CHEMICAL RESEARCH, DEVELOPMENT & ENGINEERING CENTER

AD-A255 087

CRDEC-TR-384

OPERATIONAL DEAD AIR SPACE TESTING OF THE CHEMICALLY PROTECTED DEPLOYABLE MEDICAL SYSTEMS (CP DEPMEDS)

A. Seitzinger
T. Richardson

RESEARCH DIRECTORATE

July 1992

U.S. ARMY ARMAMENT MUNITIONS CHEMICAL COMMAND

Aberdeen Proving Ground, Maryland 21010-5423

Disclaimer

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (*Leave blank*)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	1992 July	Final, 91 Aug - 91 Oct

4. TITLE AND SUBTITLE
Operational Dead Air Space Testing of the Chemically Protected Deployable Medical Systems (CP DEPMEDS)

5. FUNDING NUMBERS
None

6. AUTHOR(S)
Seitzinger, A.; and Richardson, T.

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
CDR, CRDEC, ATTN: SMCCR-RSP, APG, MD 21010-5423

8. PERFORMING ORGANIZATION REPORT NUMBER
CRDEC-TR-384

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (*Maximum 200 words*)
This report documents the results and findings of dead air space tests on the chemically protected deployable medical systems (DEPMEDS) conducted at Fort Indiantown Gap, PA. The DEPMEDS are composed of various sized, overpressurized chemically protected shelters connected by viaducts. Designed by the U.S. Army Natick Research, Development and Engineering Center (NATICK), the shelters provide a clean air conditioned atmosphere to treat wounded personnel in a chemical warfare environment. NATICK requested the U.S. Army Chemical Research, Development and Engineering Center's support to identify any dead air spaces, because these spaces would be a potential chemical agent vapor accumulation location, and threaten the collective protection of the shelters. Initially, a smoke generator was utilized to observe the air flow patterns within the DEPMEDS, and suspect dead air space locations were identified. However, subsequent dissemination of sulfur hexafluoride into the ventilation system of the shelter indicated that no dead air spaces were present. This report includes a few suggestions to improve the air circulation of the DEPMEDS, namely elimination of the interior shelter liners and using doors between the viaducts connecting the various shelters.

14. SUBJECT TERMS

Sulfur	Ventilation kinetics
Shelters	Collective protection
Hexafluoride	Chemical agent simulants

15. NUMBER OF PAGES
43

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL

Blank

PREFACE

The work described in this report was authorized under the Chemically Protected Deployable Medical Systems (CP DEPMEDS) program. This work was started in August 1991 and completed in October 1991.

The use of trade names or manufacturers' names in this report does not constitute an official endorsement of any commercial products. This report may not be cited for purposes of advertisement.

Blank

CONTENTS

LIST OF FIGURES AND TABLES

Figure No.

Table No.

OPERATIONAL DEAD AIR SPACE TESTING OF THE CHEMICALLY PROTECTED DEPLOYABLE MEDICAL SYSTEMS (CP DEPMEDS)

1. INTRODUCTION

1.1 Purpose.

This report documents the results and findings of dead air space testing conducted on an assembled representative DEPMEDS. The objective of this testing was to identify the location of any dead air spots within the DEPMEDS. These dead air spaces pose as potential chemical agent vapor accumulation locations, and threaten the collective protection performance of the DEPMEDS in a nuclear, biological or chemical (NBC) warfare environment.

1.2 Background.

The DEPMEDS consisted of shelters of various sizes (approximately 20 ft.x 20 ft.x 10 ft. to 64 ft. x 20 ft.x 10 ft.). The shelters were overpressurized/chemically protected and connected to each other by viaducts (see figure 1). Designed by the U.S. Army Natick Research, Development and Engineering Center (Natick), the shelters provide a clean air conditioned atmosphere to treat personnel wounded in a NBC warfare environment. The test site for these field trials was Ft. Indiantown Gap, PA, 26 Aug 91 through 29 Aug 91. The test DEPMEDS consisting of six shelter units was slightly smaller than a complete fielded system with ten units. However, all of the various types of shelters were represented. The shelters assembled were in the correct configuration and ventilated by C100 air handling (A/C) units and had M20 personnel entrances (PE). The shelters were ventilated with an input volumetric flow rate of 1750 cubic feet per minute (CFM), which produced a designed overpressure of 1.5 inches of water (in.WG). One of the shelter units was installed with a beige cotton interior liner. The liner was attached to the shelter support pipes by strings and was designed to provide a warmer atmosphere for the environment of the occupants.

1.3 Test Theory/Methodology.

The approach for determining the location of dead air spaces within the DEPMEDS was first to identify potential areas by observing air flow patterns with smoke, and then confirm these areas as dead air spots using gaseous sulfur hexafluoride (SF_6), a chemical agent simulant vapor. This testing was carried out while the DEPMEDS was operating under normal designed field conditions (i.e., ventilation system running at designed air flow rate and overpressure). A Nutem Limited, NPL-type, smoke generator (w/vaporization probe) was used to observe the air flow patterns in each of the shelter units and connecting viaducts of the DEPMEDS. Close attention was given to restricted air flow areas, such as the viaducts and the air space between the interior lining and the shelter wall (for those shelters with interior linings). After the locations of the observed potential dead air spaces were discovered, miniature infrared air analyzers (MIRAN-1As) were set-up to monitor the concentration of SF_6 in these spaces. A known quantity of simulant gas was then introduced into the shelter ventilation system. The introduction of SF_6 directly into the ventilation system of the shelter units ensured a uniform dispersion of the simulant through the ducts and vents along with the forced air. If no significant increase in SF_6 concentration was indicated by the MIRAN-1A for a particular location during dissemination, then that location was considered a dead air space. However, if the concentration of the simulant did increase significantly during dissemination, and decreased afterwards (indicating the dilution of SF_6 with air), then that location was not considered a dead air spot. Both background SF_6 concentration within the given shelter unit and ambient SF_6 concentration during and after simulant dissemination was determined by analyzing syringe samples collected in a sequential sampler. Analysis was performed using an electron capture gas chromatograph (ECGC).

2. TEST SET-UP/PROCEDURE

2.1 Air Flow Pattern Observation Set-up/Procedure.

The most critical element for this test was the smoke generator. Care had to be taken to allow smoke oil to run freely from the probe before heat was applied. This safety measure prevented the possibility of a flame being produced at the vaporization probe tip. A ribbon of smoke was produced when the generator fuel pump speed was set to 5, and the heater voltage control was set to 23.(see appendix C) Figure 1 shows the general DEPMEDS test set-up and air flow observation points conducted throughout the system.

