EDGEWOOD

CHEMICAL BIOLOGICAL CENTER

U.S. ARMY RESEARCH, DEVELOPMENT AND ENGINEERING COMMAND

ECBC-TR-362

DEMONSTRATION/VALIDATION OF THE TC-25 DONOVAN BLAST CHAMBER PORTON DOWN, UK FINAL DEMONSTRATION TEST REPORT APRIL-SEPTEMBER 2003

Timothy A. Blades
Raymond DiBerardo
Gregory Misko

CHEMICAL BIOLOGICAL SERVICES DIRECTORATE

Neil McFarlene

dstl

DEFENCE SCIENCE AND TECHNOLOGY LABORATORY
Porton Down, UK

May 2004

ABERDEEN PROVING GROUND, MD 21010-5424

Disclaimer

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorizing documents.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*
XX-05-2004

2. REPORT TYPE
Final

3. DATES COVERED *(From - To)*
Apr 2003 - Sep 2003

4. TITLE AND SUBTITLE
Demonstration/Validation of the TC-25 Donovan Blast Chamber
Porton Down, UK
Final Demonstration Test Report, April - September 2003

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Blades, Timothy, A.; DiBerardo, Raymond; Misko, Gregory (ECBC); and McFarlene, Neil (DSTL)

5d. PROJECT NUMBER
622622

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) AND ADDRESS(ES)
DIR, ECBC, ATTN: AMSRD-ECB-CB-C, APG, MD 21010-5424
DSTL, Porton Down, UK

8. PERFORMING ORGANIZATION REPORT NUMBER
ECBC-TR-362

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

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

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

13. SUPPLEMENTARY NOTES

14. ABSTRACT

In the FY2002 Defense Appropriations Bill, Congress mandated that the U.S. Army conduct a demonstration/validation test for using a transportable detonation chamber technology to dispose of recovered chemical warfare materiel. The TC-25 Donovan blast chamber (DBC) is a transportable system designed to contain the repeated detonations of up to 25 lb of TNT. The TC-25 DBC uses donor explosive charges to detonate the munition's shell, energetic components, and chemical fill.

Demonstration/validation testing of the TC-25 DBC was performed at the Defence Science and Technology Laboratory (DSTL), Porton Down, UK, May - September 2003. The overall test objective was to demonstrate that the TC-25 DBC can safely and effectively destroy recovered munitions with or without explosive components. Data was collected throughout these subtests to verify the safety, integrity, and efficacy of the TC-25 and the ability of the operator to collect waste samples.

During Operations, the system successfully treated Phosgene (CG), chloropicrin (PS), a smoke-generating formulation based on hexachloroethane (HC) and zinc oxide, and mustard (H) agents. The system was successfully decontaminated to a 3X level and closed out following the chemical tests.

15. SUBJECT TERMS

TC-25 DBC	Controlled detonation	Warfare	ECVC
Donovan	Porton Down	Materiel	Dstl
Transportable	Chemical	Demonstration/validation	Demil International

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Sandra J. Johnson
					19b. TELEPHONE NUMBER *(include area code)*
U	U	U	UL	66	(410) 436-2914

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39.18

20040806 117

Blank

EXECUTIVE SUMMARY

In the FY2002 Defense Appropriations Bill, Congress mandated that the U.S. Army conduct a Demonstration/Validation Test of the use of transportable detonation chamber technology for disposal of recovered chemical warfare material. The program was funded by $6 million through the Deputy Assistant Secretary of the Army for Environment, Safety, and Occupational Health (DASA [ESOH]). This office tasked the Edgewood Chemical Biological Center (ECBC) with the overall project management of the Demonstration/Validation Test.

In order to expedite the contractual relationship necessary to execute the testing, ECBC chose to employ an existing contract mechanism (meeting the congressional criteria) between the U.S. Army Corp of Engineers, Huntsville and DeMil International (a wholly owned subsidiary of CH2M HILL), owners of the Donovan Blast Chamber (DBC) technology. The TC-25 DBC is a transportable system designed to contain the repeated detonations of up to 25 lb of TNT. It includes a detonation chamber, expansion chamber, and an air pollution control system. The TC-25 DBC uses donor explosive charges and the resulting heat and pressure to detonate the munition's shell and energetic component, and treat the chemical fill. Any resulting harmful degradation products are then captured and treated in the air pollution control system.

Demonstration/validation testing of the TC-25 DBC was performed at the Defence Science and Technology Laboratory (DSTL), Porton Down, UK, from April to September 2003. DSTL received funding for the test facility, site support, and support personnel. The overall test objective was to demonstrate that the TC-25 DBC can safely and effectively destroy recovered munitions with or without explosive components. Data were collected throughout four subtests to verify the safety, integrity, and efficacy of the TC-25 DBC and the operator's ability to collect waste samples. ECBC managed the project, operated the equipment, and performed monitoring and analysis of the test's simulant and chemical warfare portion. DeMil International provided data collection, training, and technical oversight for its equipment; DSTL provided local project management and support services, including decontamination of operating personnel and emergency response; and the Army Materiel Systems Analysis Activity (AMSAA) in conjunction with MITRETEK Systems provided the independent evaluation of the TC-25 DBC Demonstration/Validation Test.

The demonstration testing included four separate subtests—transportation, pre-operations, operations, and closeout. The subtests proved that the TC-25 DBC can safely and effectively destroy recovered chemical munitions without releasing hazardous materials to the environment.

During the Operations Test Phase, the system successfully treated phosgene (CG), chloropicrin (PS), hexachloroethane/zinc oxide (HC), and mustard (H) agent. The compounds were contained in recovered munitions and DOT bottles (specifically 4.2-in. UK mortars, 25-lb shells, 4-in. Stokes mortars, 105-mm projectiles, 3.5-in. DOT bottles, and 5-in. DOT bottles. The amount of each agent was up to 6.6 lb of CG or CG/PS, 6 lb of H, and 5.5 lb of HC smoke. The system was subjected to a "thermal decon" stage and successfully decontaminated to a 3X level to close out the chemical tests.

A second phase of demonstration/validation testing is planned in order to validate procedural modifications for increased safety and productivity as well as engineering modifications by DeMil International as a result of lessons learned from the first test.

PREFACE

The work described in this report was authorized under Project No. 622622. The work started in April 2003 and was completed in September 2003.

The use of either trade 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.

Acknowledgments

This project was made possible by funding from the Office of the Deputy Assistant Secretary of the Army for the Environmental, Safety, and Occupational Health. The authors would like to thank the U.S. Army Corp of Engineers and the European Research Office for their contract support.

We wish to thank all those from the U.S. Army Edgewood Chemical Biological Center (ECBC) and Defence Science and Technology Laboratory (DSTL) for their efforts in the daily operations of the TC-25 DBC. In addition, the authors would like to thank the engineers and scientists from ECBC, DeMil International, and DSTL for their efforts in collecting, analyzing, and compiling the data. Finally, a special thank you to all U.S. and British officials who contributed to the realization of the project.

The following organizations are acknowledged for their interest in visiting the test site during the TC-25 DBC testing: Department of Health and Human Services (DHHS), Defense Threat Reduction Agency (DTRA), Deputy Assistant Secretary of the Army of Environmental Safety and Occupational Health [DASA (ESOH)], Product Manager for Non-Stockpile Chemical Materiel (NSCM), Department of Defense Explosives Safety Board (DDESB), and Corp of Engineers (COE). We would like to thank the U.S. Army Materiel Systems Analysis Activity (AMSAA) and MITRETEK Systems for their independent evaluation of the demonstration/validation test.

Blank

CONTENTS

FIGURES

TABLES

DEMONSTRATION/VALIDATION
OF THE TC-25 DONOVAN BLAST CHAMBER
PORTON DOWN, UK
FINAL DEMONSTRATION TEST REPORT
APRIL-SEPTEMBER 2003

1. INTRODUCTION

The U.S. Army Corps of Engineers contracted with DeMil International, a wholly owned subsidiary of CH2M HILL, to provide equipment and technical services for the demonstration/validation testing of the TC-25 Donovan Blast Chamber (DBC) technology. These services were furnished under Contract DACA87-00-D-0047, Task Order Number 11 of February 11, 2003.

The test services were conducted in accordance with the *June 2003 Final Test Plan* prepared by the ECBC to address operational requirements established by the Deputy Assistant Secretary of the Army, Environment, Safety and Occupational Health (DASA [ESOH]).

The TC-25 DBC system was designed and constructed to be transportable and self contained. As part of the evaluation, the system's features were tested to demonstrate that it can be transported, erected, and could successfully use controlled detonation to destroy chemical munitions. The final subtest was to demonstrate that the system could be decontaminated and ready to move to a new location upon completion of a particular task. Demonstration/validation testing was organized into four subtests: transportation, preoperations, operations, and closeout, all described in appropriate sections of this report.

The overall objectives of the TC-25 DBC demonstration/validation testing were established by the *Transportable Detonation Chamber Test Plan for Defence Science and Technology Laboratory Salisbury, Wiltshire UK* (ECBC June 2003) and were to:

- Demonstrate that the TC-25 DBC can safely and effectively destroy recovered chemical munitions with or without explosive components.

- Demonstrate that the TC-25 DBC can reduce the hazardous properties of the chemical fill without release of hazardous wastes or materials to the soil or water. Data will be collected during this test to quantify the reduction.

- Develop the data necessary to demonstrate to the U.S. Army; Department of Defense (DoD); and federal, state, and local environmental agencies the safety, integrity, and efficacy of the TC-25 DBC and the ability of the operator to collect waste samples.

The required equipment was shipped to DSTL, Porton Down (United Kingdom) in April, assembled and tested for mechanical and electrical integrity in May, and a Preoperations Survey was conducted the first week of June. System testing with explosives and surrogate chemicals was conducted June 17 through July 10 and with chemical agents and recovered munitions July 14 through August 28, 2003.

Demonstration/validation accomplishments during this testing included reliability testing of firing circuits necessary to withstand the temperature, pressure, and shrapnel generated during high-explosives and recovered-chemical-munitions detonations. Vapor control systems were tested and modified to meet the test program and the host organization's requirements. The carbon adsorption system was modified to overcome manufacturing defects discovered in the process startup. Process equipment was insulated after assembly to facilitate the thermal decontamination of the equipment after exposure to persistent chemical agents.

Operating procedures were periodically reviewed and revised as lessons were learned. The operating crew's investigations for improving system throughput included a single team to prepare munitions and explosives, load, detonate, and unload the process followed by multiple teams to accomplish the same steps in parallel tasks. These investigations demonstrated a fourfold improvement in system throughput. The system was decontaminated the week of September 2, 2003, resulting in successfully meeting or exceeding the U.S. Army's requirements for decontaminating the equipment to a 3X level.

Testing Schedule and Test Munitions.

A. Schedule.

The *June 2003 Final Test Plan* established 49 shots of chemical-containing items; however, not all shots could be completed owing to the issues noted below and established work practices at the Porton Down facility. The following events impacted the testing schedule:

- The detonation chamber arrived 10 days late due to issues related to the shipping provider and U.S. Customs (Section 3, *Transportation*).

- The TC-25 DBC system was colocated with another test program at the facility during part of the TC-25 DBC testing. At times, operations from the other test program prevented TC-25 DBC test personnel from entering the test building.

- One week was lost on the vestibule and fugitive emission ventilation assessment (Section 4, *Preoperations*).

- Two misfires occurred in the Workup Phase (Section 5, *Operations*) that required 1 week to resolve.

Appendix D provides the as-performed summary of the TC-25 DBC testing.

B. Target Munitions.

Of the 49 chemical shots identified in the Test Plan, 20 chemical-containing shots were executed during testing. In addition, four shots of water-filled DOT bottles were completed. Table 1 provides a summary of changes to the originally planned chemical shots.

Table 1. Summary of Changes to the June 2003 Test (Shot) Plan

Planned Chemical Shots	Shots Completed during 2003 Test	Test Reference/ Comment
Three 4-in. Stokes mortars with a combination of CG/PS/Smoke at a max. chemical fill weight of 6.6 lb	2 shots completed CG/PS filled	Agent Test 4 and 5
Three shots GB in DOT bottles, 1.3-lb fill weight	Dropped from schedule	
Three shots of 105-mm smoke (HC)	Two shots completed	Agent Test 7 and 8
Three bursters, contaminated with H	Dropped from schedule	
Five UK 25-lb projectiles (1.54 lb of H fill)	5 shots completed	Agent Test 15-19
One UK 25-lb with 1.54 lb of H wrapped in double plastic bags to simulate destruction of a "leaker"	Not performed	
One UK 25-lb with 1.54 lb of H in a plaster of Paris casing	Not performed	
Fifteen 4.2-in. UK mortars containing 3.31 lb of H were to be destroyed in 3 days, or 5 rounds per day	As a substitute, 4 water-filled DOT bottles were shot in 3 hrs 5 min	Agent Tests 11-14
Three other H containing rounds that were to be determined	Not performed	
Two 4.2-in. U.S. mortars containing up to 6 lb of H	Two DOT bottles containing H drained from recovered munitions.	The 4.2-in. U.S. rounds were not available. Agent Tests 17 and 18
Performed but not included in the Test Plan	Two DOT bottles containing 2.7 lb MS and one DOT bottle containing 5.2 lb MS were not in the original test plan but were included as a chemical agent simulant	Agent Tests 1 and 8 Included as a surrogate for H rounds

2. SYSTEM DESCRIPTION

The TC-25 DBC is a proprietary technology developed by DeMil International, a wholly owned subsidiary of CH2M HILL, for destroying recovered chemical warfare materiel. The system uses controlled, enclosed detonation to destroy recovered chemical material for ultimate disposal. This detonation technology was originally developed as an alternative to open detonation for conventional munitions and energetic material. The technology has been modified for application to chemical warfare materiel by the addition of improved containment and an expanded air pollution control system. In the course of the treatment, the carbon monoxide resulting from detonation of high explosives is oxidized and the chemical fill materials are either oxidized or reduced to destroy the reactivity and toxicity of the chemical agents.

Detonation is controlled by balancing the energy necessary to open the munitions, vaporize and destroy the chemical contents with the temperature and pressure generated from detonation of energetic materials. Sufficient oxygen is added to oxidize organic chemical fills. Water or detonation gases are used to reduce the inorganic chemical fill materials. This sequence is a batch process tailored for each chemical agent and does not rely on controlled combustion to be effective.

The gas treatment system is designed to remove particulate matter and neutralize any acid gases resulting from the reactions of sulfur, phosphorus, or halogen components in the explosives or chemical fill. After the particulate matter and acid gases are removed, the resulting volatile organic compounds are oxidized in a catalytic oxidizer. The final treated gas is monitored to confirm the treatment of the chemical species in the munitions.

