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HYDROLYTIC DECONTAMINATION OF A 4.2" MUSTARD MORTAR

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RESEARCH AND TECHNOLOGY DIRECTORATE

August 1997

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U.S. Army Edgewood Research, Development and Engineering Center
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An empty, corroded 4.2" mustard (HD) mortar containing internal baffles was filled with HD (100 ml). Subsequently, it was subjected to a boiling water bath for 2 hr to determine if boiling water alone would be sufficient to remove HD to the 3X level (0.003 mg/m^3 vapor detection). Results showed that HD was undetectable following the boiling water treatment. The same contamination and decontamination procedure was used with 10 ml HT in the same munition with the same outcome. As a positive control, the munition was contaminated on an internal surface with 1 mg HD, which was successfully detected by the monitoring procedure. Results showed that a simple boiling water bath will decontaminate HD and HT to the 3X level from the internal surfaces of a badly corroded chemical munition containing internal baffles.

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PREFACE

The work described in this report was authorized under the Assembled Chemical Munitions Assessment Program. This work was started in January 1997 and completed in April 1997.

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CONTENTS

1. INTRODUCTION 7

2. MATERIALS AND METHODS 8

2.1 HD 8
2.2 HT 9
2.3 4.2" Mortar Specifications and Condition 9

3. RESULTS AND DISCUSSION 12

3.1 Contamination and Decontamination with HD 12
3.2 Monitoring 13
3.3 Contamination and Decontamination with HT 13
3.4 Positive Monitoring Control 14

4. CONCLUSIONS 14

LITERATURE CITED 17

FIGURES

1.a	Side views of 4.2" mortar used for these studies	9
1.b	Top and bottom views, respectively, of 4.2" mortar	10
2	Internal baffles and essential external components of 4.2" HD mortar	12
3	Copy of monitoring report following two hour boiling water decontamination of 4.2" mortar contaminated with 100 ml HD	13
4	Copy of monitoring report following two hour boiling water decontamination of 4.2" mortar contaminated with 10 ml HT	14
5	Positive monitoring control: mortar contaminated with 1 mg HD on inside surface	14

TABLES

1	Locations, type, quantity and agent tonnage of mustard munitions stored at sites with no disposal facility as of 1997	8
2	Specifications of 4.2" HD mortar	11

HYDROLYTIC DECONTAMINATION OF A 4.2" MUSTARD MORTAR

1. INTRODUCTION

In 1985, the U.S. Congress directed the Department of Defense to destroy at least 90 percent of the unitary chemical stockpile (Public Law 99-145). This program was subsequently expanded to include the entire U.S. unitary chemical stockpile. In 1988, the Army, as documented in its Final Programmatic Environmental Impact Statement (U.S. Department of the Army, 1988), decided against the transportation of the existing untreated stockpiles to one or more central facilities and recommended destruction of the stockpiles at each stockpile site. By way of the National Defense Authorization Act for Fiscal Year 1993, the deadline for completion was set at December 31, 2004.

In 1982, the U.S. Army selected incineration as the preferred chemical stockpile demilitarization technology. However, the public has frequently expressed reservations about the use of incineration for chemical weapons disposal. As a result, under Public Law 102-484, the Army was directed by Congress to report on Alternative Technologies for the disposal of chemical weapons stockpiles. Neutralization followed by biodegradation was one approach which the National Research Council recommended for further research and development (National Research Council, 1994).

The initial Alternative Technologies Program was designed for potential use at bulk-only storage sites (Aberdeen Proving Ground, MD and Newport, IN). It was reasoned that the relatively simple storage configuration of one-ton containers posed a less formidable challenge than the disposal of assembled munitions. In the course of that effort, it was demonstrated that HD could be hydrolyzed in hot water primarily to thiodiglycol (HD undetectable at 200 parts per billion [ppb]) which was readily biodegradable in sequencing batch bioreactors seeded with activated sludge. The resulting product contained no HD, no priority pollutants and had a very low toxicity to aquatic organisms. This process was selected by the National Research Council[2], and subsequently by the Army for piloting at Aberdeen Proving Ground.

