

APPENDIX D

**AGENT USE/DESCRIPTION
FORT McCLELLAN, ALABAMA**

- D.1 AGENT USE AT FORT McCLELLAN**
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APPENDIX D.1

AGENT USE AT FORT McCLELLAN

BASE ON EXCERPT FROM:

**U.S. ARMY ENVIRONMENTAL HYGIENE AGENCY
HAZARDOUS WASTE CONSULTATION NO. 37-26-1649-87
FORT McCLELLAN, ALABAMA, DECEMBER 8 - 12, 1986**

The chemical training sites in question were used for the training of personnel in various facets of chemical warfare decontamination, detection and munitions/agent disposal. Operations occurring on these sites involved various agents some of which may or may not have been used on the individual sites. These agents included Mustard (HD), the nerve agents VX and GB, and the biological simulants BG and SM. The predominant agent thought to have been used at Fort McClellan was HD. One important property of HD is that it readily undergoes hydrolysis to form thiodiglycol, a fairly nontoxic compound. The HD may also polymerize on its surface in aqueous situations to form a protective insoluble coat, thus, inhibiting further hydrolysis. This factor can lead to isolated pockets of HD in subsurface soil.

The persistence of subsurface contamination in soils and in groundwater for these agents, agent degradation byproducts, decontaminants DS-2 (70 percent diethylenetriamine, 2 percent sodium hydroxide and 28 percent ethylene glycol monomethyl ether) and supertropical bleach (STB) constituents, and byproducts from the reactions of agents with decontaminants have been evaluated. Based on the solubility, volatility, toxicity and formation potential of the compounds evaluated, it was concluded that the only toxic compounds likely to persist in the subsurface soils at Fort McClellan are HD and bis(2-diisopropylaminoethyl) disulfide, also known (DES)₂. The latter compound is the principle byproduct formed from the decontamination of VX with DS-2. The limited quantities of VX used on these sites essentially eliminates the potential for large enough quantities of (DES)₂ to be of significance in terms of environmental contaminants.

Based on similar considerations, it was concluded that the only toxic compounds likely to persist in the groundwater are divinyl sulfide (DVS), mustard sulfoxide (HO), (DES)₂ and S-(diisopropylaminoethyl) methylphosphonothioate (DESMP). Divinyl sulfide is formed from the alkaline hydrolysis of HD with DS-2, and HO is formed from the oxidation of HD with STB. The DESMP is formed from the hydrolysis of VX. Though the potential exists for these compounds to exist in groundwater, it is unlikely that they will be detected due to the limited quantities of agents used and decontaminated during training exercises. Additionally, testing for the decontaminants, DS-2 and STB is secondary to the agents themselves and the probability of detecting either of these compounds in significant quantities is remote.

APPENDIX D.2

SYNOPSIS OF CONTAMINATION DATA

EXCERPT FROM

ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.