Below are descriptions of these units' functions, based on the direction of gas flow to the atmosphere. A general description of the test facility is also provided. Representative photographs of various units are provided in Appendix B.

2.1 Facility Description.

Figure 1 presents a diagram of the DSTL Porton Down test facility, with the equipment layout. The test facility was a steel building approximately 65.6 feet (20 meters) by 65.6 feet (20 meters) and has a concrete floor, a door of suitable size to accommodate the TC-25 DBC, and clearances on all sides. Utilities such as electrical power, water, and propane were provided via portable generators, water tanks, and propane storage tanks.

2.1.1 Vestibule.

The TC-25 came equipped with a plastic-lined vestibule designed to prevent the escape of chemical vapor, outside of engineering controls. The vestibule was constructed to house the supplies and equipment needed for chamber interior maintenance and provide for gross-level personnel decontamination. The design incorporated continuous air purging directly into the detonation chamber when the main offgas treatment process fan was operational. An entry area was actively ventilated at 400 standard cubic feet per minute (scfm) to the added filter system. This provided for air in the vapor containment structure (VCS) to enter the enclosure exit doorway and be directed to a filter system.

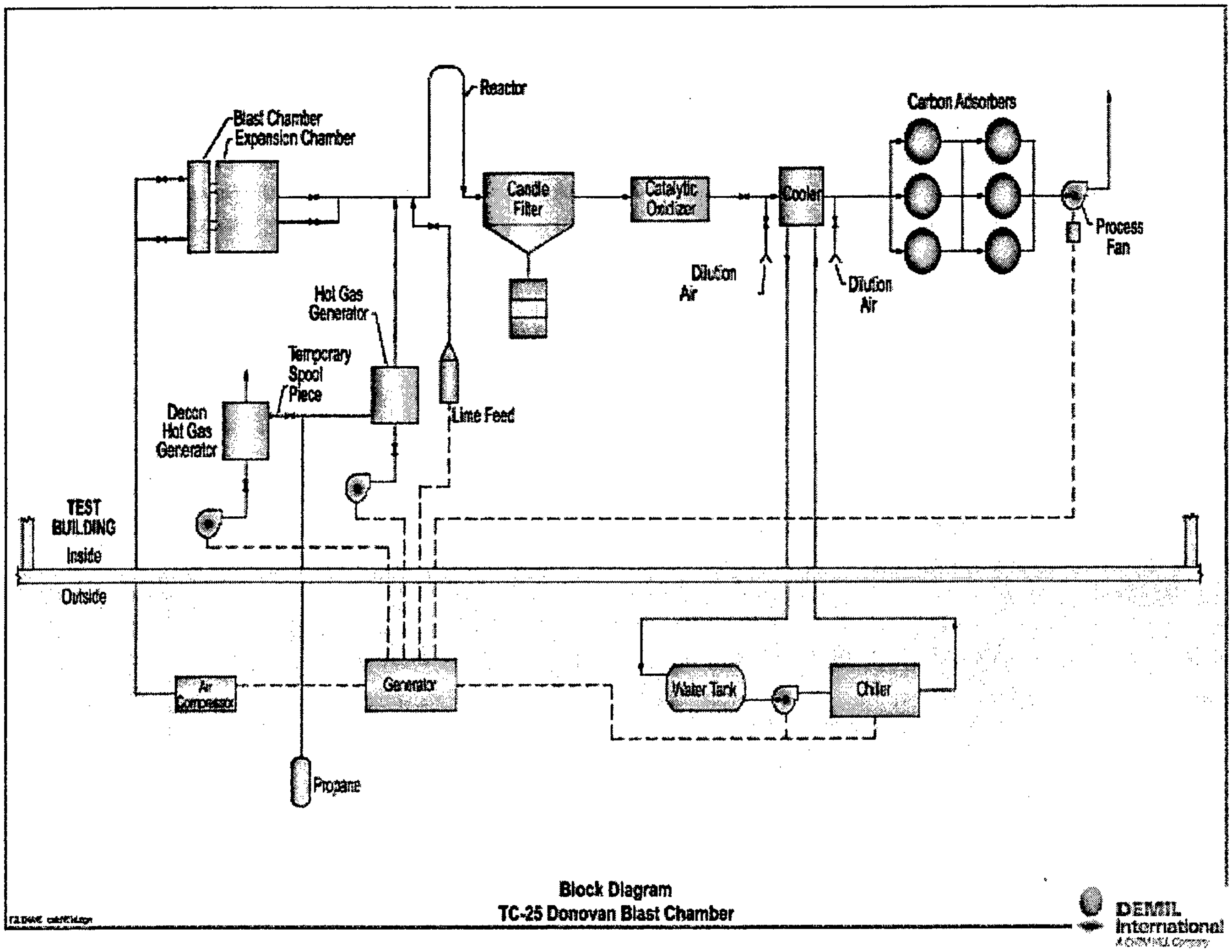


Figure 1. TC-25 DBC System Layout

As personnel make their way to the detonation chamber, they passed through an airlock (middle area) that connects the entry area to the original vestibule. The middle vestibule supplied makeup air for the detonation chamber ventilation system. In this manner, room air entering the vestibule, under vacuum, was maintained above a minimum value of about 100 feet per minute. The air direction was to the detonation chamber from ventilation of the main vestibule. There was sufficient ventilation to keep potential toxic chemicals from being released to the VCS if these chemicals were carried out of the detonation chamber from personnel activities. The middle vestibule was used as an area for gross personnel decontamination using soapy water and bleach solutions for cleaning boots and the outer surface of personal protective equipment (PPE), as well as for storing scrap metal waste. If chemicals were released from activities, such as clearing scrap metal from the chamber or from surface contamination on PPE, the vapors in the vestibule would be purged into the detonation chamber and cleared from the vestibule without release to the VCS.

2.1.2 Detonation Chamber.

The detonation chamber is fabricated from A-36 grade steel plate. The interior wall is lined with hardened, abrasive-resistant armor plating. The chamber floor is covered with about 6 in. of pea gravel. Ambient air continuously passes through the chamber, except just prior to detonating a munition. After a blast, pressures reach a quasi-steady-state condition within a few seconds (depending on the size of the munition). When excess pressure is ventilated to ambient pressure, ambient air is allowed to ventilate the chamber, in an induced draft mode, via the process fan.

2.1.3 Firing System.

This system was comprised of a RISI FS-61B firing box with a key lockout connected to a shorting plug at the front of the detonation chamber. The shorting plug was connected to a wall penetration interface at the detonation chamber outside wall. Inside the chamber, a cable terminating in bare leads was buried in the pea gravel to protect the cable from thermal stresses and shrapnel generated by the detonation. These bare leads were connected to RISI exploding bridgewire (EBW) detonators.

2.1.4 Shot Package Preparation.

The TC-25 DBC is designed to destroy recovered chemical warfare materiel by detonating a donor charge wrapped almost completely around a munition or container (i.e., DOT cylinder) in the presence of water. Water is supplied in the form of water-filled polypropylene bags and suspended by hooks from the chamber ceiling. The amount of water used depends on the high explosive (HE) content of the prepared munition .

Additionally, supplemental oxygen can be added to the chamber, prior to detonation, to enhance the fireball. At Porton Down, some tests were performed with commercially supplied compressed oxygen cylinders added to the chamber and exploded simultaneously with the package using a linear-shaped charge placed on the oxygen bottle.

2.1.5 Human Machine Interface.

The human machine interface (HMI) served as the operating interface between the system operator and the TC-25 DBC engineered system components. The HMI used resistive touch screen technology that allows operation with gloved hands, pointers, and ungloved hands. The heart of the control system was the programmable logic controller (PLC) processor. The processor stores and executes a customized computer program. Remote input/output (I/O) channels are assigned to points in the remote I/O panels. Communication between the I/O devices, PLC, and HMI was accomplished by use of an Ethernet network.

All air control valves, safety interlocks, air handling fans, and support equipment, including utilities, were able to be opened, closed, started, stopped, or held in a predetermined state by allowing the operator a single point of access through the HMI.

In addition, the HMI provided feedback to the operator on a continuous basis of critical process variables including temperatures, pressures, air flows, communication status, alarm indicators, door positions, and valve positions for safe and effective system operation. Each system component was available for viewing and control.

2.1.6 Expansion Chamber.

The detonation vent releases gases into the expansion chamber. The chamber is reinforced with channel steel for strength and serves to attenuate the overpressure condition created by detonation.

2.1.7 Hot Gas Generator.

Ambient air is heated directly by a contained propane flame that directly heats ambient air to 1,500 °F. The hot air is vented to the ductwork connecting the expansion tank to the reactive bed filtration system. As ambient air is exhausted from the expansion tank, it is mixed with hot air. At this point, the system pressure is negative relative to atmospheric pressure. The resulting temperature will be 700 to 900 °F and heats the ductwork leading to the reactive bed filter system. The hot gas generator will heat the ductwork, reactive bed filter, and catalytic converter to the operating temperature.

2.1.8 Reactive Bed Filter.

The reactive bed filter consists of a dry-solids feeding system to introduce acid gas reactive solids (hydrated lime and/or sodium bicarbonate), upstream of the particle filtration system. The reactive solids will react with acid gases in situ. In addition, further acid gas reactions take place on the solids cake that develops on the surface of the filters. Acid gases and particulate matter are generated from the destruction of a munition (smoke, chemical, or agent) in the detonation chamber. The addition of reactive solids is only necessary just prior to a detonation and lasts until the detonation chamber has been flushed sufficiently with ambient air.

The filtration system consists of rigid ceramic candle filters that remove particulate matter from the gas stream. Particulate matter would consist of the reactive solids, soot generated from blasting, and fragmentation of the pea gravel upon blasting. Applying a short burst of compressed air inside the filter cleans the filtration substrate. The burst of air dislodges the particles on the filter substrate and allows them to settle into the bottom of the housing for removal. The solids would consist of inert salts, unreacted solids, pea gravel dust, and soot.

2.1.9 Catalytic Converter.

The catalytic converter is a precious-metal catalyst supported on alumina ceramic. A catalyst serves to convert organic vapors and carbon monoxide to carbon dioxide and water. The catalyst's operating performance can be determined by measuring the temperature, upstream and downstream. The TC-25 DBC also has sampling point locations upstream and downstream of the catalyst to measure the carbon monoxide conversion performance.

2.1.10 Direct Air Dehumidifier.

Gas discharged from the catalytic converter is mixed with ambient air for cooling the offgas stream before entering a heat exchanger. Ambient air is introduced based on the vacuum provided by the process fan. The ambient air will cool the hot gas from about 1,200 to 400 °F.

2.1.11 Closed-Loop Offgas Heat Exchanger.

A heat exchanger is used to cool the hot gas to prepare it for carbon adsorption. Water (55 °F) is the heat transfer fluid in a closed-loop design. The return water (70 °F) is cooled by a chilled water system outside of the secondary containment building. The exhaust gas is cooled to less than 110 °F. Performance indicators for the heat exchanger and chiller include liquid side pressure, gas outlet temperature, and liquid flow rate. Varying the liquid flow rate can control gas discharge temperature.

2.1.12 Carbon Filtration.

There are two sets of carbon drums in series. The carbon serves to capture any trace organic compounds that may have not been destroyed in the process. Each carbon drum has a carbon fill capacity of 400 lb. There are gas-sampling locations upstream and downstream of each set of drums.

2.1.13 Process Fan.

A process fan conveys gases from the detonation chamber through the gas-cleaning components (filtration, catalytic conversion, and carbon adsorption) while maintaining a negative pressure in the system. The fan discharge will be at a positive pressure with respect to atmosphere.

2.1.14 Utilities.

The system comes with a diesel generator that supplies up to 600 kW of power. Power transformers are used to provide for 240- or 120-V AC power at multiple locations to support a variety of configurations and auxiliary equipment. Compressed dry air is provided with a rotary-screw-type compressor with a regenerative dryer capable of delivering about 100 scfm of compressed dry air at up to 105 $lb/in.^2$ gauge (psig). Compressed dry air is used for opening and closing pneumatic valves as well as for some forced air generation for purging and filter-cleaning operations. A 1,000-gal water tank, water pump, and 100-ton rotary screw chiller are supplied as an integrated package to provide chilled water for the closed-loop heat exchanger. Required raw materials for use and operation of the TC-25 DBC include diesel fuel, propane or natural gas, and water and hydrated lime for the reactive bed filter. The estimated total consumption volumes of propane, diesel fuel and water for the testing were 131,400 ft^3 (propane), 10,500 gal diesel and 850 gal of water.

3. TRANSPORTATION

3.1 Transportation Subtest Criteria.

All TC-25 DBC transportation steps were evaluated for compliance with applicable procedures and checklists to ensure safe performance. Subtest criteria established in the June, 2003 Test Plans were:

- Transportation should not cause any damage that would preclude or seriously degrade the conduct of the test. (Requirement)

- Transportation should not cause any damage resulting in other than routine maintenance upon unloading. (Requirement)

- Procedures for stowage and packaging are adequate to prepare and protect the TC-25 DBC against movement damage. (Requirement)

- Operators are to be capable of operating the TC-25 DBC. (Indicator)

- The required inventory of TC-25 DBC components, tools, spare parts, and expendables should be on-hand, complete, and undamaged. (Goal)

3.2 Transportation Subtest Results.

The TC-25 DBC system was packed in five intermodal shipping containers and the expansion and detonation chambers were shipped as bulk cargo, resulting in seven lifts for transport of the mechanical system.

Trucks transported the equipment from the final assembly site at Crescent City, Illinois, to the export ports. The detonation chamber required special travel permitting due to weight restrictions. A ship transported the equipment from the export port to the United Kingdom. The equipment was then transported by truck from the port to the test site.

The equipment was inspected upon arrival at the test site. The only damage found was a dented lime hopper and broken candles (18 out of 256) in the candle filter. From the damage sustained and shipping records available, it was not possible to determine where it had occurred. These were minor items, repaired at the test site as part of the equipment setup.

A delay occurred with the delivery of the detonation chamber. This item had been shipped later than the balance of the equipment due to a 2-day delay in getting a trailer and routing permits for an overweight shipment to the shipping location. The delivery of the detonation chamber to the site was further delayed 10 days by a hold by the U.S. Customs Service. This hold was placed because the original export permit was not presented to the Customs Officer by the transporter and the resolution process between the Customs Service and the State Department required 7 days to complete. The shipment was further delayed due to a 2-day delay in obtaining permits and escorts for transport from the port to the test site.

The Transportation Subtest was successfully completed. All transportation requirements, criteria, indicators, and goals were met.

