, or gland. Organophosphate pesticides and military nerve agents block the normal activity of AChe which results in the accumulation of excess acetylcholine at nerve endings.

Contamination	The deposition of chemical agents on personnel, clothing, equipment, structures, or areas. Chemical contamination consists of liquid, solid particles, and vapor hazards. Vapor hazards are probably the most prevalent means of contaminating the environment, although they are not necessarily a contact hazard.
Decontamination	The process of sufficiently reducing the hazard caused by chemical agents. Generally used methods for skin decontamination include removal and/or chemical neutralization of agent(s) for medical purposes, removal of clothing; for equipment, the methods are removal, destruction, covering, weathering, and chemical neutralization.
Dermatitis	An inflammation of the skin.
Edema	Swelling of the tissue due to an excessive accumulation of fluid.
Emphysema	A condition in which air spaces in the lungs are enlarged; usually accompanied by labored breathing, a husky cough, and frequently by impaired heart action.
Endotracheal tube	A tube inserted into the trachea to maintain an open and unobstructed airway and prevent aspiration.
Erythema	Red area of the skin, caused by heat or cold injury, trauma, or inflammation.
Fasciculation	Localized contraction or twitching of muscle fibers, usually visible through the skin.
Flaccid paralysis	Loss of muscle tone and capability to function. Nerve agents cause this condition.
G-agent	A liquid nerve agent such as GA, GB, or GD
GB	See nerve agent.
H	See mustard agent.

HD	See mustard agent.
HT	See mustard agent.
Hypermia	An increased amount of blood in an organ or other part of the body.
Hypoxemia	Deficient oxygenation of the blood.
Lacrimation	Secretion and discharge of tears.
Latent period	Specifically in the case of mustard, the period between exposure and onset of signs and symptoms; otherwise, an incubation period.
Lewisite	A lethal war gas. It is a fast-acting vesicant, tear-producer, and lung irritant (chlorovinyldichloroarsine). (Only located at Deseret Chemical Depot)
Miosis	Pinpoint or small pupils.
Muscarinic	A specific type of poisoning resulting from excess acetylcholine due to inhibition of acetylcholinesterase. The result is decrease in heart rate, bronchoconstriction and stimulation of saliva and tear glands.
Mustard agent	A vesicant chemical warfare agent (H, HD, and HT) which has been used extensively in warfare. Creates destruction of epidermis, eye and pulmonary injury, and, in high doses, bone marrow depression.
Necrosis	Death of tissue.
Nerve agent	Lethal organophosphate agents (GA, GB, and VX) that are colorless and odorless. Can be fatal upon skin contact or when inhaled or ingested; attack the central nervous system by inhibiting the essential production of acetylcholinesterase.

Nicotinic	Referring to the toxic effect of nicotine on autonomic ganglia, initially stimulating then inhibiting neural impulses at the ganglia level as well as the neuromuscular junction.
Organophosphate	A compound with a specific phosphate group which inhibits acetylcholinesterase. Used in chemical warfare and as an insecticide.
OSHA	Occupational Safety and Health Administration: responsible for workplace safety regulation, including HazMat responders training standards.
2-PAM Cl	Pralidoxime chloride, a.k.a. Pralidoxime or Protopam®, is an antidote to organophosphate poisoning such as might result from exposure to nerve agents or some insecticides. The drug, which helps restore an enzyme called acetylcholinesterase, must be used in conjunction with atropine to be effective. Restores normal control of skeletal muscle contraction (relieves twitching and paralysis).
Percutaneous	Through the skin, such as applying an ointment with medication or injection by needle.
Persistent agent	A chemical agent that continues to present a hazard for considerable periods after delivery, by remaining as a contact hazard and/or by vaporizing very slowly to produce a hazard by inhalation. Generally, may be in a solid or liquid state.
Pneumonia	Inflammation of the lungs, usually caused by an infective agent. May be secondary to injury to the lungs.
Pulmonary edema	The accumulation of excess fluid in the lungs producing severe shortness of breath. In later stages, produces cyanosis and the coughing up of frothy pink serous fluid.
Rhinorrhea	Thin watery discharge from the nose.

Sarin	A nerve agent of organophosphate group which inhibits acetylcholinesterase. Is used in chemical warfare. (GB)
Systemic poison	A poison that affects the whole body.
Tabun	A nerve agent member of the organophosphate group which inhibits acetylcholinesterase. Is used as a chemical warfare agent. Is the least toxic of the nerve agents but can cause death rapidly. (GA - only in stockpile at Deseret Chemical Depot)
Toxic chemical agent	Any chemical agent that is toxic, which creates a casualty, incapacitates, or kills.
V-Agent (VX)	A nerve agent of the organophosphate group that inhibits acetylcholinesterase.
Vesicant	A chemical blister agent which injures the eye and the lungs and burns or blisters the skin. Examples are H, HT, HD, and L.
Vesication	Blistering.