REASSESSMENT OF FORT McCLELLAN, ANNISTON

ALABAMA REPORT NO. 110A, JANUARY 1984

**Table D-1 Synopsis of Contamination Data
Non-Problem Areas**

**Table D-2 Synopsis of Contamination Data
Potential Problem Areas**

Table D-1 Synopsis of Contamination Data—Non-Problem Areas

Area	Size	Date Opened	Date Closed	Agents Used	Site Use	Comments	Sampling (Past)	Monitoring (Present)	Conclusion	Recommendation
T-4	0.1 ha	1965	1971	EG, BH	Biological test area	Potentially large HD spill site; biological use only	N/A	N/A	Decontaminated on surface	Allow use for surface activity
T-5	4.6 ha	1961	1973	HD, VX, GB	Agent detection and decontamination area	Training quantities; potentially large HD spill	Dec. 72—HD April 73—HD July 73—HD	N/A	Decontaminated on surface	Allow use for surface activity
T-6	3.0 ha	UNK	1973	HD	Agent decontamination area	Training quantities	Mar. 73—HD Chem. School	N/A	Decontaminated on surface	Allow use for surface activity
T-31	1.4 ha	1957	1969	HD, GB	Exocort reaction area	Training quantities used prior to T-38	N/A	N/A	Decontaminated on surface	Allow use for surface activity
Old Toxic Training	45 m ²	early 1950's	UNK	HD	Toxic training	Used prior to D and I	N/A	N/A	Decontaminated on surface	Allow use for surface activity
D and I	0.4 ha		1972	HD, GB, VX, GC, CX, AC	Detection and identification	Training quantities	1973—HD	N/A	Decontaminated on surface	Allow use for surface activity
Range I	0.2 ha	1963	1964	UNK, HD assumed	Agent shell trapping	Assumed HD use; top 60 cm of soil removed	1960—HD	N/A	Decontaminated on surface	Allow use for surface activity
Range K	0.8 ha	UNK	UNK	UNK	UNK	Site has been bulldozed; rusted toxic agent signs	1960—HD	N/A	Decontaminated on surface	Allow use for surface activity
HD spills	UNK	UNK	UNK	HD	N/A	Reported spills, unknown quantity	N/A	N/A	Decontaminated on surface	Allow use for surface activity
AAD-Decon	UNK	UNK	UNK	UNK	UNK	Posted with toxic agent signs—assumed buffer zone	N/A	N/A	Decontaminated on surface	Allow use for surface activity

Table D-1 Synopsis of Contamination Data - Non-Problem Areas (Continued, Page 2 of 2)

Area	Size	Date Opened	Date Closed	Agents Injured	Site Use	Comments	Sampling (Past)	Monitoring (Present)	Conclusion	Recommendation
Old Waterhole	UNK	UNK	UNK	UNK	UNK	Reported munitions disposal	N/A	N/A	Location and existence unconfirmed	If found, further investigation
Unidentified Range	UNK	UNK	1963	UNK	UNK	Area has been policed	1967-Free of contamination (Chem. School)	N/A	Location and existence unconfirmed	If found, further investigation
Biological Facilities (Bldgs. 3192, 3182, 3180)		1954 1965	1971 1972	Os-60	Biological training	Majority of isotopes used had short half lives and would have decayed away—longer lived isotopes are contained and secure (hot cell)	1973-No levels above maximum permissible concentrations (MPC) AEC	N/A	Decontaminated or controlled	Allow use for continued, controlled activity
Biological Areas (Iron Mt., Alpha Field, Brown Field, Bidout Field)	*	*	*	Os-60, Th-20A, Ra-226, Cs-137, Sr-90, U-233, U-238, Bk-42	Biological training	Biological sources and wastes reportedly removed	Since 1972, radiological surveys have declared all areas decontaminated	N/A	Surface and subsurface decontaminated	Allow use for surface and subsurface activity

* See Section 3 for specific information for each individual area.

UNK = Unknown.

ND = None detected.

Source: ESE, 1983.

Table D-2 Synopsis of Toxic Agent Data—Potential Problem Areas

Area	Size (ha)	Date Opened	Date Closed	Agents Used	Site Use	Comments	Sampling (Past)	Monitoring (Present)	Conclusion	Recommendation
T-38	2.4	1961	1972	HD, VX, GB	Technical escort reaction area, storage area, agents and decontaminants	Many reported spills, extensive decontaminant use; evidence of surface HD contamination potentially located over recharge/fault zone; currently in use for surface activity	Dec. 72—HD Jan. 73—Surf. HD March 73—HD (Chem. Sch.)	N/A	Potential groundwater and subsurface soil contamination	Continued Surface Use. Limited sampling and analysis by USADHWA
T-24A	0.6	UNK	1973	CG, BZ, GB, HD	Chemical munitions disposal training area	Burning pits for decontamination, 4.46 kg HD used per exercise. Pits covered with soil prior to sampling, insulating HD from evaporation or hydrolytic degradation	April 73—HD July 73—HD	N/A	Potential groundwater and subsurface soil contamination	Fence and Post. Limited sampling and analysis by USADHWA
Range J	0.4	UNK	1963	UNK, HD assumed	UNK	Reported burial site for large (110-gal) HD spill	1980—HD (CSL)	N/A	Potential groundwater and subsurface soil contamination	Fence and Post. Limited sampling and analysis by USADHWA
Range L	0.2	UNK	UNK	UNK	UNK	Lima Pond reported dump site for W II captured munitions	1980—HD (CSL)	N/A	Potential groundwater, sediment, and subsurface soil contamination if leaking chemical munitions	Fence and Post. Determine presence of munitions by geophysical means; limited sampling and analysis by USADHWA if leaking munitions found

