DEFENCE RESEARCH ESTABLISHMENT SUFFIELD

RALSTON, ALBERTA

SUFFIELD SPECIAL PUBLICATION 125

OPERATION SWIFTSURE
A PLAN FOR DISPOSAL OF WASTE HELD ON THE EXPERIMENTAL PROVING GROUND(U)

by

J.M. McAndless, A.H. Gray and C.G. Coffey

DEFENCE RESEARCH ESTABLISHMENT SUFFIELD

RALSTON, ALBERTA

SUFFIELD SPECIAL PUBLICATION NO. 125

OPERATION SWIFTSURE

A PLAN FOR DISPOSAL OF WASTE HELD ON THE EXPERIMENTAL PROVING GROUND (U)

by

J.M. McAndless, A.H. Gray and C.G. Coffey

ABSTRACT

(U) A plan is described for the disposal of waste materials currently held at protected sites on the DRES Experimental Proving Ground. The plan is based upon a disposal system which utilizes both chemical and thermal destruction technology.

(C) Chemical destruction will be employed for the disposal of highly toxic chemical warfare agents while all other materials, including the detoxified waste from the chemical destruction operation, will be subjected to thermal destruction (incineration). With certain incineration technologies available, it may be possible to dispose of vesicant chemical agents by direct incineration. Critical alternative methods will be employed to deal with small numbers of explosive-containing items which present an extreme safety hazard.

TABLE OF CONTENTS

TABLES

FIGURES

ANNEX FIGURES

ANNEXES

DRES WASTE DISPOSAL SYSTEM

ANNEX A	Identification And Screening Operation
ANNEX B	Transport And Storage Of Waste Material
ANNEX C	Opening And Chemical Destruction Operations
ANNEX D	Sampling/Analysis Operation
ANNEX E	Compactor/Shredder Unit
ANNEX F	Thermal Destruction Operation
ANNEX G	Critical Alternative Methods
ANNEX H	Environmental Impact From System Operation

DEFENCE RESEARCH ESTABLISHMENT SUFFIELD

RALSTON, ALBERTA

SUFFIELD SPECIAL PUBLICATION NO. 125

OPERATION SWIFTSURE
A PLAN FOR DISPOSAL OF WASTE HELD ON THE EXPERIMENTAL PROVING GROUND

by

J. M. McAndless, A.H. Gray and C.G. Coffey

SUMMARY

1. (C) This concept plan describes the disposal of scrap metal, empty containers and containers filled with a variety of toxic and non-toxic chemicals which are under the corporate responsibility of the Defence Research Establishment Suffield (DRES). This waste is currently held at three protected sites on the Experimental Proving Ground (EPG). In addition, potentially contaminated soil resulting from trials and exercises held on the EPG may also be included in the disposal process.

2. (C) The plan, to be implemented by a project team and called Operation Swiftsure, is based on a waste disposal system which incorporates both chemical and thermal destruction technology.

Chemical destruction will be employed where the waste involves highly-toxic chemical warfare agents while all other waste, including the decontaminated products of the chemical destruction operation, will be subjected to thermal destruction (incineration).

3. (C) Chemical destruction of toxic materials will be carried out by DRES staff who have experience in this type of operation while thermal destruction will be conducted on a contract basis.

4. (C) A schematic of the proposed waste disposal system is shown in Figure 2. This system can accommodate the variety of waste currently held with the following exceptions:

a. explosive items or explosive-containing chemical munitions, and

b. fragile or large containers filled with toxic material which cannot be handled or transported safely.

For these few cases, alternative disposal methods are described in the plan.

5. (C) With certain incineration technologies available, it may be possible to:

a. use one unit rather than the two units indicated in Figure 2; and

b. for the vesicant agent mustard, to bypass the chemical destruction operation and safely incinerate solid/liquid-filled containers directly. This agent constitutes the bulk of the toxic waste to be destroyed.

6. (U) The waste disposal system will operate according to the following principles:

a. current health and safety standards as well as environmental standards will be met;

b. stringent safety practices developed at DRES will be rigidly adhered to during inspection, handling and disposal of toxic material;

c. the system will utilize currently-available proven technology that can be purchased or leased from commercial sources and which is complemented by equipment items that can be produced in-house to meet specific requirements;

d. the disposal of designated waste will be rapid and complete once the disposal system is in operation; and

e. the system will not produce any waste products which are unacceptable for disposal/storage at commercial sites.

7. (C) The proposed plan will be implemented in three phases, starting immediately. The main activities in each phase are described as follows:

<u>Phase I</u>: inventory and identification of waste material for disposal, chemical destruction of nerve agents, acquisition of thermal destruction technology and support equipment.

<u>Phase II</u>: installation and testing of thermal destruction equipment, chemical destruction of chemical

agents, stockpiling of scrap and detoxified material for thermal destruction.

Phase III: operational disposal of waste by chemical/thermal destruction.

It is estimated that the waste currently held on the Experimental Proving Ground could be disposed of within a period of two years at a total cost of approximately 5 million dollars.

8. (U) The Swiftsure project team will be managed and staffed by DRES personnel who will interface with contract personnel associated with the thermal destruction operation. In similar fashion to commercial waste disposal operations, information exchange between DRES and contractors will remain confidential.

9. (C) The thermal/chemical destruction operations will be located at an available protected site on the Experimental Proving Ground, within practical transport distance from current holding sites.

10. (U) Transport of waste to the disposal site will utilize a containerized approach which will permit the transport containers to serve as safe temporary storage for the material scheduled for disposal.

11. (U) Proper planning and use of state-of-the-art technology will ensure the disposal operation has no significant environmental impact. In all cases, where emissions to the environment could occur, effort is devoted to the selection of technology, equipment and procedures which mitigate any possible environmental and/or health-related factors.

INTRODUCTION

12. (C) Three protected sites on the DRES Experimental Proving Ground (EPG) are used for the safe storage of approximately 3500 containers, which include artillery shells, steel drums of various volumes, tanks and a variety of bombs, boxes and cans (1). In addition, approximately 150 tonnes of scrap metal, fragments and machinery parts are also held. These items, which have been collected and stored following EPG military and research activities, range in age from World War II to the present. Most containers filled previously with toxic material have been emptied and decontaminated while some remain filled with mustard, lewisite and an assortment of nerve agents.

13. (C) A plan to systematically dispose of this accumulated waste was previously prepared and implemented (2). Although considerable progress was made, limitations in disposal technology at that time and reduction in assigned manpower prevented more rapid destruction of the waste. Figure 1 illustrates the progress made in destroying hazardous material over the last 15 years.

14. (C) The amounts of unwanted material currently held for disposal are as follows:

Scrap Metal	150 tonnes
Mustard	12 tonnes
Lewisite	1.5 tonnes
Nerve Agents	1.2 tonnes
Other Chemicals	1.3 tonnes

The types of waste including containers which have a toxic fill are described in general in Table I.