4. PREOPERATIONS

4.1 Preoperations Subtest Criteria.

Per the June 2003 Final Test Plan, the criteria for the Preoperations Subtest were:

- The TC-25 DBC system shall be complete and ready to conduct test operations (Requirement).

- Health and safety documents and procedures shall be complete and approved. Safety and emergency response equipment and supplies shall be in place and ready for use (Requirement).

- The TC-25 DBC procedures (standard operating procedures [SOPs] and checklists) shall be complete and approved (Requirement).

- Operators are to be capable of operating the TC-25 DBC (Indicator).

- The required inventory of TC-25 DBC components, tools, spare parts, and expendables should be on-hand, complete, and undamaged (Goal).

4.2 Preoperations Results.

A Preoperations Survey of the system, including smoke testing of the test building and the vestibule, was conducted June 2 through 6, 2003. The Preoperations Survey was completed successfully as presented in the Preoperations Survey team report as summarized in Table 2.

Table 2. Preoperations Survey Results

Category	No. of Items Identified in PreOp Survey	Category Definition
1	1-vestibule design which was corrected in 1 week	Items considered essential to personnel safety or the system's operational readiness. These items must be resolved prior to the start of the operations.
2	0	Items not considered critical to personnel safety personnel or the system's operational readiness, but considered deficiencies that must be corrected. Any delay in the correction of these items will be established prior to recommendation to start operations.
3	15	Items noted by the evaluation team but corrected while the survey was being conducted.
4	4	No response required.

The Preoperations Survey findings showed that the vapor capture of the original vestibule (through smoke and airflow tests) was inadequate as constructed. It was discovered during the survey that the vestibule did not provide adequate vapor capture. A design change incorporated modifications to the original single vestibule as well as a separate air exhaust system (induced draft fan and particulate and activated carbon filters located in the VCS). The modifications to the original vestibule included two other separate additions. There was an entry area that was actively ventilated at a rate of 400 scfm to the added filter system. This provided for air in the VCS to enter the enclosure exit doorway and be directed to a filter system without impacting the ventilation flow from the original vestibule. These modifications were constructed and tested by June 12, 2003.

Installation of the system began on May 12 and was completed by May 30, 2003. This schedule included a 12-day delay caused by transportation delays in delivering the detonation chamber. Other site delays were created by the requirements to coordinate construction with other parallel test activities at the Porton Down test site.

Chemical operators, maintenance personnel, and explosive operators were trained by DeMil International. Chemicals operators were defined as personnel responsible for operating the HMI. Maintenance personnel were responsible for performing routine maintenance-related activities. Explosive operators were responsible for preparing the test item by adding donor explosive and loading the prepared munition into the detonation chamber. Training consisted of classroom-style training and hands-on training in the tools, procedures, and techniques necessary for safe operation of the TC-25 DBC system.

The Preoperations Subtest was successfully completed. The survey team approved training and operating procedures for commencement of operations. With modification of the vestibule design, all other Preoperation Survey requirements were satisfied and operations began June 17, 2003.

5. OPERATIONS

The Operations (chemical-filled munitions) Subtest was divided into two phases. The first phase consisted of 16 non-agent tests for the Workup Testing. Phase 2 was agent and munitions testing consisting of 26 individual tests. During the latter part of workup testing, chemical agent monitoring was established to support Phase 2 chemical munitions testing. Chemical agent monitoring was conducted according to the Porton Down Donovan Tests Site Monitoring Plan (ECBC, June 2003). Appendix E presents a detailed site monitoring discussion.

5.1 Workup Tests.

Workup Tests were conducted with HEs only, with inert munitions, and filled with both water and surrogate chemical agent (methyl salicylate [MS]). Workup Tests emphasized training accomplished in the Preoperations Test, actively tested the TC-25 DBC system's operability, and identified any necessary changes to procedures prior to initiating chemical agent munitions testing. The June 2003 Final Test Plan did not establish specific criteria for the Workup Tests.

5.1.1 Workup Test Results.

All the workup testing was achieved without personnel injury or release of MS to the environment. There were 18 scheduled workup shots, of which 16 shots were accomplished. Workup Tests 13 and 14 were cancelled due to schedule constraints. Table 3 summarizes the Workup Tests, which included item/munition fill, weight of donor explosive, and peak pressure observed in the expansion chamber.

Workup Tests 1 through 9 were conducted with PETN donor sheet explosive and Comp B pelletized donor explosive. Several misfires were encountered that were traced to unreliable detonators (RISI 502). The detonators were replaced with RP-80 detonators, which corrected this issue. Workup Tests 1 through 9 established that operators were appropriately trained on the system, and that SOPs were fully developed and explosive operations could be conducted safely.

Workup Tests 10, 11, 12, and 15 demonstrated that adequate systems and operating practices were in place to gather data necessary to demonstrate that the TC-25 DBC system can safely and effectively destroy recovered chemical munitions. The use of Comp B was eliminated from the test program because of questions regarding the supplied Comp B formulation. However, Comp B was used during closeout for two cleanup shots. Workup Tests 13 and 14 were cancelled due to schedule constraints.

Workup Test 16 was performed to evaluate the TC-25 DBC system's capability to contain MS (a compound used to represent the vapor pressure and persistence of H). This test served to improve decontamination procedures and verify that there was no release of MS to the VCS building. In addition, no MS was observed being emitted prior to the carbon treatment system.

Workup Tests 17 and 18 were performed to optimize the application of donor explosive for the destruction of water-filled 5-in. DOT bottles and 25-lb rounds. In addition, these tests served to reinforce training of the explosive operators in preparing the chamber for future chemical munitions destruction tests that require the use of supplemental oxygen for efficient chemical destruction.

5.1.2 Equipment Modifications.

Several modifications were implemented to the TC-25 DBC system to address issues that arose during Workup Testing. The following text provides more details of those modifications.

Table 3. Workup Test Shot Description

Test Name	Date	Item	Fill	Explosives	Supplemental Oxygen Used	Peak Expansion Chamber Pressure (psig)
Workup 1	17-Jun-03	None	None	5 lb PETN*	No	3.6
Workup 2	17-Jun-03	None	None	5 lb PETN	No	3.7
Workup 3	18-Jun-03	None	None	5 lb Comp B	No	4.3
Workup 4	19-Jun-03	None	None	10 lb PETN	No	6
Workup 5	19-Jun-03	None	None	10 lb PETN	No	6
Workup 6	19-Jun-03	None	None	10 lb Comp. B	No	6.7
Workup 7	20-Jun-03	None	None	15 lb PETN	Yes	9.6
Workup 8	20-Jun-03	None	None	15 lb PETN	Yes	9.7
Workup 9	02-Jul-03	None	None	15 lb Comp B	Yes	9.3
Workup 10	02-Jul-03	25 lb empty	None	5 lb PETN	No	3.5
Workup 11	02-Jul-03	25 lb empty	None	5 lb PETN	No	3.8
Workup 12	03-Jul-03	25 lb empty	None	5.6 lb Comp B	No	4.8
Workup 13	*Cancelled (a)*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
Workup 14	*Cancelled (a)*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
Workup 15	03-Jul-03	25 lb sand filled	sand	5.2 lb Comp B	No	4.8
Workup 16	03-Jul-03	5-in. DOT Bottle-MS	5.2 lb MS	7.5 lb PETN	No	13.2
Workup 17	09-Jul-03	5-in. DOT Bottle	2,880 g water	9.65 lb PETN	Yes	6.75
Workup 18	11-Jul-03	25 lb	800 grams water	6.4 lb PETN	Yes	5.2

* PETN is pentaerythritol tetranitrate.

5.1.2.1 Firing Circuit.

There were two misfires in the first nine detonations in the Workup Phase, traced to faulty detonators (RP-502), which were replaced with RP-80-type detonators. It was noted during chemical operations that the firing circuit was susceptible to damage from heat and shrapnel, as the fire wires were frayed. Appendix C presents a more comprehensive discussion of the firing circuit issue.

5.1.2.2 Activated Carbon.

During the operations program, carbon was observed to be emitted from the discharge duct into the VCS. The emission of carbon fines can be expected for the first few days of operation, but was noted for more than a few days. A particulate filter was fitted to the exhaust system to retain the fines within the system. Eventually the particulate filter was not effective, as the emissions of fines from the carbon beds worsened. The source of the emission of carbon fines was excessive grinding of the carbon within the drums. The carbon drums were determined by the manufacturer to be improperly manufactured. The drums were retrofitted in the field to meet tolerance specifications provided by the manufacturer. This solved the issue of the emission of carbon fines.

5.1.2.3 Shooting Platform Modification.

At the start of testing, a shooting platform was used in the controlled detonation chamber to stabilize the munition in a fixed location prior to detonation. The shooting platform was too large to accommodate personnel in Occupational Safety and Health Administration (OSHA) Level B PPE. Removing the platform and hanging the munition provided an effective alternative that allowed sufficient personnel workspace within the detonation chamber. Munitions were hung from the ceiling in a mesh wrap secured with plastic cable ties.

5.2 Chemical Munitions Tests.

5.2.1 Requirements and Goals of the Chemical-Filled Munitions Tests.

The June 2003 Final Test Plan stated the following subtest criteria:

- The test munition shall be handled, assembled with a donor explosive charge, loaded into the detonation chamber, and the door closed in accordance with approved procedures. (Requirement)

- The donor explosive charges shall destroy the munition. (Requirement)

- The donor explosive charge should detonate the burster (if present). (Goal)

- The chemical fill in the munition should be destroyed such that the resultant products are not detected above the associated applicable time-weighted average (TWA) downstream of the CDC carbon filter system. (Requirement)

- Solid residues shall be removed from the detonation chamber using approved procedures and packaged to meet requirements for transportation to an approved disposal facility. (Requirement)

- No personnel injuries requiring more than first aid should result from TC-25 DBC operations or hardware. (Goal)

- No agent will be detected at the site perimeter (the site perimeter is established at the distance where a downwind hazard analysis for the maximum credible event that predicts the vapor hazard will not exceed the GPL) monitors above the general population level (72-hr TWA). (Requirement)

- Waste samples shall be capable of being analyzed, using approved analytical methods, to a detection level appropriate to validate destruction. (Requirement)

5.2.2 Agent and Munitions Testing Results.

Nineteen chemical, two smoke, and five inert items were destroyed during chemical munitions testing as summarized in Table 4. The quantities of chemicals contained in these items were as follows:

The types of munitions and chemical fills destroyed during testing were:

- DOT bottles: 3.5-in. outer diameter filled with 2.7 lb of MS, two shots
- DOT bottles: 5-in. outer diameter filled with 2 lb, one shot, and 4 lb CG, two shots
- 4-in. Stokes mortar: with 6.6 lb of CG/PS mixture, two shots
- 105-mm projectiles: 5.5 lb of hexachloroethane/zinc oxide (HC) smoke, two shots
- Recovered 25-lb UK munitions: 1.54 lb of H, five shots
- 4.2-in. UK mortar: 3.31 lb of H, three shots
- DOT bottle (5-in.): filled with 6 lb of H, two shots

The total weights of chemicals destroyed were:

- MS—5.4 lb total
- CG—10.0 lb
- CG/PS—13.2 lb total
- HC smoke—11 lb
- H—29.6 lb total

Chemical munitions testing of the TC-25 DBC system met all program requirements and goals established in the June 2003 Final Test Plan. The most significant testing accomplishments are summarized below. Individual results of agent and munitions tests are discussed in subsequent sections. A summary of chemical monitoring results is provided in Table 5.

Table 4. Agent and Munitions Test Descriptions

Test Name	Date	Item	Fill	Explosives	Supplemental Oxygen Used	Peak Expansion Chamber Pressure (psig)
Agent/Munitions 1	10-Jul-03	3.5-in. DOT Bottle - MS	2.7 lb MS	7.8 5 lb PETN	Yes	7.2
Agent/Munitions 2	14-Jul-03	5-in. DOT Bottle	2 lb CG	9.8 lb PETN	No	4.8
Agent/Munitions 3	15-Jul-03	5-in. DOT Bottle	4 lb CG	11.3 lb PETN	No	6
Agent/Munitions 4	15-Jul-03	5-in. DOT Bottle	4 lb CG	11.66 lb PETN	No	6.1
Agent/Munitions 5	16-Jul-03	4-in. Stokes Mortar, Tag No. 1618	6.6 lb CG or CG/PS	13.4 lb PETN	Yes	9.3
Agent/Munitions 6	17-Jul-03	4-in. Stokes Mortar, Tag No. 1620	6.6 lb CG or CG/PS	12.6 lb PETN	Yes	8.7
Agent/Munitions 7	31-Jul-03	25-pdr, non chemical filled	empty	5.9 lb PETN	Yes	6.2
Agent/Munitions 8	04-Aug-03	3.5-in. DOT Bottle	2.7 lb MS	8.15 lb PETN	Yes	10.5
Agent/Munitions 9	05-Aug-03	105-mm projectile	5.5 lb HC Smoke	7.95 lb PETN	No	5.9
Agent/Munitions 10	05-Aug-03	105-mm projectile + remnants from Test 9	5.5 lb HC Smoke	0.75 lb Shaped Charge only	No	2.7
Agent/Munitions 11	06-Aug-03	3.5-in. DOT Bottle	2.3 lb water	7.5 lb PETN	No	5.3
Agent/Munitions 12	06-Aug-03	3.5-in. DOT Bottle	2.3 lb water	7.5 lb PETN	No	5.4
Agent/Munitions 13	06-Aug-03	3.5-in. DOT Bottle	2.3 lb water	7.5 lb PETN	No	5.3
Agent/Munitions 14	06-Aug-03	3.5-in. DOT Bottle	2.3 lb water	7.25 lb PETN	No	5.6
Agent/Munitions 15	07-Aug-03	25-pdr, Tag No. 572	1.54 lb H	6.0 lb PETN	No	5.5
Agent/Munitions 16	11-Aug-03	25-pdr, Tag No. 586	1.54 lb H	6.3 lb PETN	No	5.6
Agent/Munitions 17	12-Aug-03	25-pdr, Tag No. 677	1.54 lb H	6.35 lb PETN	No	5.54
Agent/Munitions 18	13-Aug-03	25-pdr, Tag No. 680	1.54 lb H	6.2 lb PETN	No	5.55
Agent/Munitions 19	14-Aug-03	25-pdr, Tag No. 685	1.54 lb H	6.3 lb PETN	No	5.53
Agent/Munitions 20	20-Aug-03	4.2-in. Mortar, Tag No. 5482	3.31 lb H	9.4 lb PETN	Yes	10.1
Agent/Munitions 21	21-Aug-03	4.2-in. Mortar, Tag No. 5493	3.31 lb H	9.75 lb PETN	Yes	10.3
Agent/Munitions 22	22-Aug-03	4.2-in. Mortar, Tag No. 5475	3.31 lb H	9.75 lb PETN	Yes	9.99
Agent/Munitions 23	26-Aug-03	5-in. DOT Bottle	6 lb H	14.4 lb PETN	Yes	16.1
Agent/Munitions 24	28-Aug-03	5-in. DOT Bottle	6 lb H	13.1 lb PETN	Yes	15.1