Table D-2 Synopsis of Toxic Agent Data—Potential Problem Areas (Continued, Page 2 of 2)

Area	Size (ha)	Date Opened	Date Closed	Agents Used	Site Use	Comments	Sampling (Past)	Monitoring (Present)	Conclusion	Recommendation
Landfill	28	1967	N/A	TOE sludge, waste PCL, decontaminated materials	Sanitary landfill	Landfill has elevated metals above drinking water standards (Mn, Pb, Fe, Cr, As). Landfill was formerly in violation of state and federal requirements. Landfill is currently and has been in compliance with Alabama and Federal requirements since 1979.	1976-1978 (AEHA)	AEHA-groundwater monitor program; five wells, water quality and levels State of Alabama-water quality	Potential surface and groundwater contamination and migration by PCL, solvents, and heavy metals	Expand existing monitoring program for existing and two past landfills to include additional water quality parameters and piezometer clusters for groundwater flow direction determination

UNK = Unknown.
 ND = None detected.

Source: ESR, 1983.

APPENDIX D.3

AGENT DESCRIPTION

EXCERPT FROM

**DEPARTMENT OF THE ARMY, U.S. CHEMICAL AND
MILITARY POLICE CENTERS AND FORT McCLELLAN,
SITE INVESTIGATION,
FEBRUARY 23, 1989**

CG (Phosgene)

Chemical name. Carbonyl chloride.

Threat Designation. Fosgen.

Formula. COCl_2 .

Molecular weight. 98.92.

Physical State. Colorless gas.

Odor. New mown hay, grass, or green corn.

Vapor density (compared to air). 3.4.

Liquid density. 1.373 at 20°C for pure CG; 1.381 at 20°C, for plant purity.

Freezing point. 128°C.

Boiling point. 7.6°C.

Vapor pressure. 1,173 mm Hg at 20°C; 555 mm Hg at 0°C; 365 mm Hg at -10°C.

This is in the range of Freon refrigerant.

Volatility. 528,000 mg/m^3 at -40°C; 2,200,000 mg/m^3 at -10°C; 4,300,000 mg/m^3 at 7.6°C.

Flash point. None.

Decomposition temperature. 800°C.

Latent heat of vaporization. 59 calories per gram.

Solubility. Limited in water, decomposes immediately. Completely miscible in most organic solvents.

Rate of hydrolysis. Rapid under usual field conditions. Rain destroys effectiveness. Heavy vegetation, jungle, and forests cause considerable loss by hydrolysis on leafy surfaces.

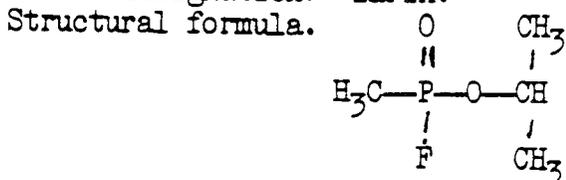
Hydrolysis products. Hydrogen chloride and carbon dioxide.

Persistence. Short. Vapor may persist in low places under calm winds and inversion conditions.

GB (SARIN)

Chemical name. Isopropyl methyl phosphonofluoridate.

Threat designation. Zarin.



Molecular formula. $\text{CH}_3\text{P}(\text{O})(\text{F})\text{OCH}(\text{CH}_3)_2$.

Molecular weight. 140.10.

Physical state. Liquid.

Odor. Almost none in pure state.

Vapor density (compared with air). 4.86.

Liquid density. 1.0887 at 25°C.

Freezing point. -56°C.

Boiling point. 158°C.

Vapor pressure. 2.9 mm Hg at 25°C.