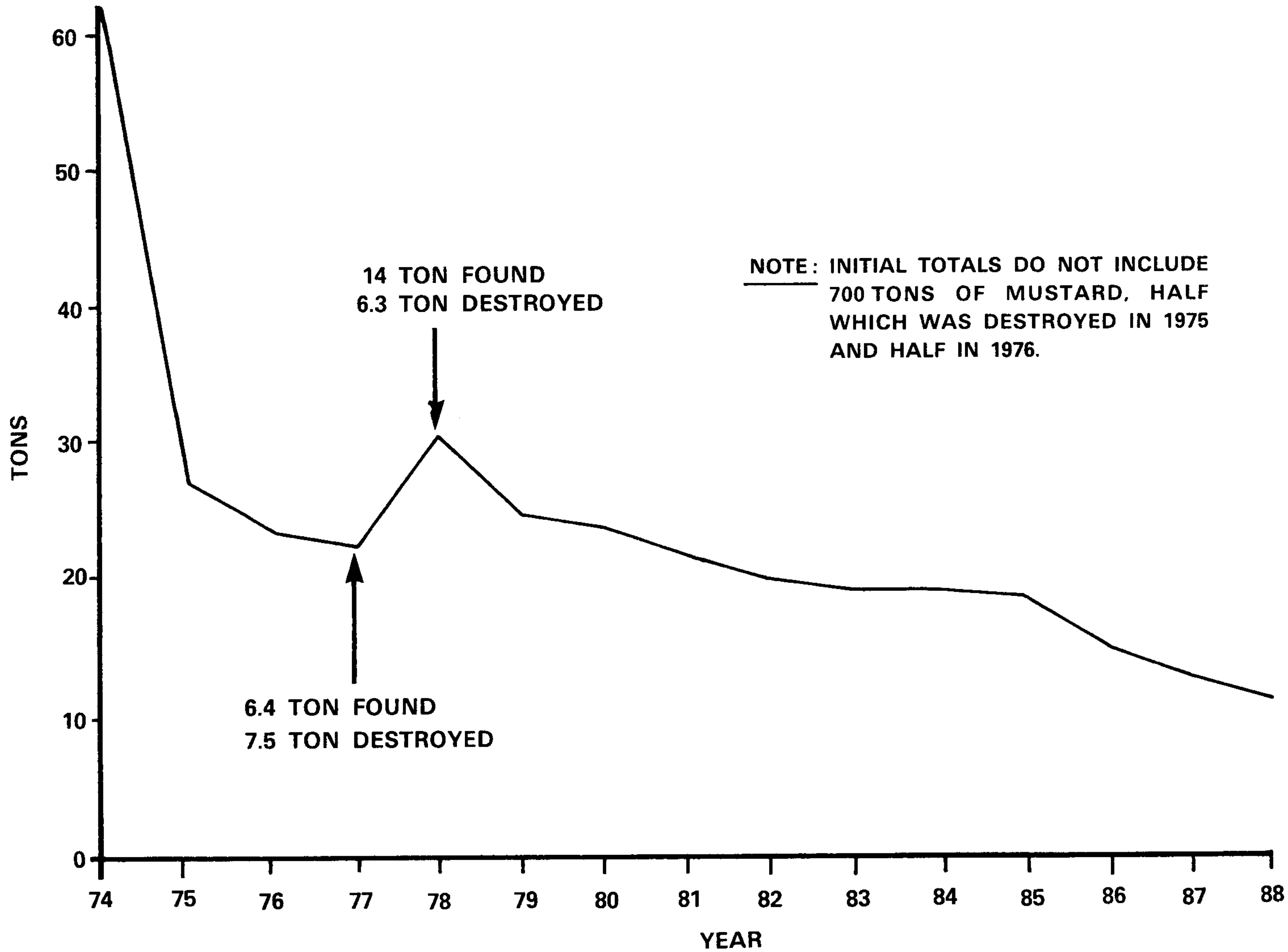

Figure 1

PROGRESS CHART FOR CHEMICAL AGENT DISPOSAL

TABLE I

TYPES OF WASTE FOR DISPOSAL

DESCRIPTION	POTENTIAL/KNOWN FILL
Scrap metal, fragments	none
Empty metal containers	none (or residual mustard)
Wood, glass, rubber, paper, soil	none (or residual mustard)
155 mm Shell	mustard, G-agents
105 mm Shell	mustard, G-agents
25 lb. Shell	mustard, nerve agents
Livens Bomb	mustard
4.2 inch Mortar	mustard
Chemical Bombs	nerve agents
45-gallon Drums	mustard, chlorosulfonic acid
Cylinders, various sizes	phosgene, lewisite, mustard nerve agents, chlorine
"Flying Cows"	mustard
Tanks	nerve agents

Information on the physical characteristics of the agent-filled containers as well as the properties of the agents themselves is given elsewhere (3,4,5).

15. (C) Certain localized areas of the EPG may contain potentially contaminated topsoil as a result of trial activity, previous disposal activities, storage or landfilling of non-toxic organic solutions. It is intended that such soil be included in the disposal process. Surveys in these localized areas will be conducted to determine the amount of soil to be removed for disposal.

DISPOSAL METHODS PREVIOUSLY USED AT DRES

16. (C) The methods used previously to destroy unwanted hazardous material have involved chemical destruction, weathering and open-pit incineration at remote field locations on the EPG. For example, explosive or chemical shells were opened individually with shaped cutting charges and the contents were allowed to flow onto decontaminant-soaked ground. When mustard was involved, the ensuing oxidation reaction caused the liquid agent to catch fire and burn. The ruptured shell was allowed to weather for a period of time, after which it was considered to be scrap metal.

17. (C) For corroded containers of mustard such as the 1940-vintage "flying cows", a burning tank was located nearby and a few containers were placed inside. This operation was usually carried out in cold weather to ensure the mustard was frozen. This prevented leakage from containers which appeared badly corroded. Cutting charges were then set, several hundred liters of fuel such as JP4 added to the burning tank and the charges detonated. The ensuing fire caused the contents of the container to burn intensely and after 4-5 hours, the chemical agent was consumed. The metal fragments were then relegated to the scrap metal storage area.

18. (U) During the 1970's, over 700 tonnes of mustard were chemically destroyed by alkaline hydrolysis methods using a specially-constructed facility created for this purpose (6). This material, which was stored in concrete vaults, represented the bulk of mustard stocks which were shipped to DRES at the end of World War II.

19. (C) For G- or V-agents, the material was poured into a quantity of 10% KOH/methanol solution with stirring. After some hours, the detoxified solution was poured into a shallow pit. The original

container was treated with KOH/methanol for several hours, then broken open with an explosive charge and allowed to weather for some months. The broken container was then considered to be scrap metal. This basic hydrolysis method successfully destroys nerve agents as well as mustard (7).

20. (U) One of the most favorable aspects of the above methods is the high degree of safety involved for personnel carrying out the disposal. For example, in the event a shell or other container was explosive, the cutting charge would detonate it. The cutting charge was fired remotely from a distance sufficient to protect against local liquid or vapour hazards. Only one shell at a time was opened and this, combined with the large size of the DRES range, was considered adequate safety in terms of potential downwind vapour drift. Any scrap metal was collected and placed into protected storage and was not further processed nor disposed of at commercial sites.