Table 5. Summary of Monitoring Results—Chemical Filled Munitions Test Process and Ambient Air Sampling (no PPE results)

Test Type	Agent/ Munitions Test ID	Date	Analyte and Result [a] Minicams (TWA) (b)	DAAMS (TWA) [b]	Dosimeter (CG Only)	Comments
System Check - MS	TEST 1	07/10/03	—	MS - NA [c]	—	
CG and CG/PS	TEST 2	07/14/03	CG - All ND	—	All ND	
	TEST 3	07/15/03	CG - All ND	—	All ND	
	TEST 4	07/15/03	CG - All ND	—	All ND	
	TEST 5	07/16/03	CG and PS - All ND	—	All ND	
	TEST 6	07/17/03	CG and PS - All ND	—	All ND	
	TEST 7	07/31/03	—	—	—	
System Check - post Decon 1 (MS)	TEST 8	08/04/03	—	MS - NA [c]	—	
Smoke (HC)	TEST 9	08/05/03	—	—	—	
	TEST 10	08/05/03	—	—	—	
Production (water fill only)	TEST 11	08/06/03	—	—	—	
	TEST 12	08/06/03	—	—	—	
	TEST 13	08/06/03	—	—	—	
	TEST 14	08/06/03	—	—	—	
Mustard	TEST 15	08/07/03	H - All ND	H - All ND	—	
	TEST 16	08/11/03	H - All ND	H - All ND	—	
	TEST 17	08/12/03	H - All ND	H - All ND	—	
	TEST 18	08/13/03	H - 0.76 (DCV-1)	All ND	—	DCV-1 MINICAMS results attributed to PPE/waste handling
	TEST 19	08/14/03	H - 1.4 (DCV-1)	H - 0.28 (DCV-1)	—	DCV-1 MINICAMS results attributed to PPE/waste handling
	TEST 20	08/20/03	H - 0.52 (DCV-1)	H -114.8 (Exp Chamber Exhaust) [d]	—	DCV-1 MINICAMS results attributed to PPE/waste handling
	TEST 21	08/21/03	H - All ND	H - 48.8 (Exp Chamber Exhaust) [d]	—	

Table 5. Summary of Monitoring Results—Chemical Filled Munitions Test Process and Ambient Air Sampling (no PPE results) (Continued)

Test Type	Agent/ Munitions Test ID	Date	Analyte and Result [a]			Comments
			Minicams (TWA) (b)	DAAMS (TWA) [b]	Dosimeter (CG Only)	
	TEST 22	08/22/03	H - All ND	H - 2.4 (Exp Chamber Exhaust) [d]	—	
	TEST 23	08/26/03	H - All ND	H - 36 (Exp Chamber Exhaust) [d]	—	
	TEST 24	08/28/03	H - All ND	H - 43 (Exp Chamber Exhaust) [d]	—	

Notes:

— Indicates no monitoring by the given method

[a] Result is maximum value reported per location

[b] Results reported as Time Weighted Average (TWA) (8 hr) equivalents where H= 0.003 mg/m3, CG= 0.40 mg/m3, PS= 0.67 mg/m3.

[c] A detection level of concern for methyl salicylate (MS) was not established

[d] Detection of H in expansion chamber but not at the entrance to carbon system indicates residual agent destroyed in reactive bed filter/catalytic oxidizer.

- Munitions preparation, handling, and TC-25 DBC operations proceeded without any injuries to testing personnel.

- No fugitive chemical agent vapors were detected outside the TC-25 DBC at any time during the testing.

- Chemical agent was never detected by Depot Area Air Monitoring System (DAAMS), Miniature Chemical Agent Monitoring Systems (MINICAMS), FTIR or dosimeter badges at any location within the VCS perimeter.

- Residual chemical agent that was detected in the expansion tank exhaust to the air pollution control unit (APCU) was destroyed by a combination of the reactive bed filter and the catalytic oxidizer prior to entering the carbon adsorption unit as planned.

- Munitions (including burster charges) and DOT bottles were destroyed by the donor explosives.

5.2.2.1 Agent/Munitions Test 1.

Test 1 was successfully conducted to show that the item type, a 3.25-in. DOT with a chemical agent simulant, MS, could be accessed and the chemical fill contained within the TC-25 DBC system.

5.2.2.2 Agent/Munitions Tests 2–6.

Both 5-in. DOT bottles and 4-in. Stokes mortar bombs containing CG were destroyed in the system. CG was not detected at any monitoring location. The 4-in. Stokes munitions also contained an undetermined quantity of PS as indicated by positive analytical results on some PPE items, at low levels in the chamber pea gravel samples, and surface wipe samples. PS was not detected in the VCS, at the inlet to the carbon beds, or in the system exhaust to the outside environment.

5.2.2.3 Agent/Munitions Tests 7 and 8.

Test 7 was performed successfully following the first thermal decontamination exercise (discussed in Section 6) to ensure that the TC-25 DBC was functioning properly following decontamination. Test 8 was successfully conducted with an inert 25-lb munition to verify that explosive wrapping procedures that were in place would be sufficient to access the fill cavity and destroy the munition body.

5.2.2.4 Agent/Munitions Tests 9 and 10.

Air monitoring and solid sample collection were not performed during testing with smoke-containing projectiles (105 mm). There was no visible release of smoke into the VCS, the criterion for successful demonstration/validation. The detonation of a 105-mm projectile with approximately 8 lb of PETN donor explosive wrapped around the munition resulted in fragments that limited the ability to visually certify that the fuze or canisters of smoke had indeed been destroyed. A second 105-mm smoke-containing projectile was detonated with a linear-shaped charge and a small quantity of PETN donor explosive to act as a booster. This resulted in better visual evidence that the fuze and smoke canisters were ruptured.

5.2.2.5 Agent/Munitions Tests 11–14.

A 1-day test was conducted to determine the TC-25 DBC's potential production capability. Four 5-in. (outside diameter) DOT bottles filled with water were sequentially destroyed in the TC-25 DBC. These DOT bottles did not contain hazardous chemicals. The destruction of these DOT bottles was carried out using two operating teams working in parallel. Operating Team 1 consisted of two explosive operators (plus a safety link) and was responsible for wrapping the DOT bottle with the donor charge and securing the detonator on the package. Team 1 performed this task while wearing OSHA Level-C PPE. After wrapping was complete, this team left the VCS, and an abbreviated decontamination was performed in the PDS. Team 2 consisted of two explosive operators (plus a safety link) in OSHA Level-B PPE and was responsible for preparing the detonation chamber by inspecting the chamber, preloading the water bags, and then loading the package in the detonation chamber. After the loading of the package, Team 2 performed an initial abbreviated self-decontamination in the main vestibule, then were subject to an abbreviated gross decontamination in the outer vestibule by a team from the PDS, and finally an abbreviated decontamination was performed in the PDS. Both teams remained in PPE between shots in order to be ready to re-enter the VCS following detonation. Each team was responsible for two detonations. After the two detonations, two new crews were put in place to perform the work. The use of parallel operations demonstrated the detonation of four DOT bottles in 3 hr and 6 min. This demonstration/validation subtest was carried out on August 6, 2003. Table 6 summarizes the time sequence for this test.

Table 6. Time Sequence of Production Capability Demonstration

	Time			
Activity	Test 11	Test 12	Test 13*	Test 14
Teams 1 (Chamber) and 2 (Wrapping) in VCS	957	1037	1155	1250
Detonation Chamber doors opened	959	1048	1158	1255
Detonation Chamber preparation complete	1003	1053	1203	1300
Start wrapping item (DOT bottle)	1007	1053	1206	1301
Transport munition to Detonation Chamber	1015	1101	1217	1308
Team 2 exits VCS	1016	1106	1219	1311
Munition in Detonation Chamber and doors closed	1025	1109	1219	1323
Team 1 exits VCS	1030	1115	1238	1329
Personnel accountability check	1033	1115	1240	1334
Detonation	1035	1121	1242	1335
	Total Time=3 hr 6 min			

*A 29-minute operational pause was requested between the second and third tests. This pause has been factored into the total time.

5.2.2.6 Agent/Munitions Tests 15–24.

The final series of tests was conducted using agent-filled munitions and DOT bottles. The agent fill quantities ranged from 1.54 lb to 5 lb of H. In similar fashion to the 105-mm munitions, the initial tests with the 25-lb UK munitions exhibited base-plate ejection on detonation and appeared to leave the fuze visually intact. This was remedied by adding one additional linear inch of PETN donor explosive to the fuze assembly. The agent fill of the larger items (the 4.2-in. UK mortar round and 5-in. DOT bottles) was successfully accessed.

H was measured in the scrap metal of exploded munitions, in the pea gravel, and on the surfaces of detonation chamber walls as well as on PPE and equipment used to manage the pea gravel. Twice, MINICAMS measured H in the main vestibule attributed to PPE and scrap stored in the vestibule when personnel exited the chamber. Prompt removal of the contaminated waste into plastic bags resulted in no additional detections of H in the vestibule.

Agent and munitions tests were successfully completed, and all the requirements and goals of the chemical-filled munitions were achieved.

6. CLOSEOUT

The closeout subtest's objective was to evaluate the operators' ability to clean and decontaminate the TC-25 DBC system and prepare it for transportation from the Porton Down location. The requirements and goals stated in the June 2003 Final Test Plan:

- The TC-25 DBC system shall be capable of being cleaned, decontaminated, and monitored to verify the efficacy of decontamination methods using approved procedures. (Requirement)
- There shall be no contamination of soil or of the test facility outside the TC-25 DBC spill control barrier. (Requirement)
- Analytical results of all final 3X verification samples are to be below established criteria per AR 385-61. (Requirement)
- All wastes shall be packaged for transport over roads and be accepted by the DSTL-approved disposal facility. (Requirement)
- The TC-25 DBC system shall meet AR 385-61, environmental, and transportation requirements for transport from the treatment location over public roads. (Requirement)
- No agent will be detected at the perimeter monitors above the general population level (72-hr TWA). (Requirement)

Decontamination.

The TC-25 DBC is designed to use a hot gas generator, similar to the process hot gas generator, to thermally decontaminate the detonation and expansion chambers if contamination builds up to levels that require its use. The decontamination hot gas generator can deliver temperatures greater than 1,500 °F to the inlet of the detonation chamber.

An alternative to thermal contamination is the implementation of high explosive donor charge with water bags and supplemental oxygen. This practice is intended to reduce any excessive contamination that may exist from time to time on the interior surfaces of the chamber.

As part of the testing program, two thermal decontamination exercises were conducted to demonstrate the ability to decontaminate the detonation chamber and expansion chamber to a 3X level. The analytical results for H from pea gravel, surface wipes, and air samples collected prior to the initiation of the thermal decontamination indicated that donor explosives alone may be sufficient to clear the interior of the detonation chamber to a 3X level. Thus, the thermal decontamination exercises may not have been necessary to achieve 3X level for the agents tested, but were performed to demonstrate that the thermal decontamination was indeed possible.

Finally, it was demonstrated that parts of the air pollution control system could be heated to temperatures greater than 1,000 °F and maintained above this temperature for more than 15 min. This is sufficient to meet the 5X level of decontamination. This decontamination status was achieved from the process hot gas generator through to the exhaust of the catalyst.

- Thermal Decontamination Exercise 1.

The TC-25 DBC was subjected to the first thermal decontamination exercise following completion of the tests with CG- and PS-containing munitions. The decontamination hot gas generator was connected to the detonation chamber in order to heat the detonation chamber to a temperature sufficient to volatilize CG and PS. Insulation blankets were placed over the detonation chamber to help retain the heat, whereas the expansion chamber was already fitted with rigid insulation. The temperature in the detonation and expansion chambers was monitored throughout the thermal decontamination exercise. Four thermocouples were placed inside the detonation chamber. Two were located in the pea gravel and the other two were adjacent to wall surfaces. One thermocouple was placed on the outside surface of the outer door in order to examine heat retention in the chamber. Figures 2 and 3 show the approximate locations of the thermocouples in the detonation and expansion chambers, respectively. The maximum temperatures measured during the Thermal Decontamination Exercise 1 are summarized in Table 7.

Preliminary MINICAMS data following cool-down after the thermal decontamination exercise indicates that no CG or PS was detected in the detonation chamber. No MINICAMS samples were taken from the expansion chamber following this first exercise. However, pea gravel sample results indicated no measured quantity of PS, which had previously been detected in the pea gravel. A summary of monitoring results is presented in Table 8.

The thermal decontamination concept was demonstrated for CG and PS.

Table 7. Thermal Decontamination Exercise 1 and Exercise 2 - Maximum Temperatures

Exercise 1		Exercise 2	
Thermocouple Location	Maximum Temperature (°F)	Thermocouple Location	Maximum Temperature (°F)
Detonation Chamber		Detonation Chamber	
A	487	A	365
B	378	B	446
C	530	C	491
D	234	D	488
E	342	E	490
F	88*	F	325
Expansion Chamber		Expansion Chamber	
A	269	A	317
B	241	B	283
C	275	C	325
D	251	D	294
E	259	E	304
F	246	F	290
G	217	G	253
H	244	H	289
J	229	J	272
K	210	K	243

Notes:
* Thermocouple F was measuring ambient temperature in the VCS.

- Thermal Decontamination Exercise 2.

The TC-25 DBC was subjected to the second thermal decontamination exercise following completion of the tests conducted with H-containing items. The decontamination hot gas generator was again connected to the detonation chamber in order to heat the detonation chamber to temperatures sufficient to decompose or volatilize H. The scrap metal that had been generated from H testing in addition to detonated oxygen cylinders was loaded into the detonation chamber and spread around the floor area. This scrap metal was then heated during the thermal decontamination exercise and decontaminated.

In addition, the air pollution control system from the hot gas generator to the catalyst exhaust was heated to a temperature greater than 1,000°F for more than 15 min to demonstrate that thermal decontamination to a 5X level was achieved. Therefore, decontamination to a 5X level was demonstrated for this section of the APCU.