APPENDIX C MATERIAL SAFETY DATA SHEETS (MSDS)

Contents

APPENDIX C. MATERIAL SAFETY DATA SHEETS
C.1 MSDS Nerve Agent GA (Tabun)
C.2 MSDS Nerve Agent GB (Sarin)
C.3 MSDS Nerve Agent VX
C.4 MSDS Blister Agent Mustard (H, HD, HT)
C.5 MSDS Blister Agent Lewisite (L)

Up-to-date versions of the MSDSs for the chemical warfare agents are maintained by the U.S. Army Soldier Biological and Chemical Command on their website. As of the publication date of the Act Fast course, this material can be accessed at the following url:

http://in1.apgea.army.mil:80/RDA/msds/index.htm

C.1 MSDS Nerve Agent GA (Tabun)

Material Safety Data Sheet

Tabun (GA)

Date: 22 September 1988
Revised: 28 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 Registry Numbers: 77-81-6

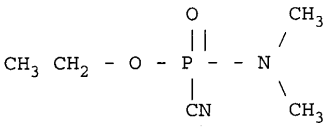
Chemical Name: Ethyl N,N-dimethylphosphoramidocyanidate

Trade Name and Synonyms:
Ethyl dimethylphosphoramidocyanidate
Dimethylaminoethoxy-cyanophosphine oxide
Dimethylamidoethoxyphosphoryl cyanide
Ethyldimethylaminocyanophosphonate
Ethyl ester of dimethylphosphoroamidocyanidic acid
Ethyl phosphorodimethylamidocyanidate
GA
EA1205
Tabun

Chemical Family: Organophosphorus compound

Formula/Chemical Structure:

$C_5H_{11}N_2O_2P$



NFPA 704 Signal:

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

Section II - Ingredients

Ingredients/Name: GA

Percentage by Weight: 100%

Threshold Limit Value (TLV): 0.0001 mg/m^3

Section III - Physical Data

Boiling Point @ 760 mm Hg: 478 °F (248 °C)

Vapor Pressure: 0.057 mm Hg @ 25 °C

Vapor Density (Air = 1 STP): 5.59 @25 °C

Solubility (g/100g solvent): Slightly soluble in water, 9.8 @ 0 °C; 7.2 @ 20 °C. Readily soluble in organic solvents.

Specific Gravity (H_20=1g/mL@25 °C): 1.076

Freezing/Melting Point (°C): -50 °C

Liquid Density (g/cc): 1.073 @ 25 °C

Volatility (mg/m^3): 490 @ 25 °C

Viscosity (CENTISTOKES): 2.18 @ 25 °C

Appearance and Odor: Colorless to brown liquid, faintly fruity odor. Odorless in pure form.

Section IV - Fire And Explosion Data

Flashpoint: 78 °C (Closed Cup Method)

Flammability Limits (% By Volume): Not Available

Lower Explosive Limit: Not Available

Upper Explosive Limit: Not Available

Extinguishing Media: Water mist, fog, and foam, CO_2. Avoid using extinguishing methods that will cause splashing or spreading of the GA.

Special Fire Fighting Procedures: GA will react with steam or water to produce toxic and corrosive vapors. All persons not engaged in extinguishing the fire should be immediately evacuated from the area. Fires involving GA should be contained to prevent contamination to uncontrolled areas. When responding to a fire alarm in buildings or areas containing GA, fire-fighting personnel should wear full fire-fighter protective clothing during chemical agent fire-fighting and fire rescue operations. Respiratory protection is required. Positive pressure, full face piece, 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 fire-fighters 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 nerve 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 liquid GA or vapors can be fatal.

Unusual Fire and Explosion Hazards: Fires involving this chemical may result in the formation of hydrogen cyanide.

Section V - Health Hazard Data

Airborne Exposure Limits (AEL): The permissible airborne exposure concentration for GA for an 8-hour workday of a 40-hour workweek is an 8-hour time weighted average (TWA) of 0.0001 mg/m^3. This value can be found in "DA Pam 40-8, Occupational Health Guidelines for the Evaluation and Control of Occupational Exposure to Nerve Agents GA, GB, GD, and VX." To date, however, the Occupational Safety and Health Administration (OSHA) has not promulgated a permissible exposure concentration for GA.

GA is not listed by the International Agency for Research on Cancer (IARC), American Conference of Governmental Industrial Hygienists (ACGIH), Occupational Safety and Health Administration (OSHA), or National Toxicology Program (NTP) as a carcinogen.

Effects of Overexposure: GA is a lethal cholinesterase inhibitor similar inaction to GB. Although only about half as toxic as GB by inhalation, GA in low concentrations is more irritating to the eyes than GB. The number and severity of symptoms that appear are dependent on the quantity and rate of entry of the nerve agent introduced into the body. (Very small skin dosages sometimes cause local sweating and tremors with few other effects.) Individuals poisoned by GA display approximately the same sequence of symptoms' despite the route by which the poison enters the body (whether by inhalation, absorption, or ingestion). These symptoms, in normal order of appearance, are: runny nose; tightness of the chest; dimness of vision and pin pointing of the eye pupils; difficulty in breathing; drooling and excessive sweating; nausea; vomiting, cramps, and involuntary defecation and urination; twitching, jerking, and staggering; and headache, confusion, drowsiness, coma, and convulsions. These symptoms are followed by cessation of breathing and death.

Onset Time of Symptoms: Symptoms appear much more slowly from a skin dosage than from a respiratory dosage. Although skin absorption great enough to cause death may occur in 1 to 2 minutes, death may be delayed for 1 to 2 hours. Respiratory lethal dosages kill in 1 to 10 minutes, and liquid in the eye kills almost as rapidly.