The present effort is directed at the application of alternative technologies to assembled chemical munitions. The scope of the potential application for such a technology is significant. The U.S. Chemical Stockpile is distributed between nine sites. Two of these sites (Johnston Island and Tooele, UT) have operating incinerators as of 1997. According to the U.S. Department of Defense[3], four of the remaining sites (Aberdeen Proving Ground, MD, Newport, IN, Pine Bluff, AK, and Umatilla, OR, have no mustard (HD or HT) munitions. Three other sites, Anniston, AL, Blue Grass, KY, and Pueblo, CO all have varying types and numbers of mustard munitions, distributed as follows:

Site	Item	Agent	Quantity	Tons
Anniston	105MM Cartridge, M60	HD	23,064	34.25
Anniston	155MM Projectile, M110	HD	17,634	103.21
Anniston	4.2" Cartridge, M2A1	HD	75,360	226.08
Anniston	4.2" Cartridge, M2	HT	183,552	532.3
Blue Grass	155MM Projectile, M110	HD	15,492	90.63
Pueblo	105MM Cartridge, M60	HD	383,418	569.38
Pueblo	105MM Projectile, M104	HD	33,062	193.41
Pueblo	155MM Projectile, M110	HD	266,492	1,558.98
Pueblo	4.2" Cartridge, M2A1	HD	76,722	230.17
Pueblo	4.2" Cartridge, M2	HT	20,384	59.11
		Total:	**1,095,180**	**3,597.52**

Table 1. Locations, type, quantity and agent tonnage of mustard munitions stored at sites with no disposal facility as of 1997[3].

The fact that the U.S. has over a million mustard munitions at sites with no disposal facility suggests that the demonstration of a simple neutralization-based decontamination procedure could be important in meeting the 2004 disposal deadline. An effective decontamination procedure must be one which is reliable and easily scaled up to an acceptable throughput rate. For this reason, a boiling water approach was investigated for the decontamination of a 4.2" mortar contaminated with mustard.

The 4.2" mortar was selected for this decontamination study because it represents a potentially difficult decontamination challenge. The munition contains several internal baffles which occlude access to the internal components of the munition. In addition, the mortar used for these studies was badly corroded from age and weather, having been stored outside.

2. MATERIALS AND METHODS

2.1 HD

HD (2,2'-dichlorodiethyl sulfide) was used as received after being removed from a one ton storage container where it had been held for approximately 50 years. It was black in color and approximately 90% pure as determined by gas chromatography/mass spectroscopy (GC/MS).

2.2 HT

HT was used as received from Tooele Army Depot. It was determined by nuclear magnetic resonance spectroscopy to contain 51.4 mole % HD, 28.3 mole % T (bis-(2-(2-chloroethylthio)ethyl) ether) and 20.3 mole % impurities (mostly appearing to have ether linkages).

2.3 4.2" Mortar Specifications and Condition

The munition used for these studies was a 4.2" M2 mortar (pictured in Figure 1). It was highly corroded, having been stored outside for several years. There was a hole in one side about 3 cm in diameter created by a shaped charge. The other side had a drilled hole about 3 mm in diameter. The fuze had been removed.