The procedure for observing air flow patterns in the DEPMEDS with the smoke generator was as follows:

1. Set the smoke generator controls
   - Fuel pump speed = 5
   - Heater voltage = 23
2. Turn-on pump
3. Let oil drip from vaporization probe (give about 2 to 3 minutes for oil to run threw small fuel line to probe tip)
4. Turn-on power to probe once oil starts to drip from tip

5. Allow smoke to stabilize before bringing probe over to area of interest
6. Place probe initially close to the floor and slowly raise the probe up to the shelter ceiling
7. Observe movement of smoke plume
8. Move probe to next area of interest and repeat steps 6 and 7 until all areas have been tested.
9. Turn-off power to vaporization probe
10. Turn-off oil pump

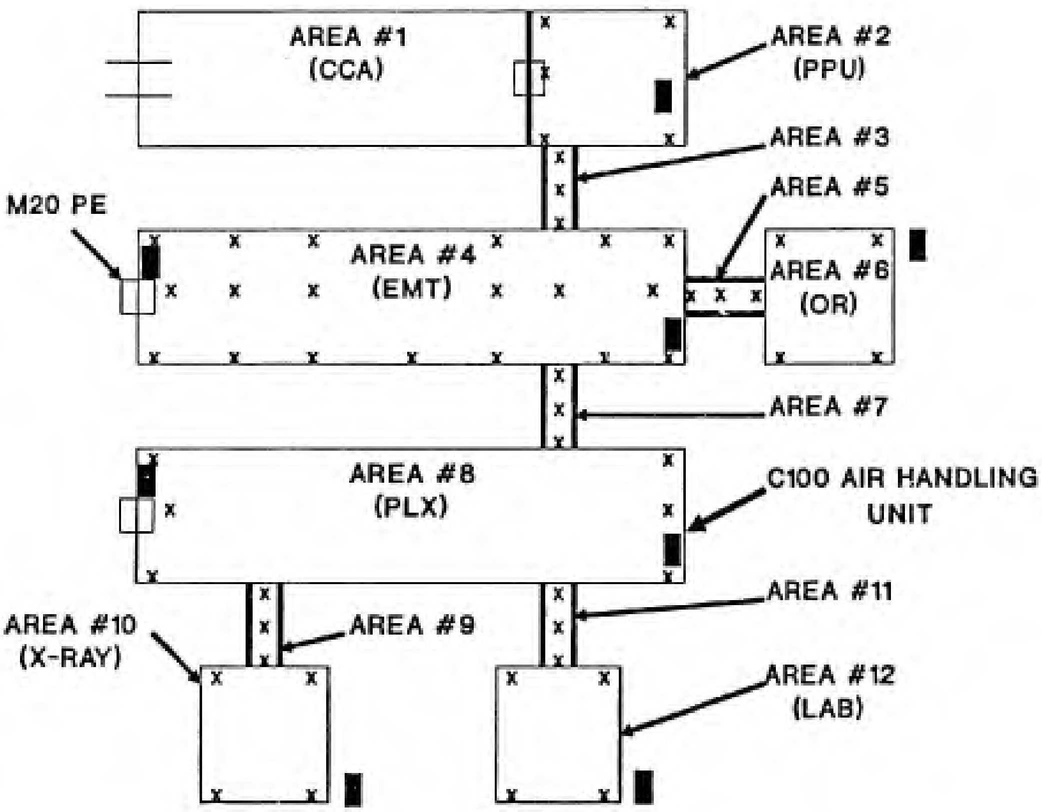


Figure 1. General Set-up of DEPMEDS and Air Flow Pattern Observation Points.

Again, care was taken in handling the vaporization probe, because it was very hot. During testing, contact between the probe and any materials of construction was avoided. The probe was not allowed to be rested on anything that could melt, unless a cool down period was allowed.

2.2 SF_6 Dissemination Test Set-up/Procedure.

The potential dead air spaces, identified in observing the air flow patterns within the DEPMEDS, had input sample lines installed to the MIRAN-1As. Only two MIRAN-1As were available for testing, so more than one dissemination test would be required if more than two locations were identified. One MIRAN-1A had a strip chart recorder to record the SF_6 concentration throughout the test. The SF_6 concentration for the other MIRAN-1A was recorded manually every five minutes by an operator. Four sequential syringe samplers were placed within the DEPMEDS at various elevations. The samplers had 12 syringes and were programmed to sample a 30 cubic centimeter syringe every five minutes. Ten minutes prior to simulant dissemination, the syringe samplers were activated and continue sampling for a hour. At the end of a test, the syringes were analyzed for both background SF_6 concentration prior to dissemination, and simulant concentration during and after dissemination. Analysis of the syringe samples was conducted using a S-Cubed, Model 215AUP, electron capture gas chromatograph (ECGC). The ECGC is normally used to analyze samples for trace concentrations (parts per trillion to parts per billion) of SF_6. Because the concentration of SF_6 in the DEPMEDS following dissemination was estimated to be in the parts per million range, so the least sensitive scale on the ECGC was used to avoid reaching the upper limit (off-scale response) of the instrument. Sulfur hexafluoride was introduced from a regulated cylinder through a calibrated flowmeter into the ventilation system at a rate of 2.77 CFM (see figure 2). The SF_6 was manually turned-on for a ten minute dissemination period, then manually shut-off.

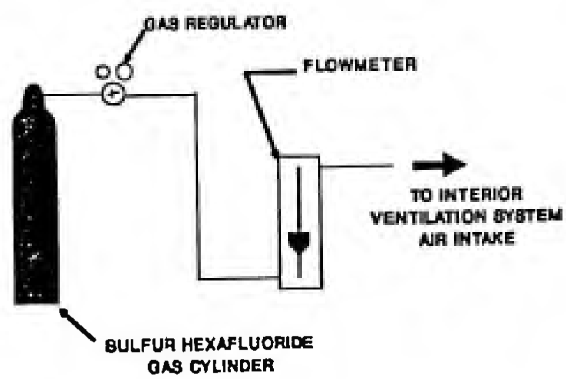


Figure 2. Sulfur Hexafluoride Dissemination Set-up.