Median Lethal Dosage, Animals:

LD50 (monkey, percutaneous) = 9.3 mg/kg (shaved skin)

LCt50 (monkey, inhalation) = 187 mg-min/m(t = 10)

Median Lethal Dosage, Man:

LCt50 (man, inhalation) = 135 mg-min/m[(t = 0.5-2 min) at RMV (Respiratory Minute Volume) of 15 l/min];

200 mg-min/m[T at RMV of 10 l/min]

Emergency and First Aid Procedures:

Inhalation: Hold breath until respiratory protective mask is donned. If severe signs of agent exposure appear (chest tightens, pupil constriction, in coordination, etc.), immediately administer, in rapid succession, all three Nerve Agent Antidote Kit(s), Mark I injectors (or atropine if directed by a physician). Injections using the Mark I kit injectors may be repeated at 5 to 20 minute intervals if signs and symptoms are progressing until three series of injections have been administered. No more injections will be given unless directed by medical personnel. In addition, a record will be maintained of all injections given. If breathing has stopped, give artificial respiration. Mouth-to-mouth resuscitation should be used when mask-bag or oxygen delivery systems are not available. Do not use mouth-to-mouth resuscitation when facial contamination exists. If breathing is difficult, administer oxygen. Seek medical attention **Immediately**.

Eye Contact: Immediately flush eyes with water for 10-15 minutes, then don respiratory protective mask. Although miosis (pinpointing of the pupils) may be an early sign of agent exposure, an injection will not be administered when miosis is the only sign present. Instead, the individual will be taken **Immediately** to a medical treatment facility for observation.

Skin Contact: Don respiratory protective mask and remove contaminated clothing. **Immediately** wash contaminated skin with copious amounts of soap and water, 10% sodium carbonate solution, or 5% liquid household bleach. Rinse well with water to remove excess decontaminant. Administer nerve agent antidote kit, Mark I, only if local sweating and muscular twitching symptoms are observed. Seek medical attention **Immediately.**

Ingestion: Do not induce vomiting. First symptoms are likely to be gastrointestinal. **Immediately** administer Nerve Agent Antidote Kit, Mark I. Seek medical attention **Immediately.**

Section VI - Reactivity Data

Stability: Compound is stable in steel for several years.

Incompatibility: Not Available.

Hazardous Decomposition Products: Decomposes within 3 months at 65 °C. Complete decomposition in 195 minutes at 150 °C. May produce hydrogen cyanide (HCN), oxides of nitrogen, oxides of phosphorus, and carbon monoxide.

Hazardous Polymerization: Not available.

Section VII - Spill, Leak, And Disposal Procedures

Steps To Be Taken In Case Material Is Released Or Spilled: If leaks or spills of GA occur, only personnel in full protective clothing will remain in the area (See Section VIII). In case of personnel contamination, see Section V for emergency and first aid instructions.

Recommended Field Procedures: Spills must be contained by covering with vermiculite, diatomaceous earth, clay, fine sand, sponges, and paper or cloth towels. Decontaminate with copious amounts of aqueous sodium hydroxide solution (a minimum 10 wt.%). Scoop up all material and place in a DOT approved container. The decontaminant solution must be treated with excess bleach to destroy the HCN formed during the hydrolysis. Cover the contents with decontaminating solution as above. After sealing, decontaminate the exterior 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 material 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).

If 10 wt.% aqueous sodium hydroxide is not available, then the following decontaminants may be used instead and are listed in the order of preference: Decontaminating Agent (DS2), Sodium Carbonate, and Supertropical Bleach Slurry (STB).

Recommended Laboratory Procedures:

A minimum of 56 grams of decon solution is required for each gram of GA. The decontamination solution is agitated while GA is added and the agitation is maintained for at least one hour. The resulting solution is allowed to react for 24 hours. At the end of 24 hours, the solution must be titrated to a pH between 10 and 12. After completion of the 24-hour period, the decontamination solution must be treated with excess bleach (2.5 mole OCl/mole GA) to destroy the CN formed during the hydrolysis.

Scoop up all material and clothing. Place all material in a DOT approved container. Cover the contents with decontaminating solution as above. After sealing, decontaminate the exterior of the container and label according to EPA and DOT regulations. All leaking containers will be over packed with sorbent placed between the interior and exterior containers. Decontaminate and label according to EPA and DOT regulations. Dispose of contents and decontaminant 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).

Waste Disposal Method: Open pit burning or burying of GA or items containing or contaminated with GA in any quantity is prohibited. The detoxified GA (using procedures above) can be thermally destroyed by incineration in EPA approved incinerators according to appropriate provisions of Federal, state, and local Resource Conservation and Recovery Act (RCRA) Regulations.

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

Section VIII - Special Protection Information

Respiratory Protection

Concentration

<0.0001 mg/m^3

Respiratory Protective Equipment

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.

Concentration

>0.0001 or = 0.02 mg/m^3

Respiratory Protective Equipment

A NIOSH/MSHA approved pressure demand full face piece SCBA or supplied air respirators with escape air cylinder may be used. Alternatively, a full face piece, chemical canister air-purifying protective mask is acceptable for this purpose (See DA Pam 385-61 for determination of appropriate level)

Concentration

>0.02 mg/m^3 or unknown

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 385-61 for examples)

Ventilation:

Local exhaust: Mandatory. Must be filtered or scrubbed to limit exit concentrations to >0.0001 mg/m^3. Air emissions will 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 GA.

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

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

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

Other Protective Equipment: For laboratory operations, wear lab coats and 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 GA is the M8/M9 detector paper, detector ticket, M256/M256A1 kits, bubbler, Depot Area Air Monitoring System (DAAMS), Automated Continuous Air Monitoring System (ACAMS), Real-Time Monitor (RTM), Demilitarization Chemical Agent Concentrator (DCAC), M8/M43, M8A1/M43A1, CAM-M1, Hydrogen Flame Photometric Emission Detector (HYFED), the Miniature Chemical Agent Monitor (MINICAM), and the Real Time Analytical Platform (RTAP).