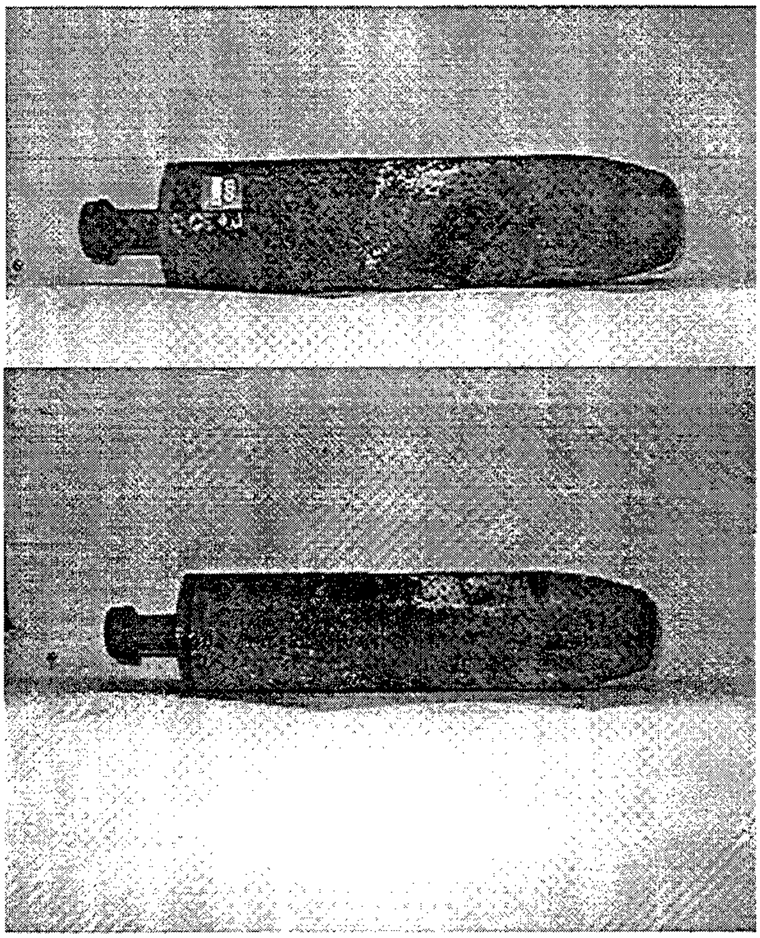

Figure 1.a. Side views of 4.2" mortar used for these studies.