DISPOSAL PLAN CONCEPT

21. (U) In view of current regulations such as the Canadian Environmental Protection Act, certain aspects of the disposal methods used previously at DRES now are considered unacceptable. To address this concern, as well as to respond to a strong renewed interest in disposing of the remaining unwanted material held on the Experimental Proving Ground, a plan is described herein which can meet the stringent environmental and safety requirements imposed on any current waste disposal operation. This plan expands upon a review and description of a chemical destruction operation which was recently proposed (1) for disposal of materials held on the DRES EPG.

22. (U) The plan, called Operation Swiftsure, utilizes a waste

disposal system which is shown schematically in Figure 2. This system incorporates both chemical destruction and thermal destruction (incineration) operations in order to accommodate the variety of waste listed in Table I. In particular, chemical destruction is employed to destroy the highly toxic chemical agent fills in various containers while thermal destruction is used to dispose of the scrap metal, emptied and decontaminated containers, as well as detoxified materials and solutions from the chemical destruction operation. Thermal destruction would also be employed to dispose of any contaminated soil which may be present.

23. (U) The principal features of the waste disposal system are listed in Table II along with reference to Annexes where each feature or particular operation is described in more detail.

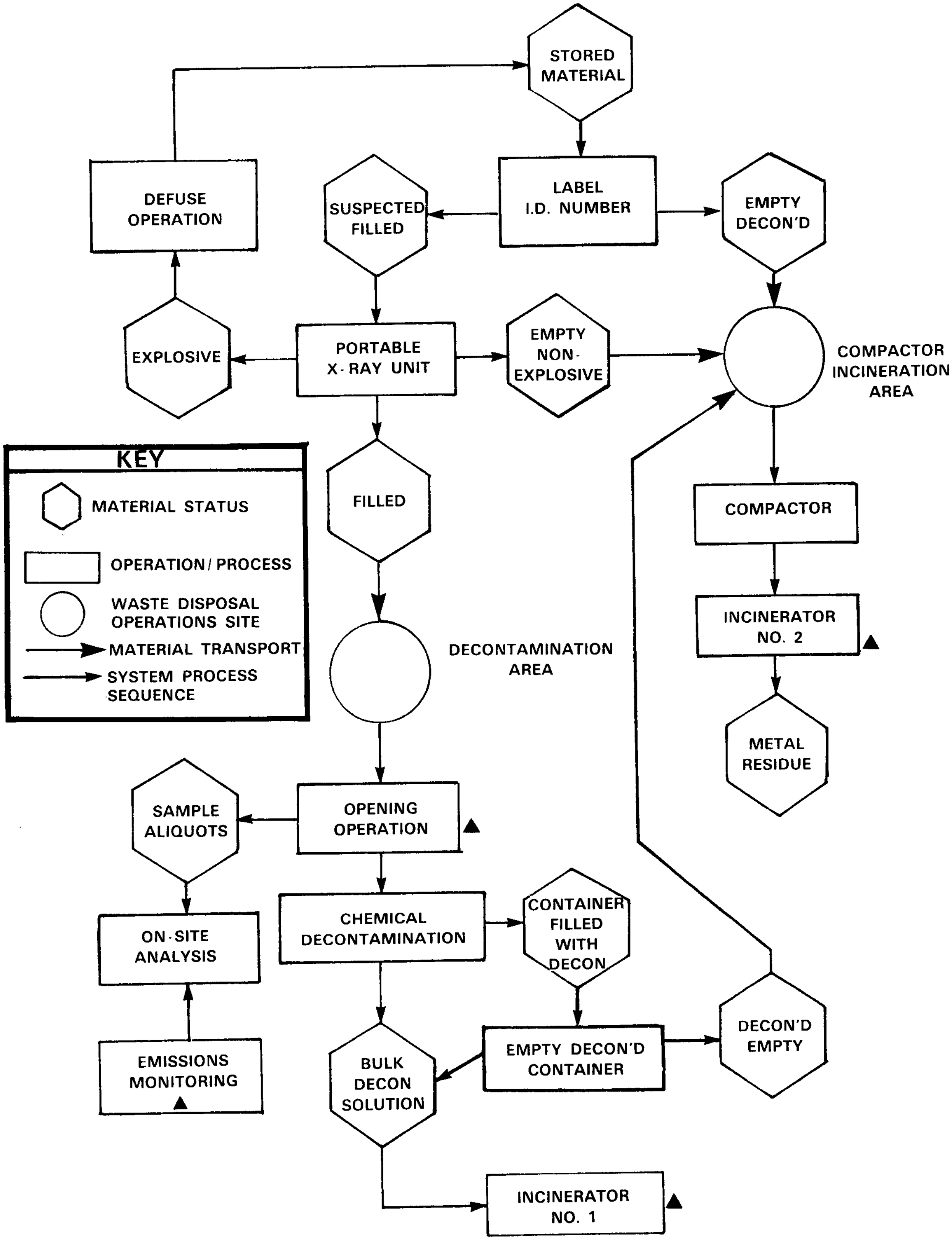

Figure 2

DRES WASTE DISPOSAL SYSTEM

TABLE II

MAJOR FEATURES OF THE DRES WASTE DISPOSAL SYSTEM

FEATURE	FUNCTION	DESCRIPTION
Screening	identification and screening of items for disposal	Annex A
Transportation	movement of materials to the disposal site	Annex B
Chemical Destruction	opening containers, detoxifying chemical agents	Annex C
Analysis	verification and monitoring activities	Annex D
Compaction	preparing material for thermal destruction	Annex E
Thermal Destruction	incineration of waste material	Annex F

24. (U) In preparing the Operation Swiftsure plan, several alternative disposal methods were considered, including:

a. large-scale open-pit incineration;

b. transport to and disposal of waste material at a commercial site;

c. maintaining long-term storage of toxics while eliminating the accumulation of scrap metal and empty containers (thermal destruction only);

d. complete chemical destruction with no incineration; and

e. land-filling.

These alternatives are unacceptable because of safety and environmental considerations as well as political and administrative problems.

25. (U) By itself, chemical destruction has been used successfully to dispose of toxic materials (1,3). However, previous methods were slow, labour intensive, required substantial amounts of decontaminants and did not address the problem of scrap metal/empty container disposal.

26. (U) Thermal destruction is widely accepted by private and public organizations dealing with waste disposal problems and is recognized by regulatory authorities as producing minimal environmental impact combined with acceptable health and safety factors. A comprehensive plan based on a thermal destruction system for the disposal of chemical munitions stored at US military installations has been described and implemented previously (4,5). However, to directly dispose of nerve agents by thermal destruction, extremely sophisticated, expensive facilities and safety systems are required.

27. (C) For Operation Swiftsure, chemical destruction will be employed for the following toxic materials, in order of priority:

All nerve agents
Lewisite
Mustard (neat liquid)

This destruction, involving alkaline hydrolysis, will be conducted by DRES staff who have extensive experience and expertise in this type of operation. Two batch processing methods for the priority destruction of nerve agents are described in Annex C. These DRES-developed methods and associated equipment will be tested using simulants prior to selecting the most appropriate method for the disposal operation. In all cases, detailed procedural descriptions will be approved (e.g., Field Trial Procedures) prior to commencing any disposal activity involving chemical warfare agents.