Real-time, low-level monitors (with alarm) are required for GA 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: 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 Nerve Agents GA, GB, GD, and VX."

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, organic, n.o.s.

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

DOT Label: Poison

DOT Marking: Toxic liquids, organic, n.o.s. (Ethyl dimethylphosphoramidocyanidate) 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.

This page last updated on 28 September 1999

C.2 MSDS Nerve Agent GB (Sarin)

Material Safety Data Sheet

Lethal Nerve Agent (GB)

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 Registry Numbers:
107-44-8, 50642-23-4

Chemical Name:
Isopropyl methylphosphonofluoridate

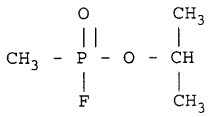
Alternate Chemical Names:
O-Isopropyl Methylphosphonofluoridate
Phosphonofluoridic acid, methyl-, isopropyl ester
Phosphonofluoridic acid, methyl-, 1-methylethyl ester

Trade Name And Synonyms:
Isopropyl ester of methylphosphonofluoridic acid
Methylisopropoxyfluorophosphine oxide
Isopropyl Methylfluorophosphonate
O-Isopropyl Methylisopropoxfluorophosphine oxide
Methylfluorophosphonic acid, isopropyl ester
Isopropoxymethylphosphonyl fluoride
Isopropyl methylfluorophosphate
Isopropoxymethylphosphoryl fluoride
GB
Sarin
Zarin

Chemical Family:
Fluorinated organophosphorous compound

Formula/Chemical Structure:

$C_4H_{10}FO_2P$



NFPA 704 Signal:

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

Section II - Ingredients

Ingredients/Name: GB

Percentage by Weight: 100%

Threshold Limit Value (TLV): 0.0001 mg/m^3

Section III - Physical Data

Boiling Point @ 760 mm Hg: 316 °F (158 °C)

Vapor Pressure (mm Hg): 2.9 @ 25 °C

Vapor Density (Air = 1 STP): 4.83 @ 25 °C

Solubility: Miscible with water. Soluble in all organic solvents.

Specific Gravity (H_20=1g/mL): 1.0919 @ 25 °C

Freezing/Melting Point (°C): -56 °C

Liquid Density (g/cc): 1.0887 @ 25 °C
1.102 @ 20 °C

Volatility (mg/m^3): 22,000 @ 25 °C

Viscosity (CENTISTOKES): 1.283 @ 25 °C

Appearance and Odor: Colorless liquid. Odorless in pure form.

Section IV - Fire and Explosion Data

Flashpoint: Did not flash to 280 &degF (McCutchan - Young)

Flammability Limits (% By Volume): Not Applicable

Lower Explosive Limit: Not Applicable

Upper Explosive Limit: Not Applicable

Extinguishing Media: Water mist, fog, foam, CO_2. Avoid using extinguishing methods that will cause splashing or spreading of the GB.

Special Fire Fighting Procedures: GB will react with steam or water to produce toxic and corrosive vapors. All persons not engaged in extinguishing the fire should be immediately evacuated from the area. Fires involving GB should be contained to prevent contamination to uncontrolled areas. When responding to a fire alarm in buildings or areas containing GB, fire fighting personnel should wear full firefighter protective clothing during chemical agent firefighting and fire rescue operations. Respiratory protection is required. Positive pressure, full face piece, 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 nerve 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 liquid GB or vapors can be fatal.

Unusual Fire And Explosion Hazards: Hydrogen may be present.

Section V - Health Hazard Data

Airborne Exposure Limits (AEL): The permissible airborne exposure concentration for GB for an 8-hour workday of a 40-hour work week is an 8-hour time weighted average (TWA) of 0.0001 mg/m^3. This value can be found in "DA Pam 40-8,Occupational Health Guidelines for the Evaluation and Control of Occupational Exposure to Nerve Agents GA, GB, GD, and VX." To date, however, the Occupational Safety and Health Administration (OSHA) has not promulgated a permissible exposure concentration for GB.

GB is not listed by the International Agency for Research on Cancer (IARC), American Conference of Governmental Industrial Hygienists (ACGIH), Occupational Safety and Health Administration (OSHA), or National Toxicology Program (NTP) as a carcinogen.

Effects Of Overexposure: GB is a lethal cholinesterase inhibitor. Doses which are potentially life-threatening may be only slightly larger than those producing least effects.

Route	*Form*	*Effect*	*Type*	*Dosage*
ocular	vapor	miosis	ECt50	<2 mg-min/m^3
Inhalation	vapor	runny nose	ECt50	<2 mg-min/m^3
Inhalation (15 l/min)	vapor	severe incapacitation	ICt50	35 mg-min/m^3
Inhalation (15 l/min)	vapor	death	LCt50	70 mg-min/m^3
Percutaneous	liquid	death	LD50	1700 mg/70 kg man

Effective dosages for vapor are estimated for exposure durations of 2-10 minutes.

Symptoms of overexposure may occur within minutes or hours, depending upon the dose. They include: miosis (constriction of pupils) and visual effects, headaches and pressure sensation, runny nose and nasal congestion, salivation, tightness in the chest, nausea, vomiting, giddiness, anxiety, difficulty in thinking, difficulty sleeping, nightmares, muscle twitches, tremors, weakness, abdominal cramps, diarrhea, involuntary urination and defecation. With severe exposure symptoms progress to convulsions and respiratory failure.