3. TEST RESULTS

3.1 Air Flow Pattern Observations.

Test Conditions:
1. Date: 27 Aug 91
2. Time: 1200 hrs
3. Dry Bulb Temperature: 76 °F
4. Wet Bulb Temperature: 62 °F
5. Relative Humidity: 44%
6. Barometric Pressure: 29.75 in.Hg

The following observation point comments are in reference to the areas indicated in figure 1:

(2) No potential dead air spaces observed
(3) No potential dead air spaces observed, however air movement was definitely restricted (air movement was slower)
(4) Two potential dead air spaces were observed up between the ceiling of the shelter unit and ceiling of its interior lining
(5) No potential dead air spaces observed, but air movement was slower
(6) No potential dead air spaces observed
(7) No potential dead air spaces observed, however air movement was slower
(8) No potential dead air spaces observed
(9) No potential dead air spaces observed, but air flow was restricted
(10) No potential dead air spaces observed
(11) No potential dead air spaces observed, however air flow was restricted
(12) No potential dead air spaces observed

Figure 3 shows the general air circulation patterns observed for the various DEPMEDS shelter units (i.e., (2) and (3)).

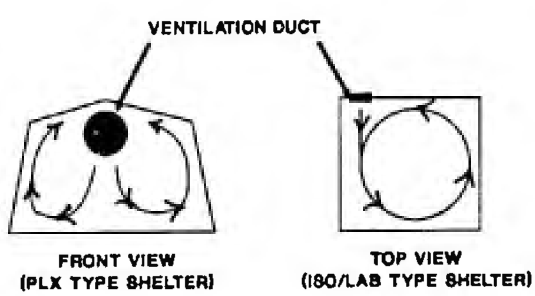


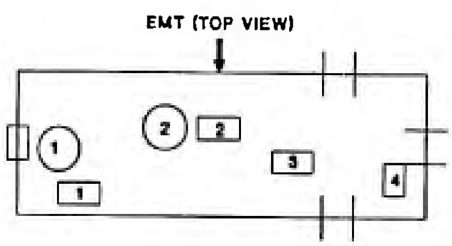
Figure 3. General Air Circulation Patterns Observed for DEPMEDS.

3.2 SF_6 Dissemination.

Only two potential dead air spaces were identified in area (1) (see figure 1) as a result of air pattern observation testing. These spaces were located in the EMT shelter up in the ceiling area between the shelter ceiling and lining. The EMT was the only shelter with an interior lining. Figure 4 shows the location of these spaces that were monitored for SF_6 using the MIRAN-1As and the sequential samplers. Tables 1 and 2 show the recorded SF_6 concentrations throughout the test. Table 3 contains the SF_6 concentration data determined from subsequent analysis of the syringe samples using the ECGC. Figures 5 shows the corresponding plots of the data in Tables 1 and 2.

Test Conditions:		Initial	Final
1.	Date	28 Aug 91	28 Aug 91
2.	Time	1100 hrs	1215 hrs
3.	Dry Bulb Temperature	82/68 °F	91/80 °F
4.	Wet Bulb Temperature	75.5/60 °F	79/64 °F
5.	Relative Humidity	75/62 %	61/40 %
6.	Barometric Pressure (in.Hg)	29.75/29.76	29.79/29.81
7.	Dissemination Time	1110 hrs	1120 hrs

* (outside/inside shelter measurements)



LOCATION	HEIGHT ABOVE FLOOR
DEAD AIR SPOT #1	10 FEET
DEAD AIR SPOT #2	10 FEET
SAMPLER #1	0 FEET
SAMPLER #2	8 FEET
SAMPLER #3	0 FEET
SAMPLER #4	3 FEET

Figure 4. Potential Dead Air Space And Sequential Syringe Sampler Locations

Table 1. MIRAN-1A SF_6 Concentration Readings For Potential Dead Air Space #1.

Test Time (hrs)	Response (volts)	SF_6 Concentration (ppm)
1100	0.00	0
1105	0.00	0
1110	0.00	0
1115	>1.10	>900
1120	>1.10	>900
1125	>1.10	>900
1130	>1.10	>900
1135	>1.10	>900
1140	>1.10	>900
1145	0.95	744
1150	0.60	404
1155	0.52	334
1200	0.45	276

Table 2. MIRAN-1A SF_6 Concentration Readings For Potential Dead Air Space #2.

Test Time (hrs)	Response (volts)	SF_6 Concentration (ppm)
1100	0.00	0
1105	0.00	0
1110	0.00	0
1115	0.81	600
1120	1.05	847
1125	>1.10	>900
1130	1.06	858
1135	0.95	742
1140	0.84	630
1145	0.73	523
1150	0.68	476
1155	0.64	439
1200	0.55	359

Table 3. Sequential Syringe Sampler #3 SF_6 Concentrations.

Test Time (hrs)	Syringe #	ECGC Response (milli-volts)	SF_6 Concentration (ppb)
1105	1	0.185	4.134×10^1
1110	2	0.198	4.908×10^1
1115	3	117.49	$>3.329 \times 10^5$
1120	4	114.71	$>3.329 \times 10^5$
1125	5	114.58	$>3.329 \times 10^5$
1130	6	115.35	$>3.329 \times 10^5$
1135	7	115.02	$>3.329 \times 10^5$
1140	8	113.87	$>3.329 \times 10^5$
1145	9	112.64	$>3.329 \times 10^5$
1150	10	110.53	$>3.329 \times 10^5$
1155	11	108.63	$>3.329 \times 10^5$
*1200	12	85.42	4.290×10^8

* Extrapolated value on calibration curve, not considered a valid value due to proximity to upper limit of ECGC.