Table 8. Summary of Monitoring Results - Closeout Test
Process and Ambient Air Sampling (no PPE results)

		Analyte and Result [a]			
Test Type	Date	Minicams (TWA) (b)	DAAMS (TWA) [b]	Dosimeter (CG Only)	Comments
Thermal Decon 1	07/21/03	CG and PS - All ND	—	CG – All ND	Prior to start of thermal decon
	07/22/03	CG and PS - All ND	—	CG – All ND	Prior to start of thermal decon
	07/23/03	CG and PS - All ND	—	CG – All ND	
	07/24/03	CG and PS - All ND	—	CG – All ND	
	07/25/03	CG and PS - All ND	—	CG – All ND	
Thermal Decon 2	09/01/02	H - 0.4 (Exp Chamber)	H - All ND	—	Heat-up phase
	09/02/02	H - 1.7 (Exp Chamber)	H - All ND	—	Heat-up phase
	09/03/03	H - All ND	H - All ND	—	Cool down begins
	09/04/03	H - All ND	H - All ND	—	Cool down complete
	09/05/03	H - 0.14 (Switch)	H - All ND	—	Detonation chamber inner door closure switch (after disassembly)
Closure Monitoring	09/08/03	H - All ND	H - All ND	—	
	09/09/03	H - All ND	H - All ND	—	
	09/10/03	H - All ND	H - All ND	—	

Notes:
— Indicates no monitoring by the indicated method
[a] Result is maximum value reported per location
[b] Results reported as Time Weighted Average (8 hr) equivalents where H= 0.003 mg/m3, CG= 0.40 mg/m3, PS= 0.67 mg/m3

Figures 2 and 3 show the approximate locations of the thermocouples in the expansion and detonation chambers, respectively. The maximum temperatures measured during the Thermal Decontamination Exercise 2 are summarized in Table 7.

Preliminary MINICAMS and DAAMS results following cool-down after the thermal decontamination exercise indicates that no H was detected inside the detonation and expansion chambers, thus demonstrating the ability to achieve a 3X decontamination level. The scrap metal and detonated oxygen cylinders were also monitored and cleared to a 3X level. A summary of monitoring results is presented in Table 8.

Waste Disposal.

The primary wastes requiring disposal from operation of the TC-25 DBC are:

- Spent lime from the reactive bed filter
- Carbon from the carbon adsorption units
- Pea gravel from the detonation chamber
- Scrap metal, consisting of fragments of test munitions and DOT bottles, and ruptured oxygen cylinders, from the detonation chamber

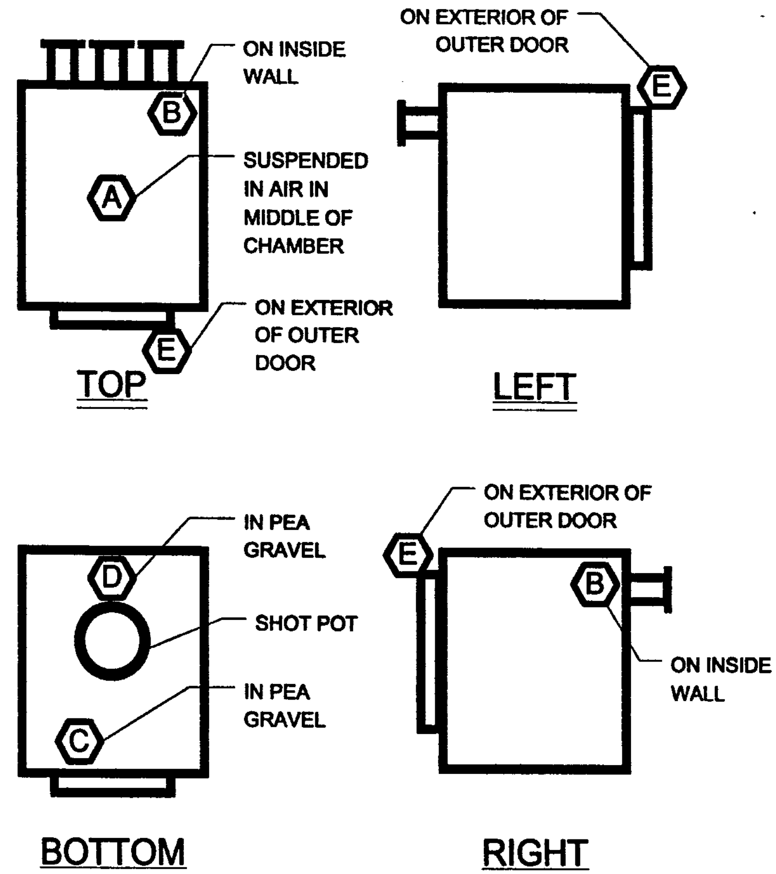
The quantities of the wastes generated during testing are summarized in Table 9.

Table 9. Wastes Generated During Testing

Material	Quantity (lb)	Final Disposition
Lime	1,050 (1)	DSTL Incinerator
Carbon	3,000 (1)	*TBD* (3)—Landfill
Pea Gravel	3,085 (2)	DSTL Incinerator
Scrap Metal	1,440 (1)	DSTL Incinerator

(1) Estimate, based on material used.
(2) Actual weight.
(3) To be determined based on discussion with local facility.

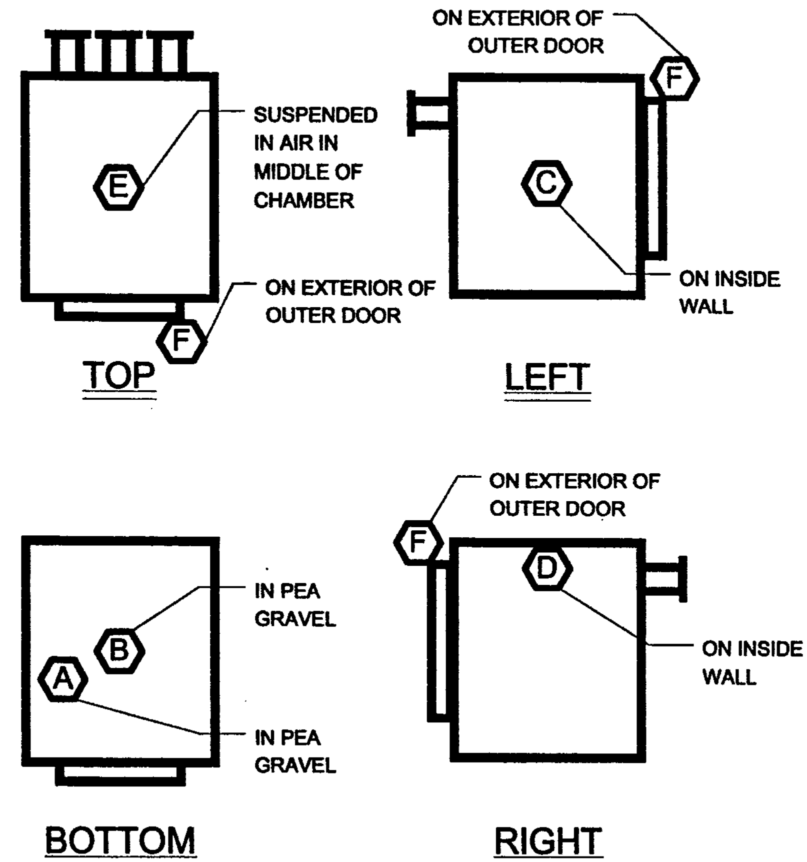
The quantity of carbon waste generated is not indicative of that expected from a production system. All of the original carbon units supplied by the vendor were manufactured improperly and all were subsequently replaced at the end of the thermal exercise with new units. Had the units not been defective from the start, it would not have been necessary to dispose of any carbon since the analytical results demonstrated that no chemical agent was detected after the catalytic oxidizer.



FIRST THERMAL DECONTAMINATION EXERCISE

NOTES:

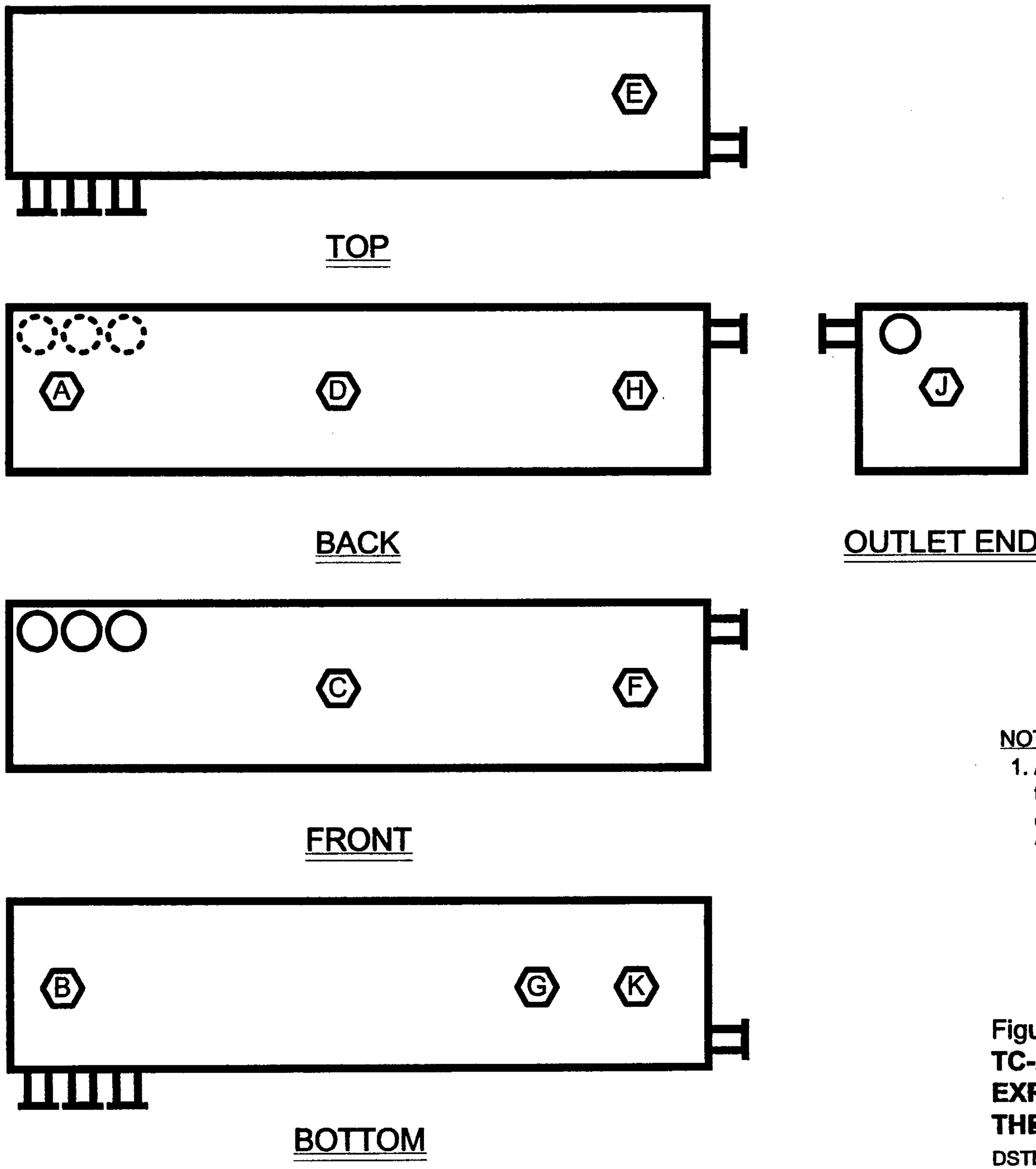
1. Thermocouple F was measuring ambient temperature in the VCS near Skid 1 Control Panel.



SECOND THERMAL DECONTAMINATION EXERCISE

Figure 2
TC-25 DBC
DETONATION CHAMBER
THERMOCOUPLE LOCATIONS
DSTL
Porton Down, UK

CH2MHILL



NOTES:
1. All thermocouples were attached to the outside skin of the expansion chamber underneath the insulation.

Figure 3
TC-25 DBC
EXPANSION CHAMBER
THERMOCOUPLE LOCATIONS
DSTL
Porton Down, UK

CH2MHILL

The quantity of pea gravel waste generated is greater than that expected from a production system. All of the pea gravel remaining in the detonation chamber was removed following testing. In a production system, the complete removal of all pea gravel will not routinely be necessary.

The closeout subtest was successfully completed. The TC-25 DBC system was decontaminated. The analytical results of all final 3X verification samples were below established criteria. All required criteria for the closeout subtest were met.

7. CONCLUSIONS/RECOMMENDATIONS

7.1 Conclusions.

The TC-25 DBC testing conducted at DSTL Porton Down, UK, successfully demonstrated that the DBC system met the three primary test objectives as defined in the June 2003 Final Test Plan. Specifically, the testing had the following results:

- The TC-25 DBC was demonstrated to safely and effectively destroy recovered chemical munitions with or without explosive components.

- The TC-25 DBC was demonstrated to reduce the hazardous properties of the chemical fill without release of hazardous wastes or materials to the soil or water. Data was collected during the test to quantify this reduction.

- Data was acquired to demonstrate to the U.S. Army, DoD, and federal, state, and local environmental agencies the safety, integrity, and efficacy of the TC-25 DBC. In addition, the ability of the operator to collect waste samples was also demonstrated.

The following are key results of the testing:

- The TC-25 DBC system was successfully constructed, transported, and set-up at DSTL's Porton Down UK facility.

- Fugitive vapor emissions of chemical agents from the TC-25 DBC system were not detected at any time during the testing.

- Detonation of sheet explosive-wrapped recovered CWM and DOT cylinders resulted in the destruction of all but residual quantities of chemical agent. Residual agent, detected inside the TC-25 DBC between the expansion chamber and the inlet to the air pollution control system, was destroyed by a combination of the reactive bed filter and the catalytic oxidizer prior to the carbon adsorption unit. No chemical agent was detected prior to the carbon adsorption units.

- Thermal decontamination of the entire TC-25 DBC was demonstrated to a 3X level without the use of conventional liquid decontamination solutions. In addition, the ability to decontaminate the system by non-thermal means, using a series of high explosive detonations only, was demonstrated in principle.

- Secondary process waste including ordnance-related scrap, pea gravel, and spent lime were shown to be agent-free following system decontamination.

7.2 Recommendations.

The successful results obtained during this first phase of demonstration/validation testing show the efficacy of the process for use in the destruction of munitions-containing chemical agents and smoke-producing compounds.

During the course of testing, several minor issues were identified with some TC-25 DBC subsystems that will require further development; therefore, further testing is recommended. Specific subsystems and operational procedures that will be considered for further testing include:

- Further evaluation and subsequent development of the firing system are necessary to increase system reliability as well as to improve accessibility.