Emergency And First Aid Procedures:

Inhalation: Hold breath until respiratory protective mask is donned. If severe signs of agent exposure appear (chest tightens, pupil constriction, in coordination, etc.), immediately administer, in rapid succession, all three Nerve Agent Antidote Kit(s), Mark I injectors (or atropine if directed by a physician). Injections using the Mark I kit injectors may be repeated at 5 to 20 minute intervals if signs and symptoms are progressing until three series of injections have been administered. No more injections will be given unless directed by medical personnel. In addition, a record will be maintained of all injections given. If breathing has stopped, give artificial respiration. Mouth-to-mouth resuscitation should be used when mask-bag or oxygen delivery systems are not available. Do not use mouth-to-mouth resuscitation when facial contamination exists. If breathing is difficult, administer oxygen. Seek medical attention **Immediately**.

Eye Contact: Immediately flush eyes with water for 10-15 minutes, then don respiratory protective mask. Although miosis (pinpointing of the pupils) may be an early sign of agent exposure, an injection will not be administered when miosis is the only sign present. Instead, the individual will be taken **Immediately** to a medical treatment facility for observation.

Skin Contact: Don respiratory protective mask and remove contaminated clothing. **Immediately** wash contaminated skin with copious amounts of soap and water, 10% sodium carbonate solution, or 5% liquid household bleach. Rinse well with water to remove excess decontaminant. Administer nerve agent antidote kit, Mark I, only if local sweating and muscular twitching symptoms are observed. Seek medical attention **Immediately.**

Ingestion: Do not induce vomiting. First symptoms are likely to be gastrointestinal. **Immediately** administer Nerve Agent Antidote Kit, Mark I. Seek medical attention **Immediately.**

Section VI - Reactivity Data

Stability: Stable when pure. Plant grade material stablized with tri-n-butylamine can be stored in steel containers for long periods of time at temperatures up to 70 °C, but unstablized material tends to build-up pressure within a few weeks.

Incompatibility: Attacks tin, magnesium, cadmium plated steel, and some aluminum. Slightly attacks copper, brass, and lead; practically no attack on 1020 steels, Inconel and K-monel.

Hazardous Decomposition Products: Hydrolyzes to form HF under acid conditions and isopropyl alcohol and polymers under basic conditions.

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 GB occur, only personnel in full protective clothing will remain in the area (See Section VIII). In case of personnel contamination see Section V for emergency and first aid instructions.

Recommended Field Procedures: Spills must be contained by covering with vermiculite, diatomaceous earth, clay, fine sand, sponges, and paper, or cloth towels. Decontaminate with copious amounts of aqueous sodium hydroxide solution (a minimum 10 wt.%). Scoop up all material and place in a DOT approved container. Cover the contents with decontaminating solution as above. After sealing, the exterior 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 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).

If 10 wt.% aqueous sodium hydroxide is not available then the following decontaminants may be used instead and are listed in the order of preference: Decontaminating Agent (DS2), Sodium Carbonate, and Supertropical Bleach Slurry (STB).

Recommended Laboratory Procedures: A minimum of 56 grams of decon solution is required for each gram of GB. Decontaminant and agent solution is allowed to agitate for a minimum of one hour. Agitation is not necessary following the first hour. At the end of one hour, the resulting solution should be adjusted to a pH greater than 11.5. If the pH is below 11.5, NaOH should be added until a pH above 11.5 can be maintained for 60 minutes. An alternate solution for the decontamination of GB is 10 wt.% sodium carbonate in place of the 10% sodium hydroxide solution above. Continue with 56 grams of decon for each gram of agent. Agitate for one hour but allow three hours for the reaction. The final pH should be adjusted to above zero. It is also permitted to substitute 5.25% sodium hypochlorite or 25 wt.% Monoethylamine (MEA) for the 10% sodium hydroxide solution above. MEA must be completely dissolved in water before addition of the agent. Continue with 56 grams of decon for each gram of GB and provide agitation for one hour. Continue with same ratios and time stipulations. Scoop up all material and clothing. Place all material in a DOT approved container. Cover the contents with decontaminating solution as above. After sealing, decontaminate the exterior of the container and label according to EPA and DOT regulations. All leaking containers will be over packed with sorbent 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).

Waste Disposal Method: Open pit burning or burying of GB or items containing or contaminated with GB in any quantity is prohibited. The detoxified GB (using procedures above) can be thermally destroyed by incineration in EPA approved incinerators according to appropriate provisions of Federal, state and local Resource Conservation and Recovery Act (RCRA) Regulations.

Note: Some decontaminate 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	Respiratory Protective Equipment
< 0.0001 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.
>0.0001 or = 0.2 mg/m^3	A NIOSH/MSHA approved pressure demand full face piece SCBA or supplied air respirators with escape air cylinder may be used. Alternatively, a full face piece, chemical canister air-purifying protective mask is acceptable for this purpose (See DA Pam 385-61 for determination of appropriate level)
>0.2 mg/m^3 or unknown	NIOSH/MSHA approved pressure demand full face piece SCBA suitable for use in high agent concentrations with protective ensemble (See DA Pam 385-61 for examples).

Ventilation:

Local exhaust: Mandatory. Must be filtered or scrubbed to limit exit concentrations to < 0.0001 mg/m^3. Air emissions will 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 GB.