28. (U) The waste disposal system can destroy the vast majority of waste currently held on the Experimental Proving Ground by direct thermal destruction or with a combination of chemical and thermal destruction with the following exceptions:

a. explosive devices and explosive chemical munitions;

b. fragile or large containers filled with toxic materials.

In these few cases, some form of alternative destruction must be carried out (see Critical Alternative Methods, Annex G). Such methods include transferring agent contents to safe containers, container reinforcements or explosive destruction.

29. (C) With certain technology currently under investigation, it may be possible to conduct direct thermal destruction of the hazardous, but less toxic, thickened mustard and mustard residues. This would be advantageous as the bulk of this agent is stored in non-explosive containers which can be readily compacted or shredded (e.g., 45 gallon drums). In many cases, the agent is in the form of an intractable sludge which will be difficult to decontaminate by the usual methods.

30. (U) Transport of containers and scrap to a centralized disposal facility following an on-site screening operation is favoured over a truly portable disposal facility, as the bulk of the waste to be disposed of can be readily transported. A system to transport and temporarily store waste in a containerized fashion is proposed (see Annex B). The major facilities will be located at a protected site within the Experimental Proving Ground as near as practical to the holding sites. The chemical destruction and thermal destruction operations will be carried out within the same site but in separate facilities.

31. (C) Several sites have been investigated as a possible location for the chemical/thermal destruction operations. The Cameron Center, where the DRES Decontamination Center is now located, most closely meets requirements for the protected waste disposal site in terms of available facilities, access, utilities, location and environmental considerations such as water table proximity, elevation, etc.

PLAN IMPLEMENTATION

32. (C) The Identification, Screening, Opening/Chemical Destruction and Sampling/Analysis operations shown in Figure 2 can be carried out using Establishment resources. Extra manpower and financial resources will be required to acquire additional facilities and equipment and to speed up the pace of chemical destruction of the waste.

33. (U) Compactor/incinerator technology is under intensive investigation for the thermal destruction operation. Five hazardous waste management firms have been contacted, meetings held with company representatives, statement of requirements prepared and proposals submitted (or are in preparation) by the companies for consideration. One company will be selected to conduct the thermal destruction operation under contract, using technology most appropriate to meet

stated requirements and environmental regulations.

34. (C) The plan will be implemented on a first priority basis by a project team managed and staffed by DRES personnel who will interface with personnel assigned to operate the thermal destruction system under contract. All chemical destruction operations, particularly those involving containers with nerve agent fills, will be conducted by DRES staff only.

35. (C) It is proposed that waste disposal operations be conducted year round and in phases, starting immediately with the chemical destruction operation and proceeding concurrently with the acquisition of the thermal destruction system and support equipment. These phases are as follows:

<u>Phase I</u> (Chemical Destruction Start-Up and Equipment Acquisition)

a. identification, inventory and characterization of the types and quantity of waste for disposal;

b. screening of potentially explosive devices for destruction by critical alternative methods (Annex G);

c. design and acquisition of permanent chemical destruction facilities;

d. Disposal of nerve agent filled containers by priority chemical destruction methods (Annex C);

e. acquisition of specialty sampling equipment;

f. completion of technology investigation and acquisition of thermal destruction equipment through contract award;

g. draining and decontaminating large containers of nerve agent, mustard and lewisite and chemical destruction of the fills;

h. survey of localized areas to determine extent of soil contamination.

Phase II (Thermal Destruction Start-Up)

a. preparation of site, installation of thermal destruction equipment including compactor/shredder unit(s) and integration with chemical destruction operation;

b. continuing chemical destruction of nerve agent fills, vesicant fills, decontamination of containers;

c. destruction of explosive devices by critical alternative methods;

d. transport and stockpiling of scrap metal, soil, decontaminated containers, decontaminant solutions at the waste disposal site;

e. testing of thermal destruction system on scrap metal items and commencing scrap metal disposal operations;

f. continuing thermal destruction of scrap metal, operational phase;

g. testing of incinerator equipment on detoxified solutions (used decontaminants) either directly or mixed with contaminated soil, as appropriate;

h. testing of incinerator equipment for direct thermal destruction of small quantities of mustard fill, if possible.

Phase III (Operational Phase)

a. continued transport, stockpiling, thermal destruction of metal items, decontaminated containers, etc;

b. disposal of toxic materials by chemical destruction and direct thermal destruction of vesicant materials where possible;

c. thermal destruction of used decontaminants and contaminated soil;

d. storage of thermal destruction products (solids) for eventual disposal at a commercial site.

Phase IV (potential)

The thermal destruction equipment and other portions of the waste disposal system have potential for becoming a permanent resource for disposal of hazardous wastes by CFB Suffield, DRES and other DND Units. For example, DRES laboratory chemical waste, solids etc., could be temporarily stockpiled to provide sufficient quantity to operate the thermal destructor cost-effectively for short periods of time. Alternatively, this waste could be integrated into other waste produced by CFB Suffield and other sources to permit thermal destruction on a more regular basis. In this phase, it is presumed that the thermal destructor would be operated by the commercial supplier under e.g., standing offer contract.

36. (C) A schedule showing estimated times for particular planning and operational steps in the three phases listed above is shown in Figure 3 along with an accompanying legend. Important milestones are indicated in this Figure as well.