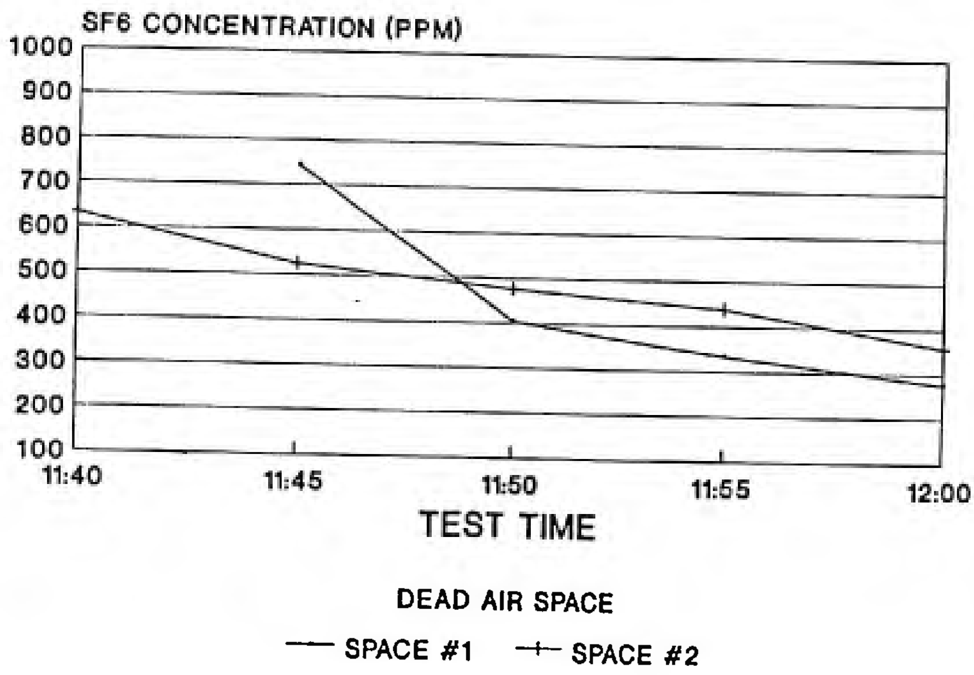


Figure 5. Plots of SF_6 Concentration Monitored for Potential Dead Air Space #1 and #2.

3.3 Calculations.

The overall relationship for time versus SF_6 concentration shown in figure 5 is inverse exponential. However, during the last ten minutes of test time, both MIRAN-1A SF_6 concentration plots show essentially a linear relationship with almost identical slopes. The slopes of these plots represent the rates of SF_6 dilution for the two potential dead air spaces monitored. The slope of the last ten minutes is a good approximation for the average dilution rate. Therefore, the average rate of dilution of SF_6 for potential dead air space #1 (D1):

D1 = (404 - 276) ppm/(1200 - 1150) hrs
= 128 ppm/10 min
= 12.8 ppm/min

Average rate of dilution of SF_6 for potential dead air space #2 (D2):

D2 = (476 - 359) ppm/(1200 - 1150) hrs
= 117 ppm/10 min
= 11.7 ppm/min

4. DISCUSSION

The observed air flow patterns using smoke suggested the possibility of two potential dead air spaces. However, simulant test data and calculated dilution rates (for these spaces) indicated there were NO DEAD AIR SPACES IN THIS TEST ITEM. This conclusion must be qualified because this test DEPMEDS was essentially empty of medical equipment. Equipment and other obstacles inside the DEPMEDS, might create some dead air spaces due to the restricted air movement. However, this was not the situation for this test, and observed air flow patterns only indicated two potential dead air spots, and restricted air flow in the viaducts. Simulant test data showed that the concentration of the simulant increased sharply (off-scale) upon dissemination, and decreased steadily after dissemination. Subsequent dissemination test calculations of the two suspect dead air spaces determined dilution rates of 12800 mg/m^3-min (D1) and 11700 mg/m^3-min (D2) for SF_6. This slight difference in rates can probably be attributed to D2 being approximately 15 feet further down the ventilation duct from D1, the volumetric flow rate would be slightly less due to the line resistance of the duct. The input ventilation rate of 1750 CFM for the C100 air handling unit seems to perform satisfactorily in providing both enough air movement in the shelters and maintaining 1.5 in.WG overpressure. In judging the overall test data, no dead air spaces would be available within the DEPMEDS to provide potential accumulation spots for chemical agent vapors brought in gradually by the exit/entry of personnel. A large data, no dead air spaces would be available within the DEPMEDS to provide potential accumulation spots for chemical agent vapors brought in gradually by the exit/entry of personnel. A large amount of chemical agent vapor would have to penetrate into the shelter to pose a real threat. Agent detector alarms would sound long before this breach in collective protection became a threat to personnel in the DEPMEDS.

5. RECOMMENDATIONS

It is highly recommended that no doors be installed in the via ducts between the DEPMEDS shelter units. Air flow was definitely restricted between the shelters, and doors (even vented doors) would probably restrict air flow even more, possibly creating dead air spaces. If doors must be installed, circulation blowers or fans should also be installed to maintain air flow. Finally, it is recommended that dynamic minimum overpressure testing be performed on the DEPMEDS. This testing would indicate if the designed overpressure would preclude an exterior chemical agent simulant challenge from penetrating into the DEPMEDS in a 30, 40, or 50 mile per hour test wind.

LITERATURE CITED

1. Military Chemistry and Chemical Agents, TM 3-215/AFM 355-7, Departments of the Army and the Air Force, Washington, D.C., 6 Dec 63, UNCLASSIFIED Technical Manual.

Blank

APPENDIX A

MATERIAL SAFETY DATA SHEET FOR SULFUR HEXAFLUORIDE

MATERIAL SAFETY DATA SHEET

LIQUID CARBONIC
SPECIALTY GAS CORPORATION
[illegible] SOUTH LA SALLE STREET • CHICAGO, ILLINOIS 60603-4287
PHONE (312) 855-2[illegible]

Sulfur Hexafluoride

Revision Feb. 1989

24 Hour Emergency Phone Numbers: (504)673-8831; CHEMTREC (800)424-9300

SECTION I—PRODUCT IDENTIFICATION

CHEMICAL NAME:	Sulfur Hexafluoride	
COMMON NAME AND SYNONYMS:	Sulfur Hexafluoride, Sulfur Fluoride	
CHEMICAL FAMILY:	Inorganic Fluoride	FORMULA: SF_6

SECTION II—HAZARDOUS INGREDIENTS

MATERIAL	VOLUME %	CAS NO.	1988-9 ACGIH TLV UNITS
Sulfur Hexafluoride	99.9%	2551-62-4	8 Hr. TWA 1000 PPM No STEL (OSHA & ACGIH)

SECTION III—PHYSICAL DATA

BOILING POINT (°F.)	Sublimes -82.8°		
SPECIFIC GRAVITY (H_2O=1)	@1 ATM. and @ 70°F - 6.4		
VAPOR PRESSURE @ 70°F	319 PSIA	% VOLATILE BY VOLUME	100%
VAPOR DENSITY (AIR=1)	@70°F 5.13	EVAPORATION RATE (BUTYL ACETATE=1)	Rapid
SOLUBILITY IN WATER	Slightly		
APPEARANCE AND ODOR	Colorless, odorless gas		

SECTION IV—FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (METHOD USED) Non-flammable FLAMMABLE LIMITS LEL N/A UEL N/A

EXTINGUISHING MEDIA: Use media appropriate for surrounding fire

SPECIAL FIRE FIGHTING PROCEDURES: Use water spray to cool fire exposed containers. Use self-contained breathing apparatus as SF_6 can decompose at high temperatures to give off toxic and corrosive fumes.