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

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

Eye Protection: At 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 GB is the M8/M9 detector paper, detector ticket, M256/M256A1 kits, bubbler, Depot Area Air Monitoring System (DAAMS), Automated Continuous Air Monitoring System (ACAMS), Real-Time Monitor (RTM), Demilitarization Chemical Agent Concentrator (DCAC), M8/M43, M8A1/M43A1, CAM-M1, Hydrogen Flame Photometric Emission Detector (HYFED), the Miniature Chemical Agent Monitor (MINICAM), and the Real Time Analytical Platform (RTAP).

Real-time, low-level monitors (with alarm) are required for GB 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: 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 Nerve Agents GA, GB, GD, and VX."

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, organic, n.o.s.

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

DOT Label: Poison

DOT Marking: Toxic liquids, organic, n.o.s. (Isopropyl methylphosphonofluoridate) 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.

This page last updated on 28 September 1999

C.3 MSDS Nerve Agent VX

Material Safety Data Sheet

Lethal Nerve Agent (VX)

Date: 14 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 Registry Numbers:
50782-69-9, 51848-47-6, 53800-40-1, 70938-84-0

Chemical Name:
O-ethyl-S-(2-diisopropylaminoethyl) methylphosphonothiolate

Trade Name And Synonyms:
Phosphonothioic acid, methyl-, S-(2-bis(1-methylethylamino)ethyl) 0-ethyl ester O-ethyl
S-(2-diisopropylaminoethyl) methylphosphonothiolate
S-2-Diisopropylaminoethyl O-ethyl methylphosphonothioate
S-2((2-Diisopropylamino)ethyl) O-ethyl methylphosphonothiolate
O-ethyl S-(2-diisopropylaminoethyl) methylphosphonothioate
O-ethyl S-(2-diisopropylaminoethyl) methylthiolphosphonoate
S-(2-diisopropylaminoethyl) o-ethyl methyl phosphonothiolate
Ethyl-S-dimethylaminoethyl methylphosphonothiolate VX
EA 1701
TX60

Chemical Family: Sulfonated organophosphorous compound

Formula/Chemical Structure:

$C_{11}H_{26}NO_2PS$

```
CH3  0                      CH(CH3)2
   \ ||                      /
    P - S - CH2CH2 - N
   /                         \
CH3CH2O                     CH(CH3)2
```

NFPA 704 Signal:

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

Section II - Ingredients

Ingredients/Name: VX

Percentage by Weight: 100%

Threshold Limit Value (TLV): 0.00001 mg/m^3

Section III - Physical Data

Boiling Point @ 760 mm Hg: 568 °F (298 °C)

Vapor Pressure: 0.00063 mm Hg @ 25 °C

Vapor Density (Air = 1 STP): 9.2 @ 25 °C

Solubility (g/100g solvent): 5.0 @ 21.5 °C and 3.0 @ 25 °C in water. Soluble in organic solvents.

Specific Gravity (H_20=1g/mL@25 °C): 1.0113

Freezing/Melting Point (°C): -50 °C

Liquid Density: 1.0083 g/mL@25 °C

Volatility: 8.9 mg/m^3 @ 25 °C

Viscosity (CENTISTOKES): 9.958 @ 25 °C

Appearance and Odor: Colorless to straw colored liquid and oderless, similar in appearance to motor oil.

Section IV - Fire and Explosion Data

Flashpoint: 159 °C (McCutchan - Young)

Flammability Limits (% By Volume): Not Available

Lower Explosive Limit: Not Applicable.

Upper Explosive Limit: Not Applicable

Extinguishing Media: Water mist, fog, foam, CO_2. Avoid using extinguishing methods that will cause splashing or spreading of the VX.

Special Fire Fighting Procedures: All persons not engaged in extinguishing the fire should be immediately evacuated from the area. Fires involving VX should be contained to prevent contamination to uncontrolled areas. When responding to a fire alarm in buildings or areas containing VX, fire fighting personnel should wear full firefighter protective clothing during chemical agent firefighting and fire rescue operations. Respiratory protection is required. Positive pressure, full face piece, 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 nerve 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 liquid VX or vapors can be fatal.

Unusual Fire And Explosion Hazards: None known.

Section V - Health Hazard Data

Airborne Exposure Limits (AEL): The permissible airborne exposure concentration for VX for an 8-hour workday of a 40-hour work week is an 8-hour time weighted average (TWA) of 0.00001 mg/m^3. This value can be found in "DA Pam 40-8, Occupational Health Guidelines for the Evaluation and Control of Occupational Exposure to Nerve Agents GA, GB, GD, and VX." To date, however, the Occupational Safety and Health Administration (OSHA) has not promulgated a permissible exposure concentration for VX.

VX is not listed by the International Agency for Research on Cancer (IARC), American Conference of Governmental Industrial Hygienists (ACGIH), Occupational Safety and Health Administration (OSHA), or National Toxicology Program (NTP) as a carcinogen.

Effects of Overexposure: VX is a lethal cholinesterase inhibitor. Doses which are potentially life-threatening may be only slightly larger than those producing least effects. Death usually occurs within 15 minutes after absorption of a fatal dosage.