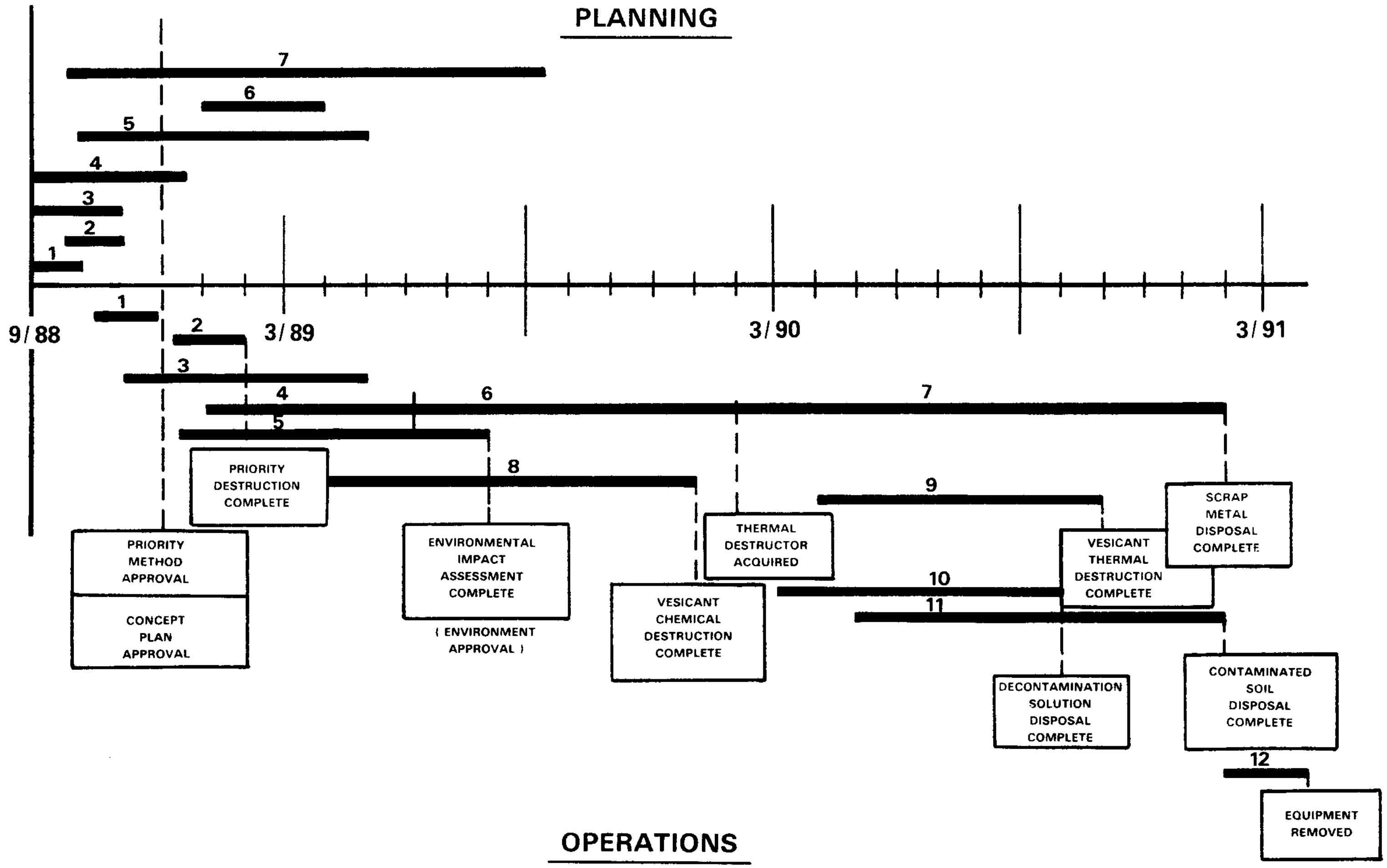

Figure 3

TIME CHART FOR DISPOSAL PLAN IMPLEMENTATION

FIGURE 3 LEGEND

PLANNING	OPERATIONS
1. Establish Project Structure	1. Demonstrate Priority Chemical Destruction Technology
2. Develop Priority Chemical Destruction Methods	2. Conduct Priority Destruction Using Approved Method
3. Complete Concept Plan Document	3. Prepare Disposal Site
4. Review Proposals for Thermal Destruction Technology	4. Prepare and Award Thermal Destruction Technology Contract
5. Devise Procedures for Vesicant Chemical/ Thermal Destruction	5. Environmental Impact Assessment
6. Devise Materials Handling Procedures for Thermal Destruction Operations	6. Acquire/Install Thermal Destruction Technology
7. Equipment Requirements, Planning and Implementation	7. Scrap Metal Disposal
	8. Vesicant Chemical Destruction
	9. Vesicant Thermal Destruction
	10. Decontaminant Solution Thermal Destruction
	11. Contaminated Soil Thermal Destruction
	12. Thermal Destruction Equipment Removal

COST ESTIMATES

37. (U) The cost of acquiring and operating the proposed waste disposal system is estimated as follows:

Item	Estimated Cost (Preliminary) ($M)
1. Portable X-Ray Unit	0.284
2. Analytical Instrumentation	0.170
a. GC/MSD plus accessories (130K)	
b. MIRAN Analyzers (2 x 19.5K)	
3. Chemical Destruction	0.320
a. Decontaminants, containers (100K)	
b. Building modifications, fume hood (30K)	
c. Container opening equipment (40K)	
d. Transport containers, protective clothing (100K)	
e. Computer-based inventory system (50K)	
4. Thermal Destruction	2.500
Compactor/incinerator (1 unit) (2.0M)	
or Compactor/incinerators (2 units) (2.5M)	
5. Operating costs of incinerator system	1.500
(15K per day for 100 days)	
6. On-site shredder (second unit)	0.150
7. Reinforced explosives container	0.020
8. Disposal site preparation	0.100
TOTAL	5.044

SAFETY

38. (U) As is the case in any operation involving hazardous materials, safety and protection of personnel is of utmost importance and these considerations take priority over all others.

39. (C) All personnel handling chemical agent-filled containers shall wear full protective clothing which consists of an encapsulating full body protective suit and self-contained breathing apparatus and/or powered air delivery system (eg., MSA Canada Life Support System). Observers will wear an intermediate protective ensemble (CF Individual Protective Equipment). This protective ensemble will also be worn by operators of the thermal destruction equipment when loading potentially contaminated soil, scrap metal or used detoxified solutions from the chemical destruction operation into the thermal destructor.

40. (U) Real-time monitoring equipment will be deployed during chemical/thermal destruction operations, especially where fugitive emissions might occur, to provide warning of any developing problems.

41. (U) During operations a medical assistant shall be present. A chemical safety officer and trials officer will determine whether a particular activity can proceed with respect to meeting all safety requirements. Such requirements are very stringent and are based on thorough experience gained in the handling of highly toxic materials.

42. (U) A decontamination facility will be maintained at the disposal site and at on-site locations during the handling of filled containers. Decontamination personnel will supply protective clothing, assist in protective clothing donning/doffing operations, decontaminate used clothing and protective equipment and act as as observers during chemical destruction operations.

43. (U) All activities inside chemical destruction facilities shall be monitored by video. An interpersonnel and network communications system will be employed to relay information during disposal operations.

WASTE DISPOSAL SYSTEM ENVIRONMENTAL IMPACT

44. (U) It is mandatory that operation of the waste disposal system meet current regulations, both federal and provincial, with respect to personnel safety, public health standards and environmental standards. For toxic materials, such as chemical warfare agents, emission standards have been established in the United States for disposal operations (8,9). These standards shall act as guides in cases where standards have not yet been established in Canada.

45. (C) Specialized air sampling equipment developed at DRES (Minitube Air Sampling System) will be deployed at specific locations to verify that chemical agent vapour is not released to the atmosphere. Where required, sample analysis will be carried out to verify container contents and to provide timely feed-back to system operating performance.

46. (U) Thermal destruction is fully recognized and approved by regulatory authorities for waste disposal operations (10,11), including demilitarization of chemical munitions (4,5). The company supplying and operating the thermal destruction equipment will employ industry-approved monitoring equipment and scrubbing technology to ensure incinerator emissions from the scrap metal, container, soil and solution destruction meet current environmental standards.

47. (U) The waste disposal system will be operated at a protected site on the DRES Experimental Proving Ground, within ready transport

distance from the material holding sites and approximately 4 km east of Base Suffield. There is no permanent habitation within 30 km east to north of the site (prevailing winds are West or South-West). The site is located in an area which is not susceptible to interaction with ground water or surface water.

48. (U) Initial assessment indicates there are no significant environmental effects which could arise from site preparation, installation of equipment or connection of utilities at the waste disposal site.

49. (U) During opening/chemical destruction operations, there is a possibility that small quantities of agent vapour could be released to the local atmosphere within the facility. Methods and procedures to mitigate this release are described in Annex H.