- Testing of other munitions types and chemical fills that would be typical of the range of recovered CWM and smoke-producing compounds.

- Development of additional systems and procedures focused on reducing the degree of human participation in munition preparation, chamber loading, and chamber unloading operations (human factors).

- Further minimization of process wastes, including spent lime and PPE, by developing an appropriate combination of engineering controls and operating procedures.

It is recommended that a second phase of demonstration/validation testing be conducted to validate procedural modifications for increased safety and productivity as well as to test engineering modifications that may be made by DeMil International Inc., as a result of lessons learned from the first test.

Blank

ACRONYMS AND ABBREVIATIONS

AMSAA	Army Materiel Systems Analysis Activity
APCU	Air pollution control unit
CDC	Historical acronym used to refer to the DBC
CG	Phosgene
CWM	Chemical warfare material
DAAMS	Depot Area Air Monitoring System
DASA ESOH	Deputy Assistant Secretary of the Army for Environment, Safety, and Occupational Health
DBC	Donovan Blast Chamber
DoD	Department of Defense
DOT	Department of Transportation
DSTL	Defence Science and Technology Laboratory
ECBC	Edgewood Chemical Biological Center
EBW	Exploding bridgewire detonator
GPL	General Population Limit
H	Mustard agent
HC	Hexachloroethane/zinc oxide
HE	High explosive
HMI	Human machine interface
I/O	Input/output
lb	Pound, pounds
MINICAMS	Miniature Chemical Agent Monitoring Systems
MS	Methyl salicylate
OPFTIR	Open Path Fourier Transform Infrared Spectrometer
OSHA	Occupational Safety and Health Administration
PETN	Pentaerythritol tetranitrate
PLC	Programmable logic controller
PPE	Personal protective equipment
PS	Chloropicrin
psig	Pounds per square inch gauge
scfm	Standard cubic feet per minute
SOPs	Standard operating procedures
TWA	Time-weighted average
VCS	Vapor containment structure

Blank

APPENDIX A

GENERAL DESCRIPTION OF ACTIVITIES RELATED TO DETONATION OF MUNITIONS IN THE TC-25 DBC

The TC-25 DBC is designed to treat recovered chemical warfare materiel by detonating a donor charge that is wrapped nearly completely around a munition or container (i.e., DOT cylinder) in the presence of water. Water is supplied in the form of water-filled polypropylene bags and suspended from the chamber ceiling by hooks. The amount of water depends on the high explosive (HE) content of the prepared munition. The typical staff required for the tests is listed in the Table below.

Table. TC-25 DBC Testing Staff—Typical Operations

Position	No.of Personnel
DeMil Donovan System Test Director	1
DeMil Data Collector	1
DeMil Operation Maintenance Supervisor	1
ECBC Donovan Test Director	1
ECBC Site Manager	1
ECBC Chemical Operators	2
TEU (Technical Escort Unit) Crew	2
ECBC Monitoring Crew	3
ECBC Support Crew	2
DSTL Trial Conducting Officer	1
DSTL Safety Link	1
DSTL PDS (Personnel Decontamination System) Supervisor	1
DSTL PDS Crew	2
Fire Brigade Crew	3
Total	22

Additionally, supplemental oxygen can be added to the chamber, prior to detonation, to enhance the fireball. At Porton Down, some tests were performed with commercially supplied compressed oxygen cylinders added to the chamber and exploded simultaneously with the target item using a linear-shaped charge placed on the oxygen bottle. Up to two oxygen cylinders were used in the destruction of 6 lb of H requiring 2 linear-shaped charges and an RP-80 EBW detonator for each bottle and the DOT bottle containing H.

Upon detonation, there is an almost simultaneous fracture of the munition (item), along with the detonation of any burster or fuze energetic material in the round and the combustion of the contained chemical fill. When supplemental oxygen is added, the oxygen provides additional oxidant directly to the fireball. The steps in this detonation process are as follows:

1. **STARTUP**—This step requires that an air pollution control unit (APCU) be operational and at conditions that allow for interlock clearance so that access to the chamber is allowed. The step is terminated by the operator after inspection of the various equipment and determination that the system has reached the set point operating parameters.

2. **WAIT**—This is a step in which the equipment is operable but held in a safe condition while other activities are occurring. This step will be terminated by an operator decision to proceed to the "LOAD" step. The door to the detonation chamber is open, there is no explosive material or agent inside the detonation chamber, the air amplifiers are off, and the ball valves (isolation valves with respect to the air amplifier) are closed. The air pollution control system is on-line waiting for status ready or at status ready. The wait condition normally follows an INSPECTION.

3. **LOAD**—This step requires that the operator place the wrapped munition inside the detonation chamber, load any required oxygen bottles with the shaped charge affixed to the bottles, and attach the water bags to hooks in the ceiling of the chamber. A final inspection of the interior of the chamber will be made. The connections to the firing device will then be placed and the operator will close the door to the detonation chamber as the operator leaves the chamber. This step terminates when the door to the detonation chamber is closed and latched and the detonation chamber isolation ball valves are open, allowing air to pass though air amplifiers and into the detonation chamber.

4. **CLEAR**—This is a wait and inspection step for the operators to clear the area after the detonation chamber is loaded and for the blaster to account for all the people, inspect the area, check the firing circuits, check the position of the valves, and operate the motors. This step terminates when the blaster has completed his checklist and verifies all system set points are within their operating range.

5. **DETONATE**—This step requires the blaster to fire the blasting caps, which detonate the donor charges in the detonation chamber. Just prior to detonation, the air amplifier isolation ball valves are closed and the orifice damper is closed. NOTE: the closure of the isolation ball valves for the air amplifiers shuts off the air supply to the offgas control system. Therefore, the time between valve closure and detonation is usually no more than 10 seconds. The step terminates when the blast has occurred and the pressures have equilibrated between the detonation chamber and the expansion tank.

6. **PRESSURE CONTROL**—This step requires that the gases in the expansion tank and the detonation chamber be vented through the reactive bed filter, the catalytic converter, the gas cooler, the carbon adsorption system, and the process blower. The step terminates after the pressure in the expansion tank has returned to atmospheric pressure. At such time, the air amplifier isolation ball valves are activated open and the orifice damper is open.

7. **VENTILATE**—This step requires the purging of the system with air and the detonation chamber to be ventilated for sufficient time to allow for any vapors and gases to be diluted and processed through the offgas control train. The door to the detonation

chamber is closed and the air amplifier isolation valves are open. At a minimum, the time delay should be at least 10 min before the step terminates. The next step is INSPECTION.

8. **INSPECTION**—This step requires that the detonation chamber be opened and the chamber inspected to affirm that the charges in the chamber functioned. The air amplifier isolation ball valves are closed. This step terminates when the blaster affirms functioning of the charges and verifies the integrity of detonation chamber and integrity of the air pollution control system. The system then is ready for WAIT status.

9. **PHYSICAL CLEANOUT**—This step allows for opening the detonation chamber and removal of any debris that is necessary for safely loading the next charge. During this step, the reactive bed filter may be cleaned of excessive particulate matter buildup. This step terminates when the operator decides that the cleanout is complete. Termination of this step will return the controller to the STARTUP step if a logical indicator is set to return to SHUTDOWN.

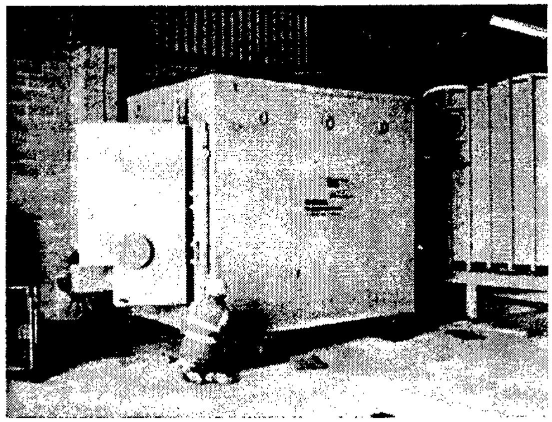
10. **SHUTDOWN**—Otherwise, the controller is returned to the WAIT step.

Further steps will be identified to allow for interim decontamination of the system and for final decontamination of the system prior to TC-25 DBC system disassembly and transport.

Blank

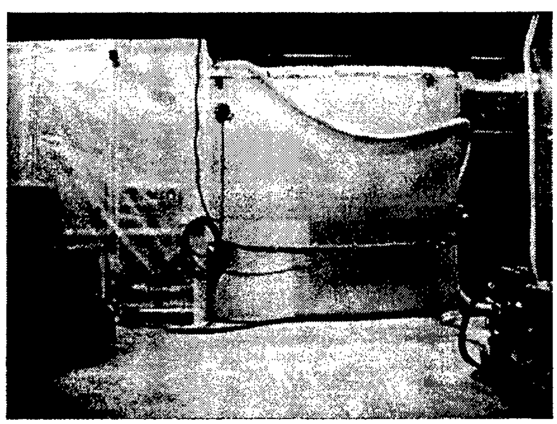
APPENDIX B

PHOTOGRAPHS



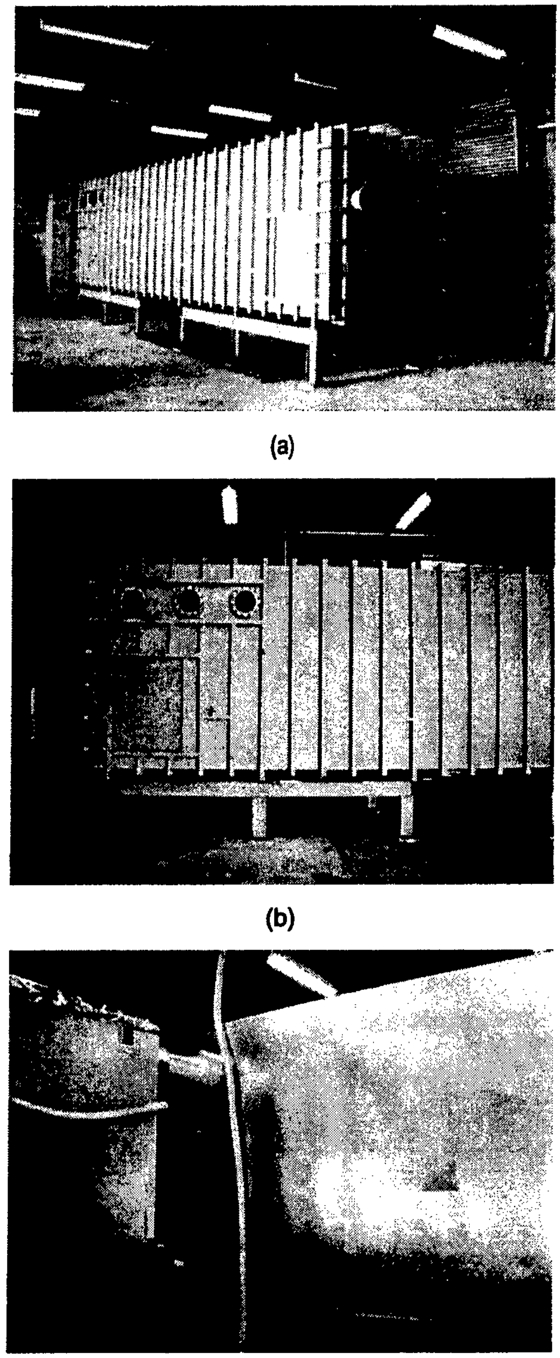
(a)

(b)



(c)

Figure 1
TC-25 DBC Detonation Chamber
(a) During installation.
(b) Front of chamber with insulation.
(c) Side of chamber with insulation.

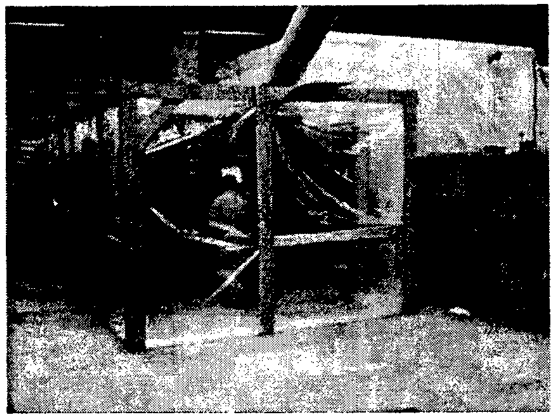


(a)

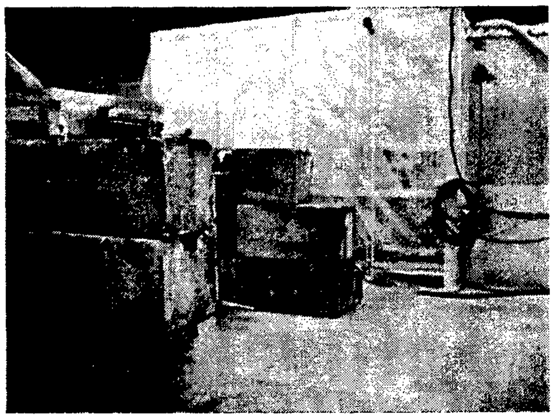
(b)

(c)

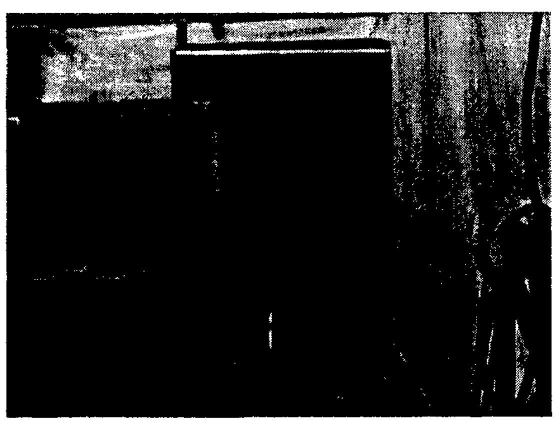
Figure 2
TC-25 DBC Expansion Chamber
(a) and (b) During installation.
(c) Side of chamber with insulation.