UNUSUAL FIRE AND EXPLOSION HAZARDS: Vapors are five times heavier than air and will tend to accumulate in low places. SF_6 can be an asphyxiant in enclosed areas.

SECTION V--HEALTH HAZARD DATA

THRESHOLD LIMIT VALUE: TWA is 1000 PPM

EFFECTS OF OVEREXPOSURE: Sulfur hexafluoride is non-toxic. However it can act as an asphyxiant in high concentrations. Symptoms are headache, dizziness, labored breathing and eventual unconciousness. Persons in ill health where such illness would be aggravated by exposure to Sulfur Hexaflouride should not be allowed to work with or handle this product.

EMERGENCY AND FIRST AID PROCEDURES: If inhaled move to fresh air and obtain prompt medical attention. Administer oxygen. Give artificial respiration if not breathing. Rescue personnel should be equipped with self-contained breathing appartus. In case of contact with Liquid SF_6, flush affected areas with lots of warm water to reduce tissue freezing.

Sulfur Hexafluoride is not listed as a carcinogen or potential carcinogen by NTP, IARC Monographs, and OSHA.

E

 Form [illegible] Rev 7/86

SECTION VI--REACTIVITY DATA

STABILITY: UNSTABLE ( ) STABLE (X)

CONDITIONS TO AVOID: N/A

INCOMPATABILITY (MATERIALS TO AVOID): None

HAZARDOUS DECOMPOSITION PRODUCTS: Lower fluorides of sulfur

HAZARDOUS POLYMERIZATION: MAY OCCUR ( ) WON'T OCCUR (X)

CONDITIONS TO AVOID: N/A

SECTION VII—SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED: Evacuate personnel from affected area. Avoid high concentrations in confined space. Provide ventilation. Do not re-enter area without appropriate protective equipment.

WASTE DISPOSAL METHOD: Vent to atmosphere. Follow any applicable local, State, or Federal regulations.

SECTION VIII--SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION: If required - self contained breathing apparatus.

VENTILATION: LOCAL EXHAUST ( )
MECHANICAL (GENERAL) (X) Provide adequate ventilation in low areas to be below allowable TLV.

PROTECTIVE GLOVES: Leather EYE PROTECTION: Goggles or safety glasses

OTHER PROTECTIVE EQUIPMENT: Safety shoes recommended for cylinder handling

SECTION IX--SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING: Protect cylinders from physical damage. Store in cool, dry, well ventilated area. Cylinders should not be exposed to temperatures over 130°F. Follow normal compressed gas storage practices. Cylinders should be stored upright and firmly secured to prevent falling over. Sulfur Hexafluoride exposed to electric arcs may contain toxic by-products. Keep valve caps and plugs tight and in place.

OTHER PRECAUTIONS: Use only DOT or ASME coded storage containers. Use a check valve or trap in the Sulfur Hexafluroide discharge line to prevent hazardous backflow. Cylinders must not be recharged except by or with consent of Liquid Carbonic. Refer to CGA bulletin SB-2 oxygen Deficient Atmospheres" and pamphlet P-1 "Safe Handling of Compressed Gases in Containers."

No. 223

Blank

APPENDIX B

CHEMICAL/PHYSICAL/ENVIRONMENTAL INFORMATION ON SULFUR HEXAFLUORIDE[1]

[1]Environmental Fate and Effects: Sulfur Hexafluoride, CRDEC Data Management System, U.S. Army Chemical Research, Development and Engineering Center, Aberdeen Proving Ground, MD, 1990, UNCLASSIFIED Report.

CHEMICAL AGENT SIMULANT DATA CENTER

Entry Number
602

CRDEC Number
CRDEC-0602

CAS Reg Number
002551-62-4

Formula
F6 S

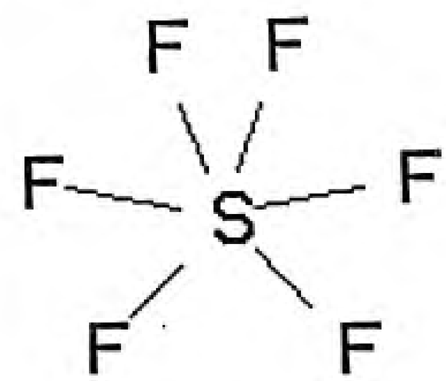
Molecular Weight
146.054

WLN
FSFFFFF

Today's Date
03/26/90

Page 1 of 5

Structure



SULFUR HEXAFLUORIDE

Synonyms

sulfur fluoride
SF6

CHEMICAL AGENT SIMULANT DATA CENTER

SULFUR HEXAFLUORIDE

2756300 @20C liq Ref 76

Vapor Pressure [torr]

2.7563E6 @20C liq Ref 76
1.0 @-133C subl Ref 78
40.0 @-102C subl Ref 78
100.0 @-91C subl Ref 78
400.0 @-73C subl Ref 78

Density [gm/cc]

1.88 @-50.8C liq Ref 42,76,78
6.602 g/l gas Ref 52,78

Boiling Point [C]

-63.8 @760 subl Ref 78,76

Surface Tension [dynes/cm]

3.28 @20C Ref 76

Vapor Density

5.04

Molar Volume

77.7 @mp

Melting Point [C]

-50.8 Ref 42,78,76

Calc Molar Ref

Viscosity [cp]

Volatility [mg/m3]

Diffusivity [cm2/sec]