Route	*Form*	*Effect*	*Type*	*Dosage*
ocular	vapor	miosis	Ect50	<0.09 mg-min/m^3
Inhalation	vapor	runny nose	Ect50	<0.09 mg-min/m^3
Inhalation (15 l/min)	vapor	severe incapacitation	Ict50	<25 mg-min/m^3
Inhalation (15 l/min)	vapor	death	Ict50	<30 mg-min/m^3
Percutaneous	liquid	death	Lct50	<10 mg/70 kg man minutes

Effective dosages for vapor are estimated for exposure durations of 2-10 minutes.

Symptoms of overexposure may occur within minutes or hours, depending upon the dose. They include: miosis (constriction of pupils) and visual effects, headaches and pressure sensation, runny nose and nasal congestion, salivation, tightness in the chest, nausea, vomiting, giddiness, anxiety, difficulty in thinking, difficulty sleeping, nightmares, muscle twitches, tremors, weakness, abdominal cramps, diarrhea, involuntary urination and defecation. With severe exposure symptoms progress to convulsions and respiratory failure.

Emergency and First Aid Procedures:

Inhalation: Hold breath until respiratory protective mask is donned. If severe signs of agent exposure appear (chest tightens, pupil constriction, incoordination, etc.), immediately administer, in rapid succession, all three Nerve Agent Antidote Kit(s), Mark I injectors (or atropine if directed by a physician). Injections using the Mark I kit injectors may be repeated at 5 to 20 minute intervals if signs and symptoms are progressing until three series of injections have been administered. No more injections will be given unless directed by medical personnel. In addition, a record will be maintained of all injections given. If breathing has stopped, give artificial respiration. Mouth-to-mouth resuscitation should be used when mask-bag or oxygen delivery systems are not available. Do not use mouth-to-mouth resuscitation when facial contamination exists. If breathing is difficult, administer oxygen. Seek medical attention **Immediately**.

Eye Contact: Immediately flush eyes with water for 10-15 minutes, then don respiratory protective mask. Although miosis (pinpointing of the pupils) may be an early sign of agent exposure, an injection will not be administered when miosis is the only sign present. Instead, the individual will be taken **Immediately** to a medical treatment facility for observation.

Skin Contact: Don respiratory protective mask and remove contaminated clothing. Immediately wash contaminated skin with copious amounts of soap and water, 10% sodium carbonate solution, or 5% liquid household bleach. Rinse well with water to remove excess decontaminant. Administer nerve agent antidote kit, Mark I, only if local sweating and muscular twitching symptoms are observed. Seek medical attention **Immediately**.

Ingestion: Do not induce vomiting. First symptoms are likely to be gastrointestinal. **Immediately** administer Nerve Agent Antidote Kit, Mark I. Seek medical attention **Immediately**.

Section VI - Reactivity Data

Stability: Relatively stable at room temperature. Unstabilized VX of 95% purity decomposes at a rate of 5% a month at 71 °C.

Incompatibility: Negligible on brass, steel, and aluminum.

Hazardous Decomposition Products: During a basic hydrolysis of VX up to 10% of the agent is converted to diisopropylaminoethyl methylphosphonothioic acid (EA2192). Based on the concentration of EA2192 expected to be formed during hydrolysis and its toxicity (1.4 mg/kg dermal in rabbit at 24 hours in a 10/90 wt.% ethanol/water solution), a Class B poison would result. The large scale decon procedure, which uses both HTH and NaOH, destroys VX by oxidation and hydrolysis. Typically the large scale product contains 0.2 - 0.4 wt.% EA2192 at 24 hours. At pH 12, the EA2192 in the large scale product has a half-life of about 14 days. Thus, the 90-day holding period at pH 12 results in about a 64-fold reduction of EA2192 (six half-lives). This holding period is sufficient to reduce the toxicity of the product below that of a Class B poison. Other less toxic products are ethyl methylphosphonic acid, methylphosphinic acid, diisopropyaminoethyl mercaptan, diethyl methylphosphonate, and ethanol. The small scale decontamination procedure uses sufficient HTH to oxidize all VX thus no EA2192 is formed.

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 VX occur, only personnel in full protective clothing (See Section VIII) will remain in the area. In case of personnel contamination see Section V for emergency and first aid instructions.

Recommended Field Procedures (For Quantities Greater Than 50 Grams):

Note: These procedures can only be used with the approval of the Risk Manager or qualified safety professionals). Spills must be contained by covering with vermiculite, diatomaceous earth, clay or fine sand. An alcoholic HTH mixture is prepared by adding 100 milliliters of denatured ethanol to a 900-milliliter slurry of 10% HTH in water. This mixture should be made just before use since the HTH can react with the ethanol. Fourteen grams of alcoholic HTH solution are used for each gram of VX. Agitate the decontamination mixture as the VX is added. Continue the agitation for a minimum of one hour. This reaction is reasonably exothermic and evolves substantial off gassing. The evolved reaction gases should be routed through a decontaminate filled scrubber before release through filtration systems. After completion of the one hour minimum agitation, 10% sodium hydroxide is added in a quantity equal to that necessary to assure that a pH of 12.5 is maintained for a period not less than 24 hours. Hold the material at a pH between 10 and 12 for a period not less than 90 days to ensure that a hazardous intermediate material is not formed (See Section VI). Scoop up all material and place in a DOT approved container. Cover the contents of the with decontaminating solution as above. After sealing the exterior, decontaminate and label 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 decontaminant 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).

If the alcoholic HTH mixture is not available, then the following decontaminants may be used instead and are listed in the order of preference: Decontaminating Agent (DS2), Supertropical Bleach Slurry (STB), and Sodium Hypochlorite.