(a)

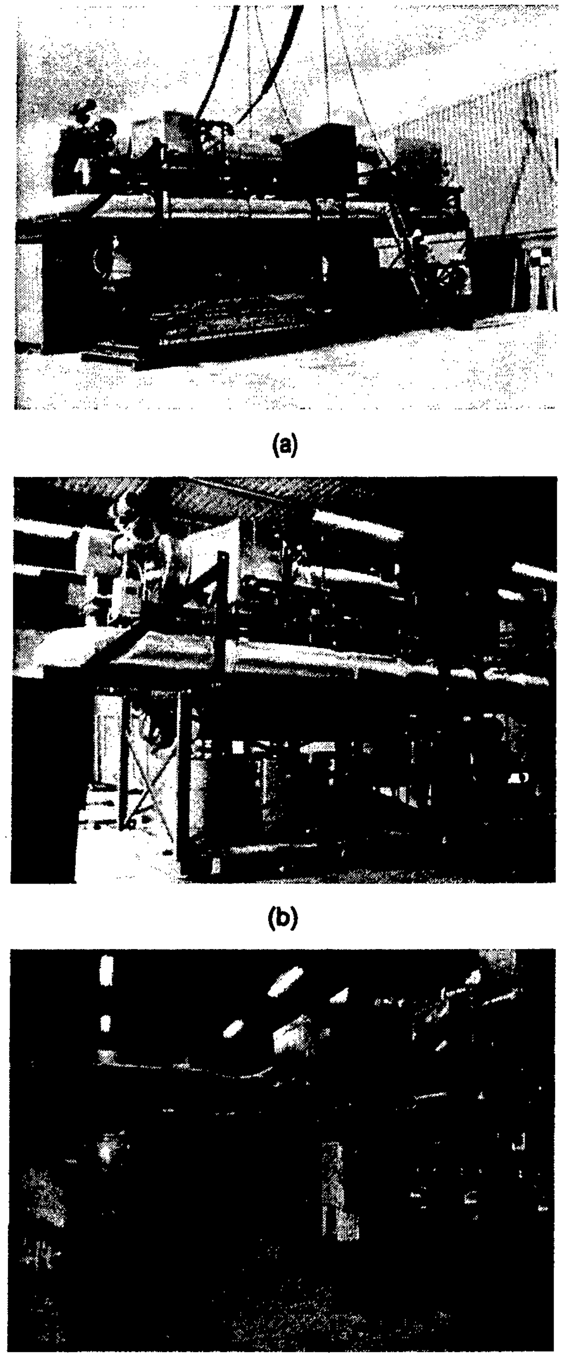


(b)



(c)

Figure 3
TC-25 DBC Vestibule
(a) Entry section.
(b) Main section.
(c) Access doorway.

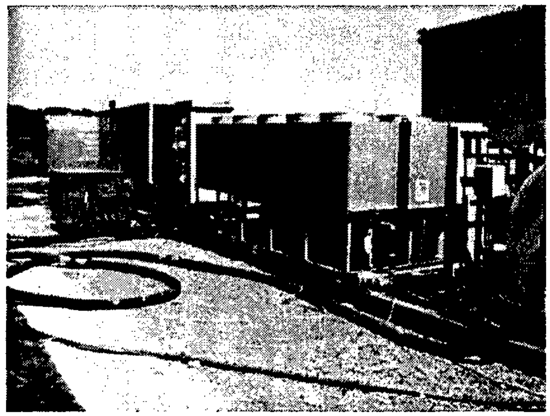


(a)

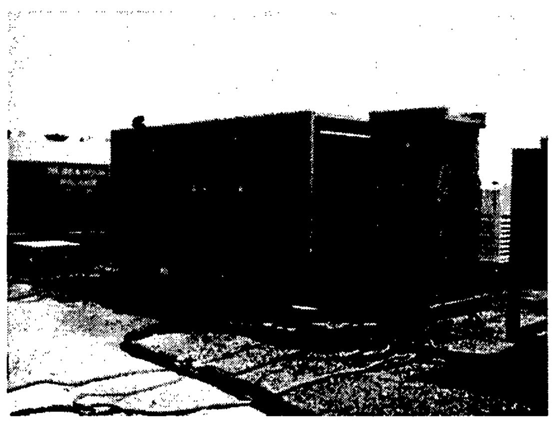
(b)

(c)

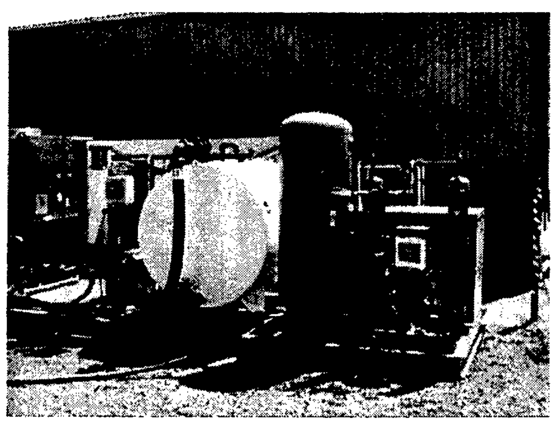
Figure 4
TC-25 DBC APCU
(a) During assembly.
(b) During installation.
(c) Installed system.



(a)

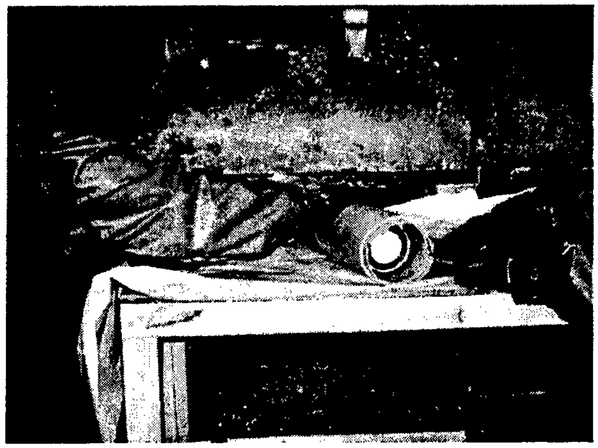


(b)



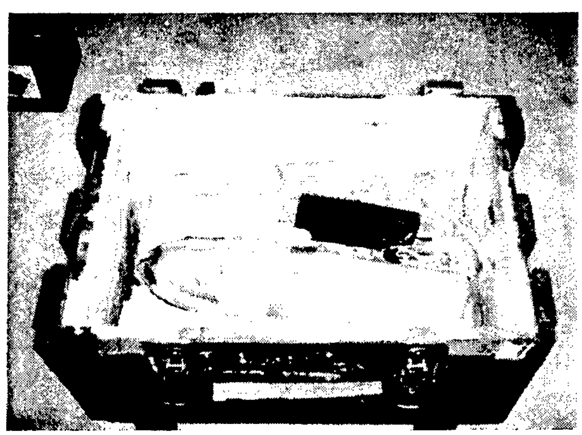
(c)

Figure 5
TC-25 DBC Auxiliary Equipment
(a) Chiller.
(b) Diesel Generator.
(c) Compressed Air System (right) and Cooling Water Tank (left).



(a)

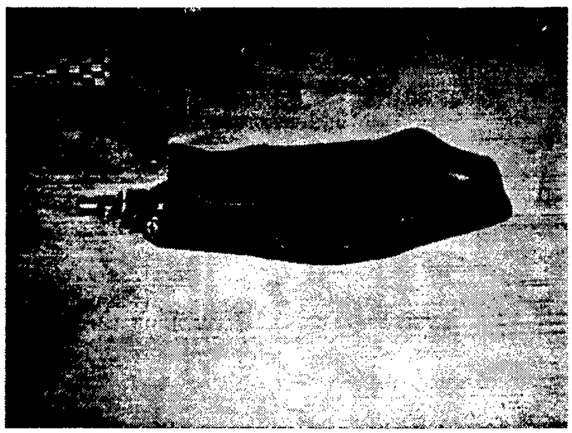
(b)



(c)

Figure 6
Wrapped Munition
(a) Wrapping munition, Test 7 105mm UK Smoke Screening Round.
(b) Wrapping munition, Test 7 105mm UK Smoke Screening Round.
(c) Wrapped munition, Workup Test 19 UK 25-Pounder.

(a)



(b)

(c)

Figure 7
Post Detonation Fragmentation
(a) Workup Test 18 3-inch DOT Bottle.
(b) Workup Test 17 Oxygen Cylinder.
(c) Workup Test 10 UK 25-Pounder.

Blank

APPENDIX C

MEMORANDUM ON FIRING SYSTEM

MEMORANDUM

DEMIL International
A CH2M HILL Company

Misfire History and Firing Circuit Modifications in the TC-25 DBC System

TO:	File
COPIES:	Jay Quimby/DeMil
FROM:	Syed Mahmood/DeMil Richard A. Johnson/WDC
DATE:	September 17, 2003

Two misfires of the RP502 detonators occurred during the initial workup testing from June 17 through 20, 2003. The misfires occurred on June18 and 20, 2003. From June 23 through 26, 2003 a series of tests were run to isolate the problem with the firing system. The potential variables were determined to be:

1. The RP502 detonators were not reliable

2. The firing circuit included too much inductance and inhibited power throughput to the detonators

3. The fire set FS61B was not generating sufficient power to properly fire the detonators

The June tests23 consisted of shooting RP502 detonators starting with the original firing wire and firing box. This set resulted in a total, including the previous workup shots, of 21 detonators fired and 16 detonated, a 24-percent failure rate.

The original firing wire (#12 single strand, THHW insulation rated for 600 V AC) was replaced on June 24 with a lighter wire. This setup resulted in a 75-percent failure rate, as the insulation would not stand up to the 10,000 V DC generated by a collapsing capacitor.

On 25 June, the test was conducted by DSTL using an FD201 fire set and a Reynolds coaxial cable designed for use with Reynolds firesets and detonators. The cable was strung directly from the fireset to the detonators. Ten out of 10 detonators functioned with this setup.

The coaxial cable was then connected to the interface and additional detonators were tested. This change resulted in three of five detonators functioning, two misfired for a 40-percent failure rate (based on a small dataset). The interface was removed and the insulation on the primary conductor was found to be frayed. The fraying appeared to be due to the insulation being heated and separating due to the high temperatures in the chamber during firing.

On June 26, the interface was removed and the coaxial cable was passed through the wall penetration to the inside of the chamber. The cable was sealed with Swagelok® fittings. The coaxial cable was connected to a piece of #12 THHW duplex wire in place in the chamber. This circuit was tested for 50 detonators, 41 functioned, and 9 misfired for an 18-percent failure rate

The final test was to use a series of 20 RP80 detonators in place of the RP 502 detonators with the final firing circuit configuration. All 20 functioned.

During these tests the firing box was switched between the FS61B used originally, a spare FS61B on hand, and an FD201 firing box supplied by DSTL. No difference in the firing box could be determined.

The conclusion from this testing was that the particular batch of RP502 detonators were not reliable in this system. This was in spite of 5 years' experience in other chambers with RP502 detonators. The RP80 detonators are more tolerant of power throughput fluctuations and hence more reliable with the TC-25 DBC system.

There is an apparent difference in the performance of the firing circuit configuration, but this experimental set does not conclusively demonstrate that effect.

The test program proceeded with using the configuration of the coaxial cable through the wall penetration, connected to a length of #12 THHW duplex wire, RP80 detonators in place of RP502 detonators, and the FS61B firing box. This system proved reliable through most of the testing in July 2003.

On July 20, 2003, the length of duplex wire in the chamber was replaced with a different high-temperature wire suitable for use up to 1,800°F. This change was put in place in order to move the connection for the lead wires on the detonators from the floor by the shooting pot to the wall of the chamber, eliminating one awkward task for operators in protective ensemble. The relocation of the lead wire connections was also required as the shooting pot was removed from the chamber to improve access in the chamber.

On August 20, 2003, the coaxial extension wire in the chamber was replaced. The insulation on the coaxial cable had melted due to the heat from the preceding 20 shots and the insulation was breaking down under high voltage.

On August 27, 2003 there were two misfires. In each case the TA-20 circuit tester had indicated that the circuit was acceptable for firing.

On August 28, 2003, the coaxial cable was pulled from the chamber and the original interface was replaced due to continuing problems with the shrapnel and the temperature degrading the firing circuit in the chamber. A short section of high-temperature, high-voltage wire was used to connect to the interface inside the chamber. This final configuration was satisfactory for completing the test program.

Conclusions and Recommendations

3. The temperature and shrapnel exposures to the circuit and wires in the chamber are too severe for the typical blasting circuit design. The circuit components inside the chamber require protection.

3. The circuit designs and detonator characteristics need to be analyzed to determine where the inefficiencies are and how to avoid impedance and inductance in the circuit design.

3. The circuit interface needs to be moved for this and similar chambers to avoid the entry to the chamber and the stooping and bending that was part of the system at Porton Down 2003.

Blank

APPENDIX D

TESTING SCHEDULE

May **2003**

Sun	Mon	Tue	Wed	Thu	Fri	Sat
				1	2	3
4	5	6	7	8	9 - Teram arrival on site	10
11	12 - System Assembly	13 - System Assembly	14 - System Assembly	15 - System Assembly	16 - System Assembly	17
18	19 - System Assembly	20 - System Assembly	21 - System Assembly	22 - System Assembly	23 - System Assembly	24
25	26 BANK HOLIDAY	27 BANK HOLIDAY	28 - System Checkout - Training	29 - System Checkout - Training	30 - System Checkout - Training	31

June 2003

Sun	Mon	Tue	Wed	Thu	Fri	Sat
1	2 - Systemization - Training	3 - Systemization - Training	4 - Pre-Operations Survey	5 - Pre-Operations Survey	6 - Pre-Operations Survey	7
8	9 - Work-Up Phase - Electricians (PM)	10 - Work-Up Phase - Insulation Contractor - Vestibule lumber delivered	11 - Load Bank arrives - Electric contractor finishes - Continue work on vestibule and insulation	12 Continue work on vestibule and insulation	13 - Vestibule Complete - Duct work complete - Smoke Test	14
15	16 - Dry Runs with IPE	17 - Workup Phase - Test – Donor Charge	18 - Workup Phase - Test – Donor Charge Mis Fire	19 - Workup Phase - Test – UK 25 Pdr Shell Mis Fire	20 - Workup Phase - Test – UK 25 Pdr Shell Mis Fire	21
22	23 - Mis Fire Trouble Shooting	24 - Mis Fire Trouble Shooting	25 Mis Fire Trouble Shooting	26 Mis Fire Trouble Shooting	27 Mis Fire Trouble Shooting	28
29	30 - Maintenance and Data Review					