Volatility. 4.100 mg/m³ at 0°C; 22,000 mg/m³ at 25°C; 29,800 mg/m³ at 30°C.

Flash point. Nonflammable.

Decomposition temperature. Complete decomposition after 2 1/2 hours at 150°C.

Latent heat of vaporization. 80 calories per gram at 25°C.

Solubility. Miscible with water. Soluble in alcohols, gasoline, oils and fats. Soluble in all organic solvents.

Rate of hydrolysis. Variable with pH. Half-life 7.5 hours at pH 1.8; 30 hours in unbuffered solution. Very rapidly hydrolyzed in alkaline solutions.

Hydrolysis products. Hydrogen fluoride (HF) under acid conditions; isopropyl alcohol and polymers under alkaline conditions.

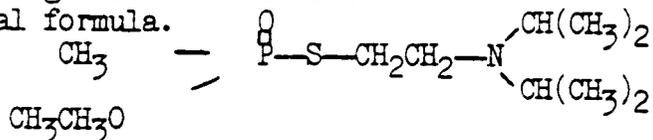
Persistency. Evaporates at approximately same rate as water.

VX

Chemical name. O-ethyl-S-(diisopropylaminoethyl)-methylphosphonothiolate.

Threat designation. Not known.

Structural formula.



Molecular formula. $\text{C}_{11}\text{H}_{26}\text{NO}_2\text{PS}$.

Molecular weight. 267.38.

Physical state. Liquid.

Odor. None.

Vapor density (compared with air). 9.2.

Liquid density. 1.0083 g/cc at 25°C.

Freezing point. Can be below -51°C due to dissolved impurities. -39°C calculated.

Boiling point. 298°C (calculated) decomposes.

Vapor pressure. 0.0007 mm Hg at 25°C.

Volatility. 10.5 mg/m³ at 25°C. This is about 2,000 times less than the volatility of GB.

Flash point. 159°C.

Decomposition temperature. Half-life: 36 hours at 150°C; 1.6 hours at 200°C; 4 minutes at 250°C; 36 seconds at 295°C.

Solubility. Miscible with water below 9.5°C. Slightly soluble in water at room temperature. Soluble in organic solvents.

Rate of hydrolysis. Half-life at 25°C. and pH 2 to 3, 100 days; at pH 13, 16 minutes; at pH 14, 1.3 minutes.

Hydrolysis products. Diethyl methylphosphonate, 2-diisopropylaminoethyl mercaptan, ethyl hydrogen methylphosphonate, bis (ethylmethylphosphonic) anhydride, bis S-(2-diisopropylaminoethyl) methylphosphonodithioate. (Toxic hydrolysis products form at pH 7-10).

Persistency. Heavily splashed liquid persists for long periods of time under average weather conditions.

AC (HYDROGEN CYANIDE)

Chemical name. Hydrogen cyanide or hydrocyanic acid.
Threat designation.
Formula. HCN.
Molecular weight. 27.02.
Physical state. Colorless liquid that quickly vaporizes.
Odor. Similar to bitter almonds.
Vapor density (compared to air). 0.93 at -17.8°C ; 1.007 at 25.7°C .
Liquid density. 0.687 at 20°C .
Freezing point. -13.3°C .
Boiling point. 25.7°C at 760 mm Hg.
Vapor pressure. 742 mm Hg at 25°C .
Volatility. $37,000\text{ mg/m}^3$ at -40°C ; $1,080,000\text{ mg/m}^3$ at 25°C .
This is approximately 50 times as volatile as water.
Flash point. 0°F . Agent is ignited 50 percent of the time when disseminated from an artillery shell.
Decomposition temperature. Above 65.5°C . (Forms explosive polymer on standing. Stabilized material can be stored up to 65°C .).
Latent heat of vaporization. 233 calories per gram.
Solubility. Soluble in water and alcohol; soluble in ether, glycerine, chloroform, and benzene.
Rate of hydrolysis. Low under field conditions.
Hydrolysis products. NH_3 , NCOOH , and amorphous brown solids.
Persistency. Short. The agent is highly volatile, and in the gaseous state it dissipates quickly in the air.