50. (U) Transport and storage of materials will be containerized to prevent escape of material to the surrounding environment, as described in Annex B.

REFERENCES

1. J.C. Muirhead, Disposal of Unwanted Material in DRES EPG (U), Research Note No. 628 (FTP. No. 166), February 1987. CONFIDENTIAL.

2. B.G. Laidlaw, R.A. Klymchuk and G.P. Smart, The DRES Range Clean-Up Program (U), Suffield Memorandum 3/77, (1977). CONFIDENTIAL.

3. Demilitarization of Toxic Munitions at US Army Materiel Command Installations. Environmental Impact Statement. Edgewood Arsenal Md. (1971) NTIS PB-203-509D.

4. J.A. Scott and R. Rife. Chemical Demilitarization: Disposing of the Most Hazardous Wastes. Minutes of the 21st Explosives Safety Seminar, Volume II, Sponsored by US Department of Defence Explosives Safety Board, Houston, Texas, August 1984. pp 853-872.

5. Disposal of Chemical Munitions and Agents. Report by the Committee on Demilitarizing Chemical Munitions and Agents, Board on Army Science and Technology, Commission of Engineering and Technical Systems, National Research Council. National Academy Press, Washington, D.C. 1984. ISBN 0-309-03527-9.

6. S.B. Mellsen. The Canadian Facility for Destruction of Mustard by Hydrolysis: Engineering Aspects. Suffield Technical Paper No. 441. (1975).

7. D.W. Mason and G.D. Sides, The Role of Alumina in Agent Decontamination, US Army Chemical Research and Development Center, CRDC Report No. CRDC-CR-84055 (1984).

8. Department of Health and Human Services, Center for Disease Control

US Federal Register Vol. 53 (50) pp 8504-8507, March 1988. Recommendations for Protecting Human Health Against Potential Adverse Effects of Long-Term Exposure to Low Doses of Chemical Warfare Agents. Morbidity and Mortality Weekly Review (MMWR), Massachussetts Medical Association, Vol. 37 (5), pp 72-74, 79, February 1988.

9. R.S. Ottinger et al, Recommended Methods of Reduction, Neutralization, Recovery or Disposal of Hazardous Waste, Vol. 1 (1973) NTIS PB-224-580.

10. Environmental Technology Handbook No. 4. How to Dispose of Toxic Substances and Industrial Wastes. P.W. Powers, Noyes Data Corporation (1976) pp. 301-315.

11. Public Hearings on Hazardous Waste Management in Alberta. Report and Recommendations. Environmental Council of Alberta, Co-op Press Ltd. December 1980.

ANNEX A
TO SUFFIELD SPECIAL PUBLICATION NO. 125
DATED NOVEMBER 1988

DRES WASTE DISPOSAL SYSTEM
IDENTIFICATION AND SCREENING OPERATION

1. Identification of Items

This operation is carried out at the waste holding sites and involves visual inspection, labelling and photographing items. A consistent identification system will be devised for record keeping and inventory control using a portable or laboratory-based computer. Hard copy records will be produced as a back-up to prevent loss of data in the event of computer malfunction or disc storage problems. Photographs of specific containers, especially those which cannot be immediately identified as to type or contents, will be taken for reference purposes. Photographs taken at periodic intervals are recommended to indicate progressive reduction of the accumulated waste. Individual items of scrap metal or broken, empty containers which will be transported directly to the disposal site or shredded in situ need not be labelled, especially if the specific items are displayed in general photographs of the holding site.

2. Screening Operation

When any doubt exists as to contents, the container is examined in situ using a portable x-ray unit before moving the item. This is especially important for those items which may contain explosives, chemical fill or both. Explosive devices must be rendered safe by EOD experts or destroyed in situ (see Critical Alternative Methods

.../A-2

Annex G). Items known to be empty and non-toxic, and certified as such following screening, may be transported directly to the waste disposal site. Liquid/solid- filled containers which can be safely handled are also transported to this site for chemical destruction or, if possible, direct thermal destruction. Large filled containers which cannot be handled and transported safely must be drained and then destroyed in situ using Critical Alternative Methods.

ANNEX B
TO SUFFIELD SPECIAL PUBLICATION NO. 125
DATED NOVEMBER 1988

DRES WASTE DISPOSAL SYSTEM
TRANSPORT AND STORAGE OF WASTE MATERIAL

Four classes of materials will require transport from holding sites to the disposal site, viz.:

a. shredded metal/empty containers, dunnage
b. agent-filled containers
c. containers filled with used decontamination solution (from holding site draining operations), and
d. potentially contaminated soil

These materials will be segregated into separate temporary holding areas at the disposal site in preparation for a particular disposal operation.

Large, enclosed strenghtened metal bins such as those utilized in municipal garbage disposal or hazardous waste transport appear suitable for the containment and safe transport of the above materials. The bins can be readily picked up and transported using e.g., flat-deck trucks equipped with hydraulic lifters, and can also serve as temporary storage containers for materials delivered to the disposal site. The bins would cycle between holding sites and the disposal site, with each bin dedicated to the containment of one class of material only. Extreme care would be exercised in packing those bins dedicated to agent-filled container transport.

.../B-2

Loading and off-loading of bins would be accomplished using for example, drum lifters, front-end loaders, fork lifts or manual labour where appropriate.

With appropriate care, the outside surfaces of the bins should remain contamination free, thus minimizing requirements to decontaminate the transport vehicles. If necessary, the inside surfaces of the bins would be decontaminated and washed using e.g., aqueous bleach solutions followed by a water wash. All washings could be safely retained within the lined holding pond available at the disposal site where the water would be returned to the atmosphere by evaporation.

ANNEX C
TO SUFFIELD SPECIAL PUBLICATION NO. 125
DATED NOVEMBER 1988

DRES WASTE DISPOSAL SYSTEM
OPENING AND CHEMICAL DESTRUCTION OPERATIONS

The purpose of the opening operation is as follows:

a. to acquire, if necessary, a small aliquot of the container fill for identification purposes;

b. to provide an opening through which the fill can be removed into decontaminating solution and decontaminant added to the container to neutralize toxic residue;

c. to provide a pressure-relief opening for containers which, if possible, can be directly introduced into the compactor/-incinerator system for destruction of the fill and the container itself (mustard fills only). In these cases, a temporary plug is installed which will release under internal pressure after the compaction (or shredding) process starts.

For containers with toxic fills, the opening operation potentially is the most dangerous part of the waste disposal scheme, in terms of personnel safety and environmental impact. The procedures employed and protective measures used by personnel to minimize risk are described previously in this report under SAFETY and elsewhere (1). Except when using cutting charges (see below), all opening operations will take place in a building where small amounts of agent vapours, if released, are contained and trapped in a fume hood/recirculating filter system. It is feasible to have the air from this facility directed into the incinerator to create a slight negative pressure in the building. All opening and chemical destruction operations will be conducted by DRES staff only.