Refractive Index

Page 2 of 5

Entry Number
602

CHEMICAL AGENT SIMULANT DATA CENTER

SULFUR HEXAFLUORIDE	Heat Capacity [cal/gm degC] 0.159 Ref 76
Heat of Vaporization [cal/gm] 27.93 @-63.8C Ref 76	Specific Heat [cal/gm]
Heat of Combustion [cal/gm]	Decomp Temp [C] / Oxygen Index
Heat of Fusion [cal/gm]	Flash Point [C]
	Autoignition Temp [C]
Heat of Formation [cal/gm]	Dielectric Constant
Energy to Vaporize [cal/gm]	Dipole Moment [debyes] 0.0 Ref 76
Page 3 of 5 / Entry Number 602	

CHEMICAL AGENT SIMULANT DATA CENTER

SULFUR HEXAFLUORIDE	Hygroscopicity
Critical Temp [C] 45.6 Ref 42,76	O/W Partition Coefficient [LogP] 1.68 Ref 72
Critical Pressure [atm] 37.11 Ref 76	Solubility Parameter [H]
Critical Volume [cc/mole]	Toxicity TLV=6000 mg/m^3
Critical Density [gm/cc] 0.524 Ref 76	
Water Solubility slight Ref 42,78	Solubility Value [gm/ml]
Hydrolyses Rate	
Industrial Application in electric circuit interrupters. in electronic ultrahigh frequency piping.	
Page 4 of 5	Entry Number 602

CHEMICAL AGENT SIMULANT DATA CENTER

Chemical Reactivity

Simulant Application

proposed as vapor tracer sim by CAN for threat/hazard assessment trials
proposed as vapor tracer sim by UK for individual protection trials
used as vapor tracer sim by US in collective protection trials
used as vapor tracer sim by US in detection trialling

Comments

Page 5 of 5	Entry Number 602	SULFUR HEXAFLUORIDE

Sulfur hexafluoride

CAS Reg No.: 2551-62-4 RTECS No.: WS4900000 CRDEC No.: 85097

Formula: SF6

SYNONYMS:

UN 1080 (DOT)
SULFUR HEXAFLUORIDE (ACGIH,DOT)
SULFUR HEXAFLUORIDE
SULFUR FLUORIDE
HEXAFLUORURE DE SOUFRE (FRENCH)

Property	Value	Condition	References
Solubility (H2O) (Calc)	31.000 mg/l		26
Solubility (H2O)	31.000 mg/l (Ca		26

Press [Return] for next page, [Backspace] for previous page
Use arrows for cursor control, Enter "Q" to quit

Fate and Effects   CRDEC Data Management System   26-MAR-90

Sulfur hexafluoride

CAS Reg No.: 2551-62-4   RTECS No.: WS4900000   CRDEC No.: 85097

Specific gravity	1.880	g/cc	-50.000	C.	497
Specific gravity	1.336	g/cc			506
Vapor specific gravity	6.089	g/l			506
Vapor specific gravity	6.500	g/l			26
Molecular weight	146.070				497
Melting point	-50.800	C.			57

DESCRIPTORS:

Sulfur hexafluoride is a nonflammable, colorless, ordorless, gas. (497)

CHEMICAL AND PHYSICAL PROPERTIES:

Press [Return] for next page, [Backspace] for previous page
Use arrows for cursor control, Enter "Q" to quit

Sulfur hexafluoride

CAS Reg No.: 2551-62-4 RTECS No.: WS4900000 CRDEC No.: 85097

MILITARY APPLICATION:

THERAPEUTIC USES

The intraocular injection of sulfur hexafluoride appears to be useful contribution to the surgical treatment of superior bullous hemi-retinal detachment, allowing effective and durable internal tamponade, while avoiding prolonged bedrest.

The investigators devised a new therapeutic method which consisted in injecting sulfur hexafluoride into the postpneumonectomy pleural space so as to maintain the chest cavity. Gas injection at intervals of 6 months can maintain a clear pleural space with neither retention of pleural effusion nor deformity of the thorax.

Fate and Effects   CRDEC Data Management System   26-MAR-90

Sulfur hexafluoride

CAS Reg No.: 2551-62-4   RTECS No.: WS4900000   CRDEC No.: 85097

INDUSTRIAL APPLICATION:

Sulfur Hexafluoride is used as a gaseous insulator for guides (507). It has been widely used as a tracer gas for both indoor and outdoor source dissemination experiments as well as for measuring gas exchange coefficients in lakes (508, 509, 510).

ENVIRONMENTAL LAWS AND REGULATIONS:

Sulfur hexafluoride is not listed in the TSCA inventory. The substance is not listed as a hazardous material by DOT, as a hazardous waste under the RCRA, or as a hazardous substance under the CERCLA or the FWPCA.

TOXICOLOGY:

Press [Return] for next page, [Backspace] for previous page
Use arrows for cursor control, Enter "Q" to quit

Fate and Effects   CRDEC Data Management System   26-MAR-90

Sulfur hexafluoride

CAS Reg No.: 2551-62-4   RTECS No.: WS4900000   CRDEC No.: 85097

Mutagencity:
Repro Effects:
Tumorigenicity:
Ecotoxicity:
Human Exposure: Time weighted avg (TWA) 1000 ppm, 6000 mg/cu m; short term exposure limit (stel) 1250 ppm, 7500 mg/cu M (1983-84).

TOXIC HAZARD RATING
Acute Systemic: Inhalation 1. 1=slight: causes readily reversible changes which disappear after end of exposure.

POISONING POTENTIAL

Press [Return] for next page, [Backspace] for previous page
Use arrows for cursor control, Enter "Q" to quit

Sulfur hexafluoride

CAS Reg No.: 2551-62-4 RTECS No.: WS4900000 CRDEC No.: 85097

It has not been possible to establish its experimental toxicity clinically (481). Essentially nontoxic gas. The chief hazard, as with other inert gases, would seem to be asphyxiation as a result of the displacement of air.

RATE	SPECIES	DOSE	EFFECT (Ref)
Intravenous	Rabbits	5790 mg/kg	LD50

Fifty rats exposed to sulfur hexafluoride atmosphere (80% with 20% oxygen for periods of from 16-24 hr) showed no effects from the exposure.

CHEMICAL REACTIVITY:

Press [Return] for next page, [Backspace] for previous page
Use arrows for cursor control, Enter "Q" to quit

Fate and Effects CRDEC Data Management System 26-MAR-90

Sulfur hexafluoride

CAS Reg No.: 2551-62-4 RTECS No.: WS4900000 CRDEC No.: 8509?