CK (CYANOGEN CHLORIDE)

Chemical name. Cyanogen chloride.

Threat designation. Klortsian.

Formula. $CNCl$.

Molecular weight. 61.48.

Physical state. Liquid that quickly evaporizes.

Odor. Like bitter almonds but will go unnoticed because of lacrimatory and irritating properties.

Vapor density (compared to air). 2.1.

Liquid density. 1.18 at $0^{\circ}C$.

Melting point. $-6.9^{\circ}C$.

Boiling point. $12.8^{\circ}C$.

Vapor pressure. 1,000 mm Hg at $25^{\circ}C$.

Volatility. 2,600,000 mg/m^3 at $12.8^{\circ}C$.

Flash point. None.

Decomposition temperature. Above $100^{\circ}C$.

Latent heat of vaporization. 103 calories per gram. This is sufficiently high to provide a satisfactory pancaking effect.

Solubility. Soluble in water, alcohol, carbon disulfide, acetone, benzene, carbon tetrachloride, chloropicrin, sulfur mustard and HCN.

Rate of hydrolysis. Very low.

Hydrolysis products. HCl and CHOH.

Persistency. Short. Vapor may persist in jungle and forest for some time under suitable weather conditions.

HD (DISTILLED MUSTARD)

- Chemical name. Bis (2-chloroethyl) sulfide.
Threat designation. Iperit, yperite.
Structural formula. $\text{ClCH}_2\text{CH}_2\text{—S—CH}_2\text{CH}_2\text{Cl}$
Molecular formula. $\text{ClCH}_2\text{CH}_2\text{—S—CH}_2\text{CH}_2\text{Cl}$.
Molecular weight. 159.08.
Physical state. Colorless to amber liquid.
Odor. Garlic-like.
Vapor density (compared to air). 5.4.
Liquid density. 1.2685 g/cm^3 at 0°C .
Freezing point. 14.45°C .
Boiling point. 217°C calculated; decomposes.
Vapor pressure. 0.072 mm Hg at 20°C .
Volatility. 75 mg/m^3 at 0°C (solid); 610 mg/m^3 at 20°C (liquid); $2,860 \text{ mg/m}^3$ at 40°C (liquid).
Flash point. 105°C . Low enough to cause occasional ignition if explosive charges in the shell are too great.
Decomposition temperature. 149° to 177°C .
Latent heat of vaporization. 94 calories per gram. (This property is not of great importance in a chemical agent of low volatility, as the sustained vapor concentration is essentially a function of the temperature of the surroundings).
Solubility. Poorly soluble in water (less than 1%); mustard on or under water undergoes hydrolysis only at the phase boundary and as a result, new mustard is constantly diffusing in small amounts into the water at the interface to replace that which had been hydrolyzed. Miscible with Diphosgene, Lewisite, Ethyldischloroarsine, Phenyldichloroarsine, and the organophosphorus nerve agents. Soluble in oils, Chloropicrin, alcohol, carbon tetrachloride, and titanium tetrachloride.
Rate of hydrolysis. Half-life is 8.5 minutes in distilled water at 25°C and 60 minutes in salt water at 25°C .
Hydrolysis products. Hydrogen chloride and thiodiglycol.
Persistency. Heavily splashed liquid persists 1-2 days...under average weather conditions and a week to months under very cold conditions.

CX (PHOSGENE OXIME)

Chemical name. Dichloroformoxime.

Threat designation. Fosgen Oksim.

Structural formula. $\begin{array}{c} \text{Cl} \\ \diagdown \\ \text{C}=\text{NOH} \\ \diagup \\ \text{Cl} \end{array}$

Molecular formula. CCl_2NOH .

Molecular weight. 113.9.

Physical state. Liquid above 39°C , solid below 39°C .

Odor. Violently irritates nose and respiratory tract.

Vapor density (compared to air). 3.9.

Liquid density. Not available.

Freezing point. 39 to 40°C .

Boiling point. 128°C . (with decomposition).

Vapor pressure. 11.2 mm Hg at 25°C for solid, 13 mm Hg at 40°C . for liquid.