Opening and chemical destruction can be carried out in several possible ways depending on the container type and equipment available. For example,

a. by using a remote drill system and containment tank similar in concept (3) to that shown in Figures 1C and 2C;

b. by direct manual opening of container closures which are not rusted shut and controlled draining of the contents into decontaminating solution;

c. by water jet cutting equipment suitably contained over a decontaminant sump. In this case, no sample is taken and the container is cut/washed followed by direct addition to the incinerator. The decontaminated washings are slurried with e.g., soil or coal powder for subsequent incineration. This equipment is an integral part of the incinerator system;

d. by employing small, remotely-activated cutting charges to rupture the container inside a larger tank while submerged

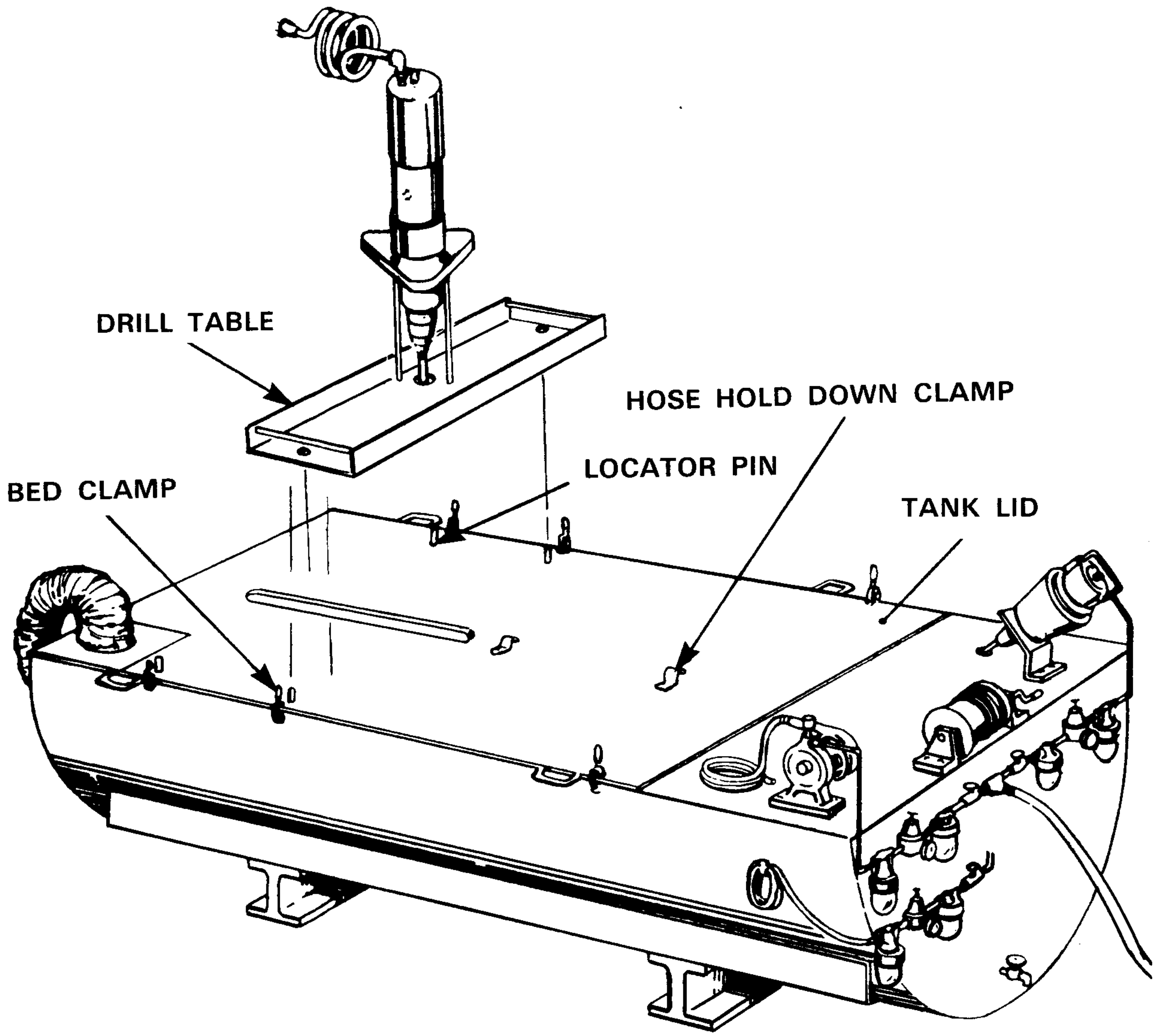

Figure 1C

MUNITION DECONTAMINATION UNIT WITH DRILL TABLE

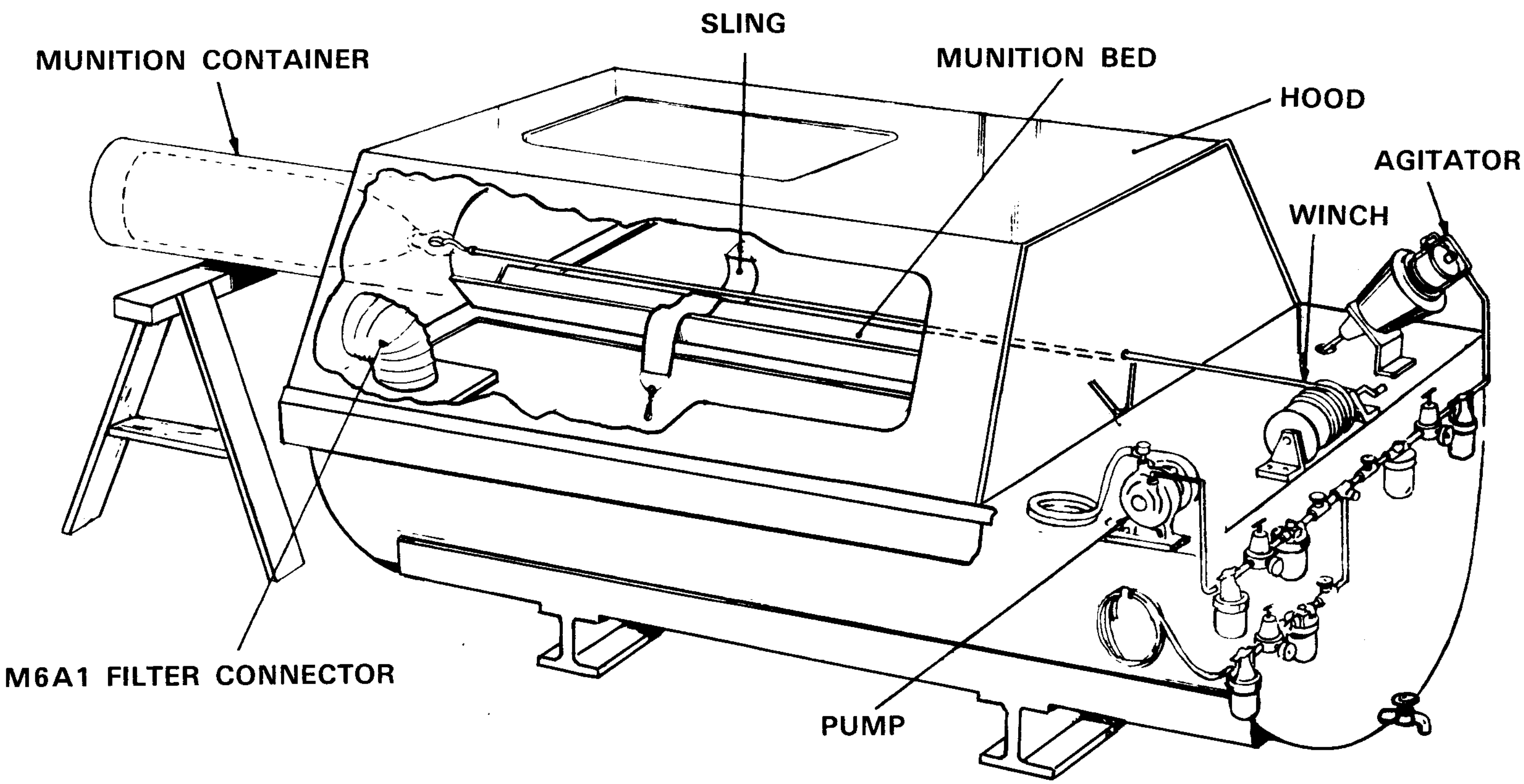

Figure 2C

PROJECTILE DECONTAMINATION UNIT WITH HOOD in decontaminating solution. This type of operation can be conducted at the sites where the toxic material is held to avoid transporting such material to the disposal site.

e. by remotely cutting containers using a powered saw inside a tank filled with decontaminant.

f. by punching holes in containers using a hydraulically-driven metal punch and draining the fill into decontaminant.

In cases c, d and e, samples of the container fill generally will not (or cannot) be taken as part of the destruction process. For containers of a type or series with a known fill, it will not be necessary to acquire a sample from each container.

To accomplish the priority destruction of nerve agents which are held in 155 mm and 105 mm shells (non-explosive), two methods are initially proposed, namely:

a. Shaped Cutting Charges (method d, above) and

b. Powered Cutting Saw (method e, above)

In the Shaped Charge Method, special, low energy explosive cutting charges designed to cut munitions and to operate underwater or under solution are attached to a shell. The shell is placed on a pedestal in a reinforced tank equipped with a latching closure and

.../C-4

chimney and covered with potassium hydroxide/methanol decontaminating solution. The cutting charge leads are then connected and fired remotely to cut the shell open and expose the contents directly to decontaminant. The explosive charge will likely ignite the alcohol upon detonation, thus causing both the agent fill and the decontaminant itself to be incinerated in a contained fashion. Following the combustion step, the tank will contain potassium hydroxide residue and metal fragments. The metal fragments are subsequently removed and melted by thermal destruction. The tank may be reused many times; fresh methanol containing lower concentrations of potassium hydroxide may be used after each disposal operation to dissolve the residue and form active decontaminant.