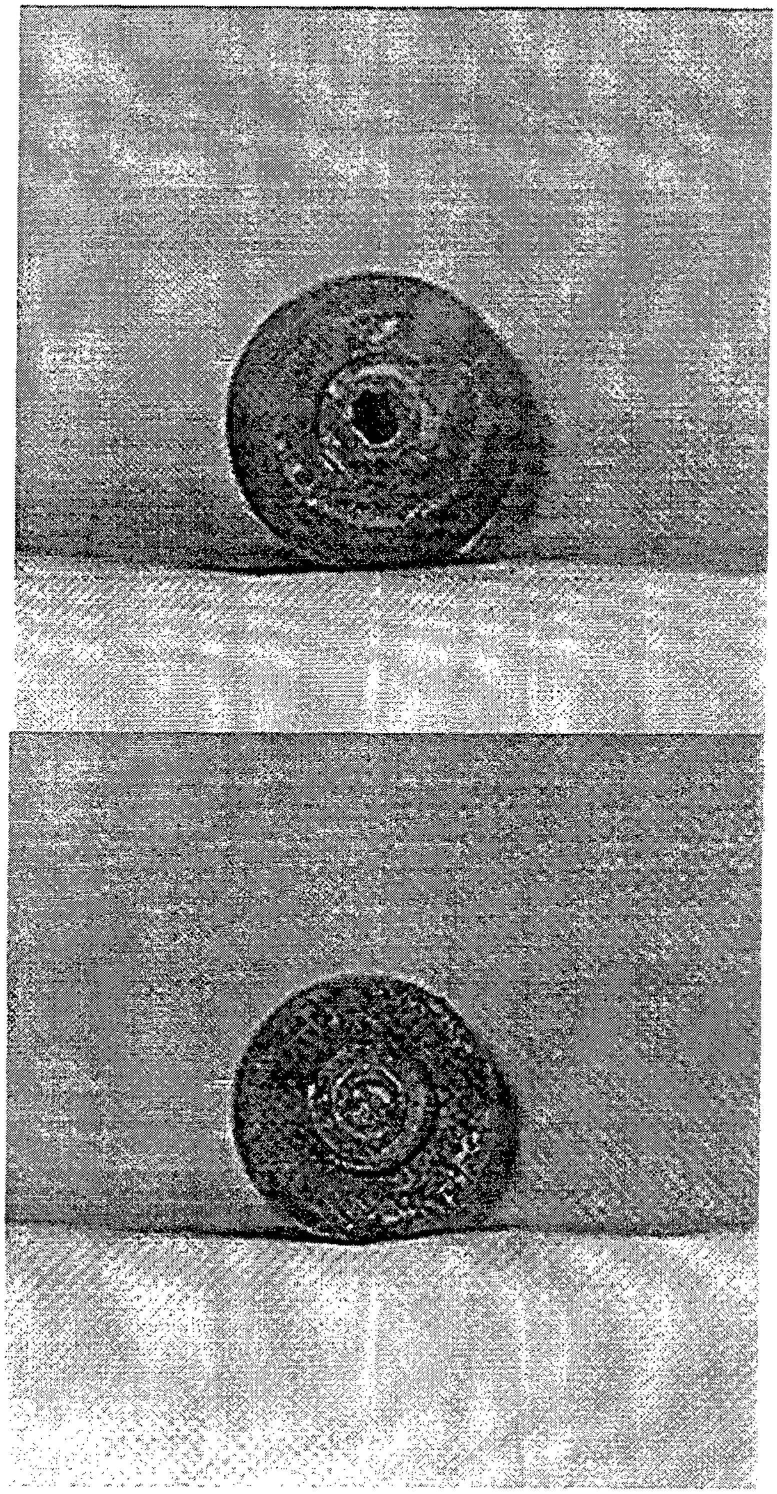

Figure 1.b. Top and bottom views, respectively, of 4.2" mortar.

The specifications of the 4.2" mortar are listed in Table 2.

Cartridge, 4.2" Mortar, HD, M2/M2A1	
Length	21.0 in
Diameter	4.2 in
Total weight	22 lb
Agent	HD
Agent weight	6.0 lb
Fuze	M8
Burster	M14
Explosive	Tetryl
Explosive weight	0.14 lb
Propellant	M6
Propellant weight	0.4 lb
Primer	M28A2
Hazard Class	(12) 1.2
Storage Compatibility Group	K

Table 2. Specifications of 4.2" HD mortar[3].

Figure 2 illustrates the internal baffle configuration and the essential external components of the 4.2" mortar.

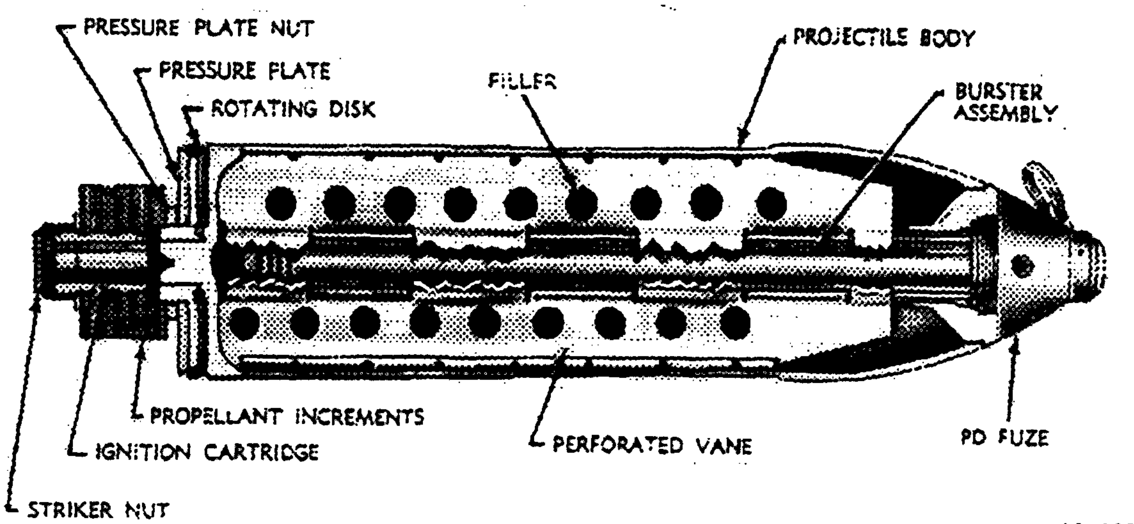

Figure 2. Internal baffles and essential external components of 4.2" HD mortar.