Volatility. 1800 mg/m^3 at 20°C ; $76,000\text{ mg/m}^3$ at 40°C .

Flash point. Not available.

Decomposition temperature. Below 128°C .

Latent heat of vaporization. 101 cal/g at 40°C .

Solubility. Dissolves slowly but completely in water; soluble in organic solvents.

Rate of hydrolysis. Slow in water at pH7 and room temperature; 5 percent in six days at ambient temperature. Not hydrolyzed by dilute acids; reacts violently in basic solutions.

Hydrolysis products. CO_2 , HCl , and hydroxylamine.

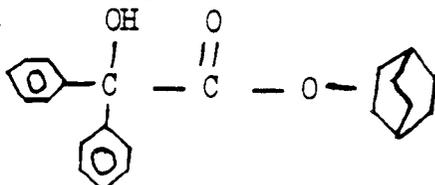
Persistence. Somewhat shorter than for HD. Very short duration under humid conditions.

BZ

Chemical name. 3-Quinuclidynyl benzilate.

Threat designation. Oksilidin.

Structural formula.



Molecular formula. $C_{21}H_{23}NO_3$.

Molecular weight. 337.41.

Physical state. Solid.

Odor. None.

Vapor Density. 11.6 (calculated).

Solid Density.

Bulk Density. 0.51 g/cm^3 .

Crystal Density. 1.33 g/cm^3 .

Freezing point. 164° to 167°C .

Boiling point. 320° .

Vapor pressure. Negligible.

Volatility. Negligible.

Flash point. 246°C .

Decomposition temperature. Begins to decompose at approximately 170°C .

Almost completely decomposed after one to two hours at 200°C .

Latent heat of vaporization. 62.9 cal/g at temperatures between 170 - 194°C .

Solubility. Soluble in dilute acids, and most organic solvents such as alcohol and chloroform; insoluble in aqueous alkali.

Rate of hydrolysis. Half-life at 25°C is 3 to 4 weeks at pH 7, 6.7 hours at pH 9.8, and 1.8 minutes at pH 13. Half-life at 37°C is 95 hours at PH 7.4 and 10 hours at pH 9.

Hydrolysis products. 3-Quinuclidinal and benzoic acid.

Persistence. Persistent in soils, water and on surfaces.

BG (BACILLUS GLOBIGII)

Bacillus globigii is a variation of *Bacillus subtilis* utilized as a simulant for biological warfare agents. As with most *Bacillus* types the cells are rod-shaped, gram positive bacteria. These are aerobic or facultatively anaerobic spore-formers and flagellated.

Species are pervasive in the environment based on the distribution and persistence of spores. *B. globigii*'s primary habitat is soil and plant litter where they play a role in carbon and nitrogen cycling. The *Bacillus* genus has been isolated in almost all natural habitats, including fresh and sea waters, food and pharmaceuticals. A site of isolation cannot be considered natural habitat for this species due to the ease of transference of the bacteria and tenacity of the spores.

It is felt *B. globigii*, as with many of the *Bacillus* species, can be opportunistic pathogens when presented with a host predisposed to establishment of infection. Hosts previously compromised are most frequently involved. *B. subtilis* has been implicated in food poisoning, cellulitis, septicemia, respiratory illness, and endocarditis, however, the association cannot be regarded as unequivocal. *B. globigii* has not been implemented in infections, however its close relationship with *B. subtilis* and general acceptance of pathogenic potential of *Bacillus* species indicate the possibility of pathogenicity.

SM (SERRATIA MERCESANS)

Serratia marcesans are straight rods generally conforming to the family Enterobacteriaceae. They are facultatively anaerobic, motile, and pigmented. *S. marcesans* can be white or pink, however, strains used as biological simulants were selected for red pigmentation.

These organisms occur in the natural environment, and have been isolated in soil, water, and on plant surfaces. Bacteriophages active on *serratis* are found in river water and sewage.

S. Marcesans is an opportunistic human pathogen prominent in hospitalized patients. Infection occurs most frequently as the result of accidental infection of contaminated perfusions or irrigation fluids. *Serratis* species have also been clinically isolated without significance.