Recommended Laboratory Procedures (For Quantities Less Than 50 Grams):

If the active chlorine of the Calcium Hypochlorite (HTH) is at least 55%, then 80 grams of a 10% slurry are required for each gram of VX. Proportionally more HTH is required if the chlorine activity of the HTH is lower than 55%. The mixture is agitated as the VX is added and the agitation is maintained for a minimum of one hour. If phasing of the VX/decon solution continues after 5 minutes, an amount of denatured ethanol equal to a 10 wt.% of the total agent/decon will be added to help miscibility. Place all material in a DOT approved container. Cover the contents with decontaminating solution as above. After sealing, decontaminate the exterior of the container and label according to EPA and DOT regulations. All leaking containers will be over packed with sorbent placed between the interior and exterior containers. Decontaminate and label according to EPA and DOT regulations. Dispose of 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).

Note: Ethanol should be reduced to prevent the formation of a hazardous waste.

Upon completion of the one hour agitation the decon mixture will be adjusted to a pH between 10 and 11. Conduct general area monitoring to confirm that the atmospheric concentrations do not exceed the airborne exposure limits (See Sections II and VIII).

Waste Disposal Method: Open pit burning or burying of VX or items containing or contaminated with VX in any quantity is prohibited. The detoxified VX(using procedures above) can be thermally destroyed by in a EPA approved incinerator according to appropriate provisions of Federal, State, or local Resource Conservation and Recovery Act (RCRA) regulations.

Note: Some decontaminate 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	Respiratory Protective Equipment
<0.00001 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.
>0.00001 or = 0.02 mg/m^3	A NIOSH/MSHA approved pressure demand full face piece SCBA or supplied air respirators with escape air cylinder may be used. Alternatively, a full face piece, chemical canister air-purifying protective mask is acceptable for this purpose (See DA Pam 385-61 for determination of appropriate level.
>0.02 or unknown	NIOSH/MSHA approved pressure demand full face piece SCBA suitable for use in high agent concentrations with protective ensemble. (See DA Pam 385-61 for examples)

Ventilation: Local exhaust: Mandatory. Must be filtered or scrubbed to limit exit concentrations to <0.00001 mg/m^3. Air emissions will 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 VX.

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

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

Eye Protection: At 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 VX is the M8/M9 detector paper, detector ticket, M256/M256A1 kits, bubbler, Depot Area Air Monitoring System (DAAMS), Automated Continuous Air Monitoring System (ACAMS), Real-Time Monitor (RTM), Demilitarization Chemical Agent Concentrator (DCAC), M8/M43, M8A1/M43A1, CAM-M1, Hydrogen Flame Photometric Emission Detector (HYFED), the Miniature Chemical Agent Monitor (MINICAM), and the Real Time Analytical Platform (RTAP). Real-time, low-level monitors (with alarm) are required for VX 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: Agent containers will be stored in a single containment system within a laboratory hood or in 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 Nerve Agents GA, GB, GD, and VX."

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, organic, n.o.s.

DOT Hazard Class: 6.1, Packing Group I, Hazard Zone A.

DOT Hazard Class: 6.1, Packing Group I, Hazard Zone A.

DOT Label: Poison.

DOT Marking: Toxic liquids, organic, n.o.s. (O-ethel S-(2-diisopropylaminoethyl)methylphosphonothiolate) 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.

This page last updated on 28 September 1999

C.4 MSDS Blister Agent Mustard (H, HD, HT)

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_20=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 nerve agents 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 28 September 1999

C.5 MSDS Blister Agent Lewisite (L)

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:

$C_2 H_2 As C_{13}$

```
                    Cl
                   /
Cl CH = CH - As
                   \
                    Cl
```

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).
lCt50 (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 x 10^{-5} to 5 x 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.

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.

This page last updated on 4 October 1999

APPENDIX D SELF CHECK ANSWERS

Chapter 4, Chemical Agents: Characteristics and Effects

4-1. a
4-2. c
4-3. d
4-4. d
4-5. d
4-6. a
4-7. d
4-8. b
4-9. c
4-10. a
4-11. a
4-12. d
4-13. d

Chapter 5, Signs and Symptoms of Exposure

5-1. a
5-2. c
5-3. a
5-4. d
5-5. a
5-6. b
5-7. b
5-8. b
5-9. a
5-10. a
5-11. d
5-12. b
5-13. a
5-14. d
5-15. b
5-16. a
5-17. d
5-18. d
5-19. b
5-20. c
5-21. b
5-22. b
5-23. a
5-24. b
5-25. d
5-26. a (Some patients may exhibit only one or two signs, others may experience several symptoms at the same time; factors such as dose received and individual sensitivity contribute to the onset of symptoms).
5-27. a (Some patients may exhibit only one or two signs, others may experience several symptoms at the same time; factors such as dose received and individual sensitivity contribute to the onset of symptoms).
5-28. amount of agent; dose concentration; duration of exposure; sensitivity of the patient's system; route of exposure
5-29. epilepsy; gastroenteritis; carbamates
5-30. sunburn; chemical burn

Chapter 6, First Aid Special Treatment (FAST)

6-1. a
6-2. a
6-3. d
6-4. c
6-5. d
6-6. a
6-7. b
6-8. c
6-9. c
6-10. b
6-11. c
6-12. administer atropine/2-PAM chloride; support airway management as necessary
6-13. any 2 of: decontamination of patient; take sterile precautions; support airway management
6-14. secretions are dry; breathing is easy