July 2003

Sun	Mon	Tue	Wed	Thu	Fri	Sat
		1 Late Start 1 x DET/Thunder Risk	2 Donor Charge/ 5 x Empty 25lb. Donor Charge/ 15lb Comp B	3 Donor Charge/ 1 x Empty 25lb. MS Shot x 1	4	5
6	7 Working to Torque Fittings	8 Pressure Test	9 1 x Water Filled DOT ?	10 1 x MS DOT 2.7lbs	11 - 1 x Water Filled 25lb - Maintenance and Data Review	12 Sat Overtime/Running MINICAM and Air Lines
13	14 Test 1 CG x 2lb DOT	15 Test 2 CG x 4lb DOT Test 3 CG x 4lb DOT	16 Test 4 CG x 4"Stokes Tag - 1618	17 Test 5 CG x 4"Stokes Tag - 1620	18 - Maintenance and Data Review Remove Vestibule	19
20	21 5 X Thermal Exercise Possible 24 Hr Working	22 5 X Thermal Exercise 24 Possible 24 Hr	23 5 X Thermal Exercise Possible 24 Hr Working	24 5 X Thermal Exercise Shot Pot Removal	25 5 X Thermal Exercise Shot Pot Removal	26 Weekend working/Checking Equipment
27 Weekend working/Checking Equipment	28 Re-Configure Equipment	29 Carbon Filtration Refit	30 Carbon Filtration Refit	31 Empty 25lb Shot Rehearse new munition hanging procedures		

August 2003

Sun	Mon	Tue	Wed	Thu	Fri	Sat
					1 - Maintenance and Data Review	2
3	4 Test 6 MS DOT 2.7lbs	5 Test 7 105mm Smoke	6 Test 8 105mm Smoke	7 Test 8 H 25lb Shell Tag -- 572	8 - Maintenance and Data Review	9
10	11 Test 9 H 25lb Shell Tag -- 586	12 Test 10 H 25lb Shell Tag - 677	13 Test 11 H 25lb Shell Tag - 680	14 Test 12 H 25lb Shell Tag - 685	15 - Maintenance and Data Review	16
17	18 Generator Failure	19 Continuity Problems	20 Test 13 H 4.2 Mortar UK Tag -- 5482	21 Test 14 H 4.2 Mortar UK Tag --5493	22 Test 15 H 4.2" Mortar (UK) Tag --TBD	23
24	25 - BANK HOLIDAY	26 Test 17 - H 6lb DOT	27 Test 18 - H 6lb DOT	28 - Maintenance and Data Review Start Preparation for Thermal Treatment	29 - Maintenance and Data Review - Remove Vestibule	30
31						

September 2003

Sun	Mon	Tue	Wed	Thu	Fri	Sat
	1 5 X/3 X Thermal Exercise Possible 24 Hr Working	2 5 X/3 X Thermal Exercise Possible 24 Hr Working	3 5 X/3 X Thermal Exercise Possible 24 Hr Working	4 5 X/3 X Thermal Exercise System Cool down	5 Maintenance and Data Review	6
7	8 Decon/Closeout	9 Decon/Closeout	10 Decon/Closeout	11 Decon/Closeout	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

Blank

APPENDIX E

PORTON DOWN SITE MONITORING

SITE MONITORING OVERVIEW

During the TC-25 Donovan Blast Chamber (DBC) testing, monitoring data were collected to:

- Protect workers, general public, and the environment
- Provide quantitative and qualitative data to decision makers
- Evaluate the effectiveness of the DBC in containment of chemical agents
- Provide historical data

Site monitoring generally followed the protocols outlined in the *TC-25 DBC Site Monitoring Plan for Defense Science and Technology Laboratory Salisbury, Wiltshire UK* (ECBC May 2003). Sampling locations in addition to those defined in the Monitoring Plan were added during testing to better assess overall system performance. Chemical agents of concern included mustard agent (H), phosgene (CG), and chloropicrin (PS). In addition, methyl salicylate (MS) was also monitored during workup run. Site monitoring was the responsibility of Edgewood Chemical Biological Center (ECBC) with laboratory support from Defense Science and Technology Laboratory (DSTL).

SAMPLING AND ANALYSIS APPROACH

The TC-25 DBC system was located in a vapor containment system (VCS), and monitoring was conducted both on process emission streams as well as within the VCS for protection of personnel. The types of monitoring equipment used during TC-25 DBC test operations included the following:

- **Miniature Chemical Agent Monitoring Systems (MINICAMS)**—Monitoring of H, CG, and PS.

- **Depot Area Air Monitoring System (DAAMS) adsorbent tubes**—Monitoring of H, PS, and MS.

- **Gas Chromatograph/Mass Spectrometer**—Analysis of H, H decomposition products, MS, and PS in solids and liquid samples.

- **Dosimeter Badges**—Monitoring of CG only.

- **Open Path Fourier Transform Infrared Spectrometer (OPFTIR)**—Chemical agents and propane and carbon monoxide.

All monitoring and sampling equipment were maintained and operated in accordance with *ECBC Monitoring Branch Internal Operating Procedures*. Figure shows the locations that were monitored during testing. Some locations were defined as optional and were only monitored during specific periods during testing. Table provides a summary of locations monitored and specific analytical methods that were employed.

In addition, monitoring was conducted during decontamination operations both during the test (for PPE and during agent feed changeover) as well as the end of testing to provide TC-25 DBC system closure monitoring to the appropriate level.

MONITORING DATA RESULTS

Site monitoring results are presented in Section 6 and Section 7 of the report.

TABLE
Sampling and Analysis Matrix

Test Phase	Method	Analyte(s)	Matrix	DCV-1: Detonation Chamber Vestibule 1 (at Det Chamber Door)	DCV-2: Detonation Chamber Vestibule 2	DCV-3: Detonation Chamber Vestibule 3 (personnel entry point)	01-300: Expansion Tank Discharge to APCU (c)	01-340: Between reactive bed filter and Catox	01-380: Between Catox and Heat Exchanger	01-400: Before First Carbon Adsorber 400	01-401: Between Carbon Adsorber 400 and 401	01-402: Between Carbon Adsorber 401 and Process Blower (d)	DC-01-101: Detonation Chamber Interior Space	DC-01-101A: Detonation Chamber Interior Wall - North (e)	DC-01-101A: Detonation Chamber Interior Wall - South (e)	DC-01-101C: Detonation Chamber Floor (Pea Gravel)	DC-01-101A: Detonation Chamber Interior Wall - East (e)	DC-01-101A: Detonation Chamber Interior Wall - West (e)	MWT: Munitions Wrapping Table	VCS-CFS1: VCS Carbon Filter Units (Between Bed 1 and Bed 2)	VCS-CFS2: VCS Carbon Filter Units (Between Bed 1 and Bed 2)	VCS-S1: VCS Carbon Filter Units (exhaust to atmosphere)	VCS-S2: VCS Carbon Filter Units (exhaust to atmosphere)	VCS-CP: Command Post (ambient air)	VCS-1: VCS Perimeter 1	VCS-2: VCS Perimeter 2	VCS-3: VCS Perimeter 3	VCS-4: VCS Perimeter 4	Spent Line	DE scape	PPE	Tools and other miscellaneous items	Process Plant Components (closure monitoring only)
Agent and Munitions Test 1 (2.7 lbs MS)	MINICAMS																																
	DAAMS (GC/MSD)	MS	Gas	X	X	X	O			X	X		O						X	X		X	X	X	X	X	X	X					
	OP-FTIR (a)																																
	Dosimeter Badge (b)																																
	Dall (GC/MS)	MS	solid											X	X		X	X															
	Dall (GS/MS)	MS	gravel													X													X				
	MINICAMS - headspace																																
	DAAMS - headspace																																
Agent and Munitions Test 2-6 (CG and CG/PS)	MINICAMS	PS and CG	gas	O		X				X			O						X	X				X									
	DAAMS (GC/MSD)	PS	Gas	X	X	X	O			X	X		O						X	X		X	X	X	X	X	X	X					
	OP-FTIR (a)	PS and CG	Gas																								X						
	Dosimeter Badge (CG Only)	CG	Gas	X						X	X								X					X									
	Dall (GC/MS)	PS	wipe											X	X		X	X															
	Dall (GS/MS)	PS	gravel													X													X				
	MINICAMS	PS and CG	headspace																											X	X	X	
	DAAMS - headspace																																
Agent and Munitions Test 7 (25 pdr - no agent fill)	None																																
Thermal Decon 1	MINICAMS	PS and CG	Gas	O		X				X			O						X	X				X									
	DAAMS (GC/MSD)	PS	Gas																														
	OP-FTIR (a)	PS and CG	Gas																								X						
	Dosimeter Badge (CG Only)	CG	Gas	X						X	X								X					X									
	Dall (GC/MS)	PS	wipe											X	X		X	X															
	Dall (GS/MS) Solid	PS	gravel													X													X				
	MINICAMS - headspace	PS and CG	headspace																											X	X	X	
	DAAMS - headspace																																
Agent and Munitions Test 8 (2.7 lbs MS)	MINICAMS																																
	DAAMS (GC/MSD)	MS	Gas	X	X	X	O			X	X		O						X	X		X	X	X	X	X	X	X					
	OP-FTIR (a)																										X						
	Dosimeter Badge																																
	Dall (GC/MS) surface wipe	MS	surface wipe											X	X		X	X															
	Dall (GS/MS)	MS	gravel													X													X				
	MINICAMS																																
	DAAMS																																
Agent and Munitions Tests 9-10 (105mm HC Smoke)	None																																
Agent and Munitions Tests 11-14 (3.5 inch DOT water fill)	None																																
Agent and Munitions Tests 9-18 -pdr, 4-inch Stokes, 4.2-inch UK, 5-inch DOT bottles, H-fill	MINICAMS - H	H	Gas	O		X				X			O						X	X				X									
	DAAMS (GC/MSD)	H	Gas	X	X	X	O			X	X		O						X	X		X	X	X	X	X	X	X					
	OP-FTIR (a)	H	Gas																								X						
	Dosimeter Badge (b)																																
	Dall (GC/MS)	H	surface wipe											X	X		X	X															
	Dall (GS/MS)	H	gravel													X													X				
	MINICAMS	H	headspace																											X	X	X	
	DAAMS	H	headspace																											X	X	X	
Thermal Decon 2 System Closeout	MINICAMS - H	H	Gas	O		X				X			O						X	X				X									
	DAAMS (GC/MSD) - H	H	Gas	X	X	X	O			X	X		O						X	X		X	X	X	X	X	X	X					
	OP-FTIR - H (a)	H	Gas																								X						
	Dosimeter Badge (b)																																
	Dall (GC/MS) surface wipe - H	H	surface wipe											X	X		X	X															
	Dall (GSMS) Solid - H	H	gravel													X													X				
	MINICAMS - headspace - H	H	headspace																											X	X	X	X
	DAAMS - headspace - H	H	headspace																											X	X	X	X

Notes:
X = location consistently monitored
O = location monitored periodically
(a) = FT-IR sample probe located near VCS-3
(b) = Dosimeter badges were located adjacent to the Minicams sampling points
(c) = location added during testing
(d) = identified location not sampled
(e) = Locations identified in the Monitoring Plan as interior and exterior doorframes: actual samples collected on inner walls of detonation chamber as indicated

APPENDIX E

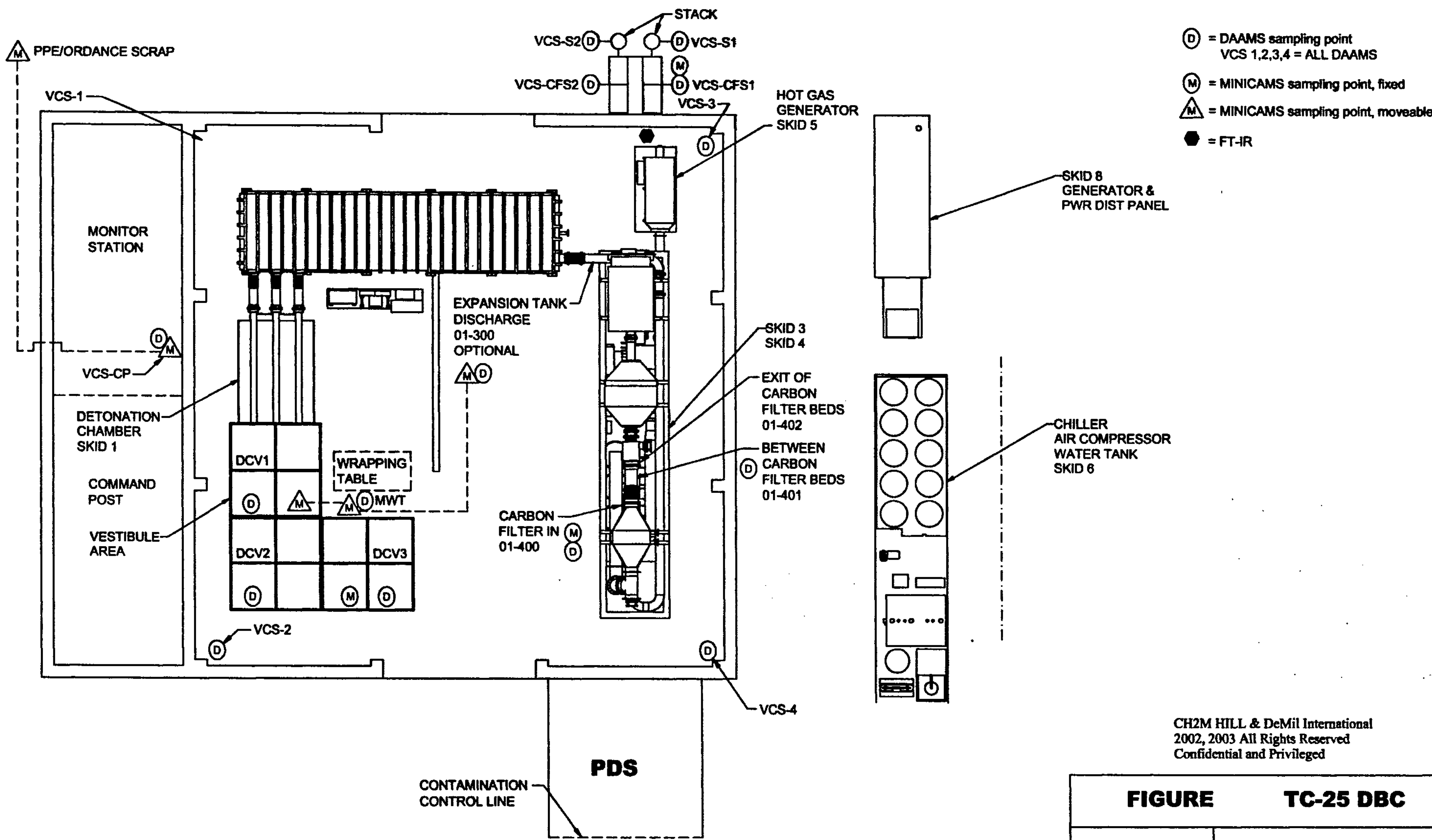


FIGURE	**TC-25 DBC**
CH2MHILL	DEMIL INTERNATIONAL
MONITOR LOCATIONS	

SCALE: 1 : 120

25-Aug-2003 Demil Layout2_1.dwg