ENVIRONMENTAL FATE:

ENVIRONMENTAL FATE/EXPOSURE - ENV

Sulfur hexafluoride may be released to the environment during its production, storage, transporation, and use as a gaseous insulator for electrical equipment and a tracer gas for source dessimation and gas exchange studies. It is an extremely inert gas and would not be expected to degrade under environmental conditions. If released on land, sulfur hexafluoride will be lost primarily by volatilization. It does not adsorb appreciably to soil and therefore, may leach into the groundwater. If released in water, it will be lost by volatiliztion. Its half-life in a model river is estimated to be 3.5 hr. In the atmosphere, it will be transported to the ground by wet and dry deposition. Sulfur hexafluoride is a very dense gas so it will mainly reside in the lowest layers of air.

Press [Return] for next page, [Backspace] for previous page
Use arrows for cursor control, Enter "Q" to quit

Fate and Effects CRDEC Data Management System 26-MAR-90

Sulfur hexafluoride

CAS Reg No.: 2551-62-4 RTECS No.: WS4900000 CRDEC No.: 85097

Exposure will be primarily occupational.

TERRESTRIAL FATE: If released on soil, sulfur hexafluoride will be lost primarily by volatilization. It does not adsorb to soil and may also transport to the subsoil and groundwater. Degradation in soil should not be significant.

AQUATIC FATE: If released into water, sulfur hexafluoride would be lost primarily by volatilization. Its estimated volatilization half-life from a model river 1 m deep having a 1 m/sec current with a 3 m/sec wind is 3.5 hr. The volatilization would be controlled by resistance in the liquid phase indicating that the rate of volatilization is more influenced by water current than wind speed. Adsorption to sediment and particulate matter in the water column should be negligible.

Press [Return] for next page, [Backspace] for previous page
Use arrows for cursor control, Enter "Q" to quit

Fate and Effects | CRDEC Data Management System | 26-MAR-90

Sulfur hexafluoride

CAS Reg No.: 2551-62-4 | RTECS No.: WS4900000 | CRDEC No.: 85097

ATMOSPHERIC FATE: Sulfur hexafluoride is one of the heaviest known gases with a vapor density approximately five times that of air (497). Therefore, if released in the atmosphere, it will tend to remain close to the ground and be transported to earth by wet and dry deposition. It is inert and should not degrade.

ABIOTIC DEGRADATION - ABIO
Sulfur hexafluoride is very resistant to attack and extreme conditions are required (511). For example it resists molten KOH and steam at 500oC (511). Sulfur hexafluoride is inert at room temperature and atmospheric pressure (506). Its high resistance has been ascribed to its high S-F bond strength, coordinate saturation, stearic hindrance, and nonpolarity (511). While hydrolysis is energetically favorable, the fluorine groups

Press [Return] for next page, [Backspace] for previous page
Use arrows for cursor control, Enter "Q" to quit

Sulfur hexafluoride

CAS Reg No.: 2551-62-4 RTECS No.: WS4900000 CRDEC No.: 85097

effectively shield the sulfur atom and impede this reaction (506).

BIOCONCENTRATION - BIOC
Using the water solubility of 31 mg/1 (508), one can estimate a biocentration factor (BCF) of 89 for sulfur hexafluoride using a recommended regression equation (512). Therefore sulfur hexafluoride would not be expected to bioconcentrate appreciably in fish and aquatic organisms.

SOIL ADSORPTION/MOBILITY - KOC
The adsorption of sulfur hexafluoride was studied in four soils that differed markedly in pH, texture, and organic carbon content by injecting 100 ppm of the gas into bottles containing 5 g soil and following the concentration of the sulfur hexafluoride in the air for 15 days (513).

Press [Return] for next page, [Backspace] for previous page
Use arrows for cursor control, Enter "Q" to quit

Sulfur hexafluoride

CAS Reg No.: 2551-62-4 RTECS No.: WS4900000 CRDEC No.: 85097

The experiments were conducted using both air-dried soils and soils moistened to fifty percent of their water-holding capacity. None of the soils tested adsorbed any sulfur hexafluoride. Sulfur hexafluoride's lack of adsorptivity is one characteristic that makes it an ideal tracer gas.