3. RESULTS AND DISCUSSION

3.1 Contamination and Decontamination with HD

In order to test the efficacy of boiling water decontamination of residual HD in this munition, the small hole was corked and 100 ml of HD was added through the large hole which was then sealed with tape. The HD was distributed throughout the inside of the mortar by rolling it in all directions for several minutes. The HD was allowed to equilibrate for 30 minutes then the tape was removed from the large hole and the mortar was placed in a gently boiling water bath. The mortar was positioned in the bath with the large hole on the top and the corked small hole on the bottom. It quickly filled with water through the large hole but no agitation was provided to the inside of the mortar. After two hours in the bath, it was removed, drained and contained within a sealed plastic bag for monitoring.

3.2 Monitoring

The decontaminated mortar was monitored using Depot Area Air Monitoring System (DAAMS) solid sorbent tubes followed by gas chromatography (GC) analysis for HD. No HD was detected at a method detection limit of 0.003 mg/m^3. This approach is the standard Army method for verification of decontamination to the 3X level. A copy of the monitoring report is shown in Figure 3.

Date: **Tue, 25 Feb 97 9:17:07 EST**
From: **Alfreda Dean <axdean@cbdcom.apgea.army.mil>**
To: **spharvey@cbdcom.apgea.army.mil**
Subject: **Clearance**

POC:	Harvey x8646	HD
Item#	02/25/97	Bldg# 3300
0206007	9702060071-M01	Clear for HD

Figure 3. Copy of monitoring report following two hour boiling water decontamination of 4.2" mortar contaminated with 100 ml HD.

3.3 Contamination and Decontamination with HT

The same munition was contaminated with 10 ml HT in the same manner as used above for the HD (a smaller amount of agent was used with the HT due to a short supply available). Decontamination and monitoring procedures were the same as described above for HD. No HT was detected at the 3X level (Figure 4.).

Date:	Thu, 13 Mar 97 10:36:56 EST
From:	Nita Snyder <jasnyder@cbdcom.apgea.army.mil>
To:	spharvey@cbdcom.apgea.army.mil
Subject:	Clearances

POC: Harvey, x2755 Bldg 3300

Item	HT	
0227001	9702270456-M01	Clear for HT

Figure 4. Copy of monitoring report following two hour boiling water decontamination of 4.2" mortar contaminated with 10 ml HT.

3.4 Positive Monitoring Control

As a positive control for the ability of the monitoring to detect HD contamination, the mortar was contaminated on an inside surface with 1 mg of HD without subsequent decontamination. The monitoring procedure successfully detected HD (Figure 5).

Date:	Mon, 24 Mar 97 13:50:07 EST
From:	Nita Snyder <jasnyder@cbdcom.apgea.army.mil>
To:	spharvey@cbdcom.apgea.army.mil
Subject:	Clearances

POC: Harvey, x8646 Bldg 3300

Item	HD	
0320001	xxxr	NOT CLEAR for HD

Figure 5. Positive monitoring control: mortar contaminated with 1 mg HD on inside surface.

4. CONCLUSIONS

An aged and corroded 4.2" mortar containing internal baffles was filled with 100 ml of HD which was distributed throughout the internal surface area. The munition was placed in a gently boiling water bath for two hours, drained, and monitored to the 3X level for the presence of HD. No HD was detected. The same munition was subsequently filled with 10 ml of HT and decontaminated by the same procedure. No HT was detected at the 3X level. As a positive control, the munition was contaminated with 1 mg of HD and monitored. HD was successfully detected by the standard monitoring procedure.

The results of this study show that a simple boiling water bath will decontaminate HD and HT to the 3X level from the internal surfaces of a badly corroded chemical munition containing internal baffles.

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