VOLATILIZATION FROM WATER/SOIL - VWS

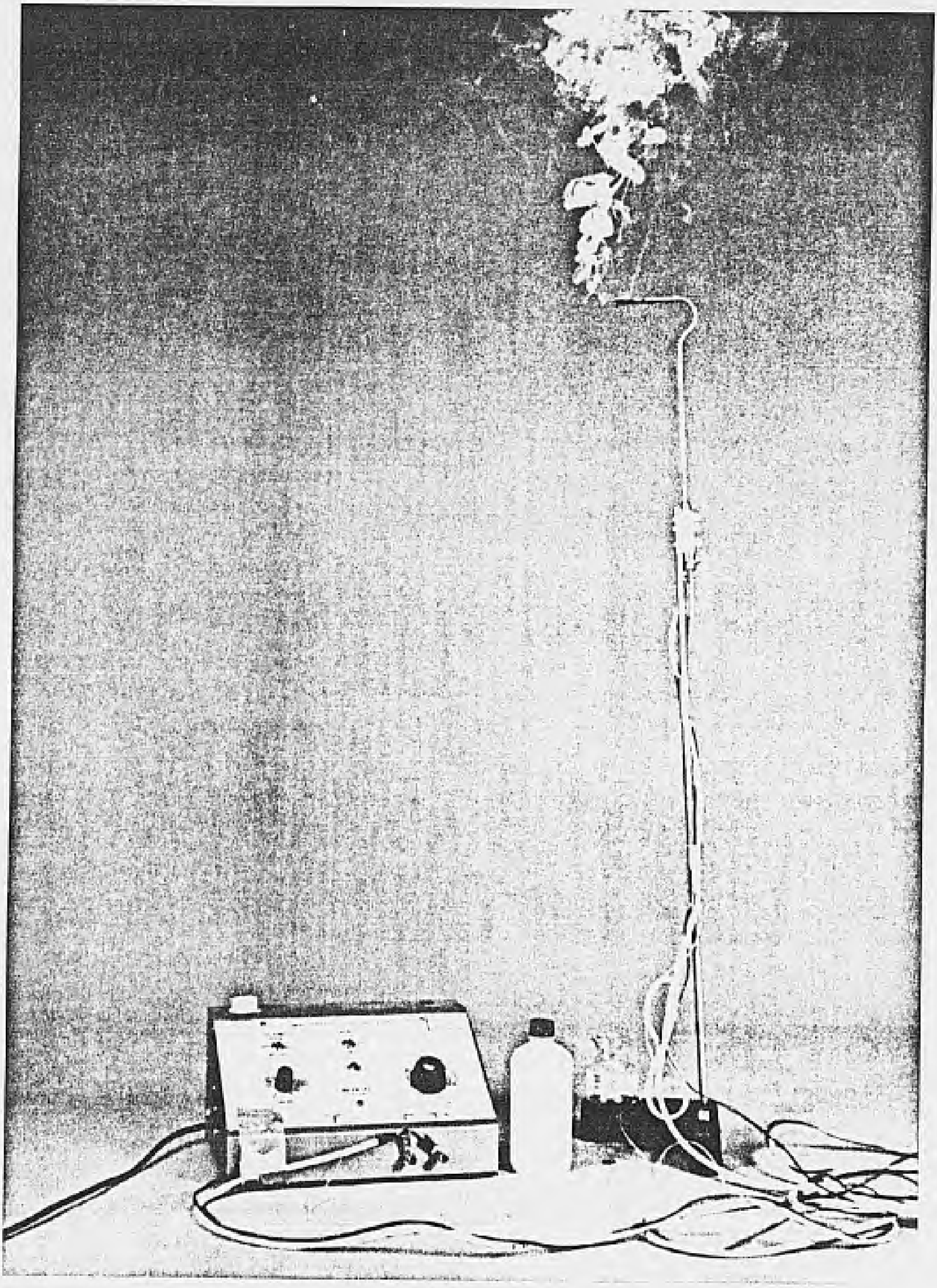
The Henry's Law Constant for sulfur hexafluoride is 4.52 atm-m3/mole at 25oC (508). Using this Henry's Law Constant, one can estimate that sulfur hexafluoride's volatilization half-life from a model river 1 m deep having a 1 m/sec current with a 3 m/sec wind would be a 3.5 hr (512). The volatilization would be controlled by resistance in the liquid phase. The half-life in a pond or lake would be much longer. Experiments in which volatilization of sulfur hexafluoride from a shower was determined, showed the amount of sulfur hexafluoride volatilized was much less than would be

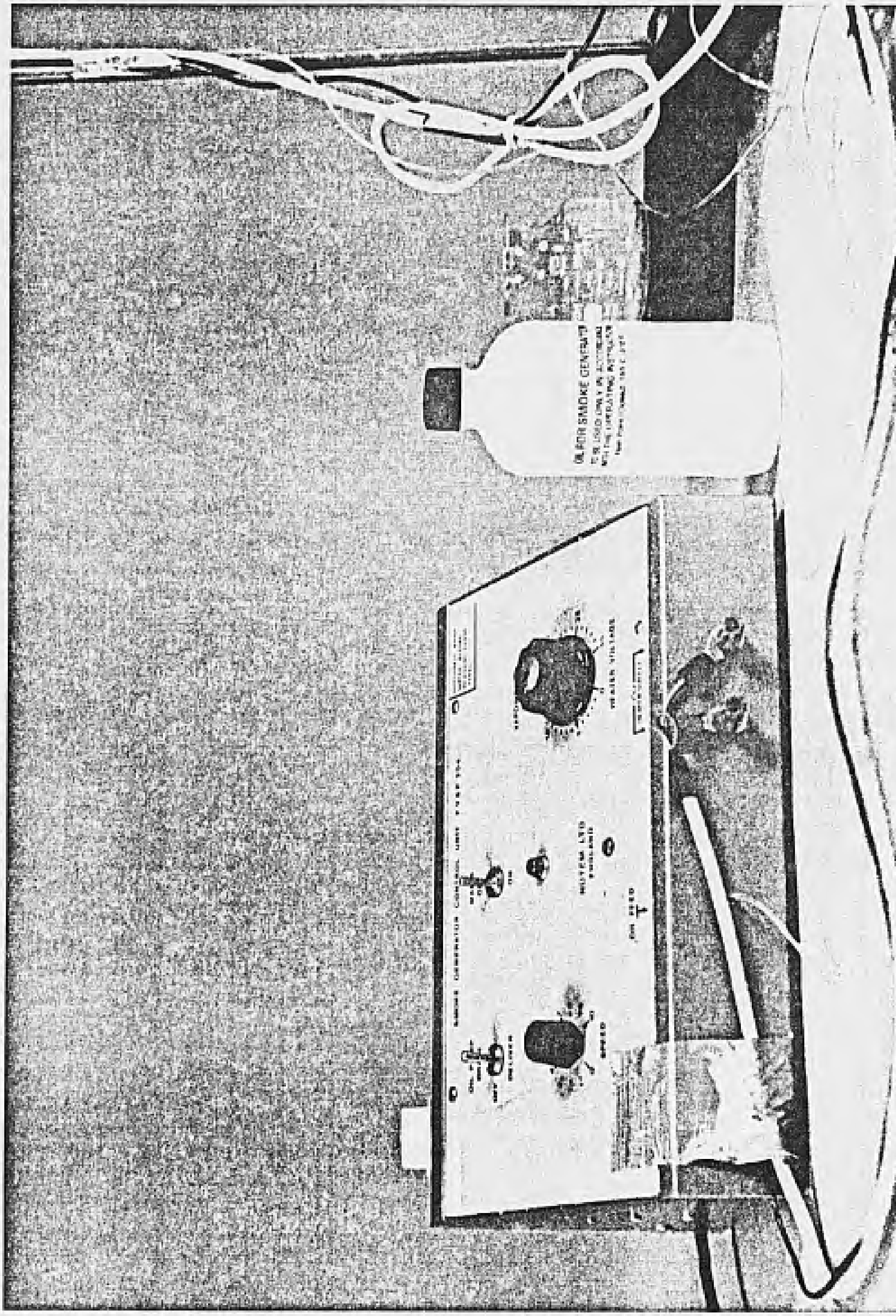
Press [Return] for next page, [Backspace] for previous page
Use arrows for cursor control, Enter "Q" to quit

Blank

APPENDIX C

SMOKE GENERATOR PICTURES





END

FILMED

DATE:
10-92

DTIC