In the operational phase of disposal, five or more such tanks could be employed in sequence to destroy e.g., 10 nerve agent filled shells per day at the holding site. Chemical agent monitors, would be used for examining tanks to determine residual vapour hazard, if any. The DRES Minitube Air Sampling System would be deployed downwind for verification purposes.

The apparatus and support equipment for the Powered Cutting Saw Method would be contained within a building equipped with a recirculating fume hood and charcoal filter bank. A video system will be installed in this building so that remote monitoring of all activities is possible. A MIRAN analyzer will continuously monitor the free air concentration of nerve agents which will be destroyed during this process.

.../C-5

ANNEX C
TO SUFFIELD SPECIAL PUBLICATION NO. 125
DATED NOVEMBER 1988

The 105 mm and 155 mm shells will be moved from the holding site in lots of no more than 25. The shells will be placed in a storage container inside the chemical destruction building and allowed to come to room temperature. To carry out a detoxification, a shell will be mounted in a holder underneath a powered cutting saw and inside a vat filled to just beneath the holder with potassium hydroxide/methanol decontaminant. Some water may be added to this decontaminant to facilitate pumping this solution to and from storage tanks located outside the building. The saw, which is activated remotely, will cut one end of the shell open in a fashion which permits the shell contents to drain into the decontaminant-filled vat. The cut fragment will fall into the vat and the remaining portion will be removed from the holder and allowed to fall into the vat as well or be placed over special decontaminant spray heads located at the bottom of the vat. After several cuttings, the vat will be drained and the fragments removed for melting by thermal destruction. The used decontaminant solution will be stored for eventual thermal destruction as well.

In operation, such a system would be capable of destroying approximately 10 shells per day.

Figures 3C and 4C show schematically the apparatus which would be employed for the Shaped Charge or Powered Cutting Saw methods, respectively. The advantages and disadvantages of these two methods are summarized in Table I-C (Shaped Charge Method) and Table II-C (Powered Cutting Saw Method).

.../C-6

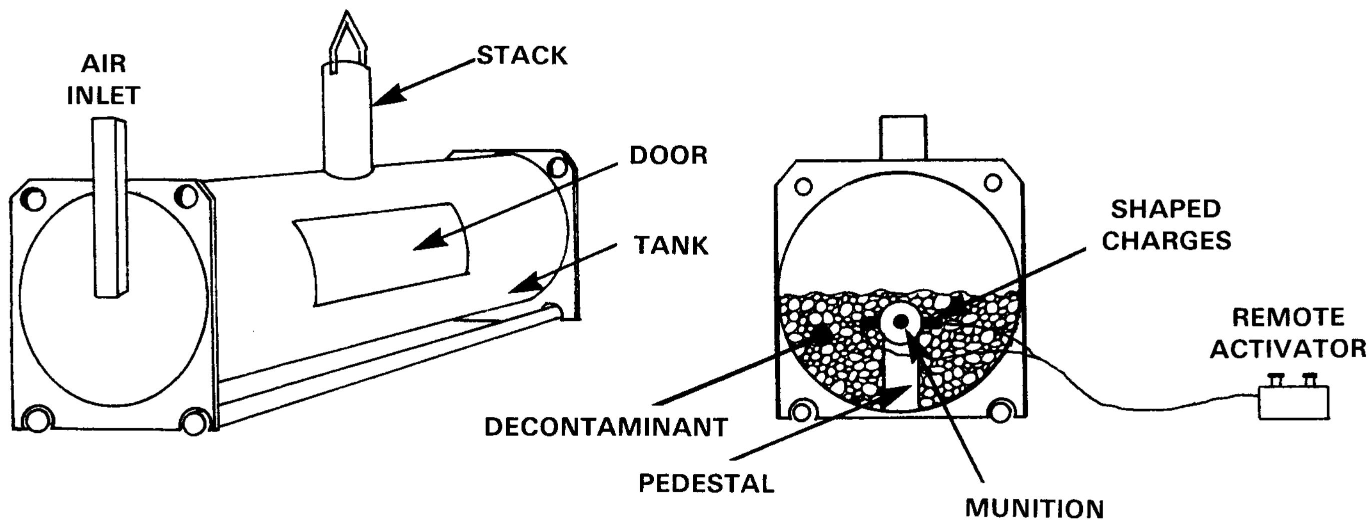

Figure 3C

CONTAINMENT TANK FOR SHAPED CUTTING CHARGE DISPOSAL METHOD
(SCHEMATIC)

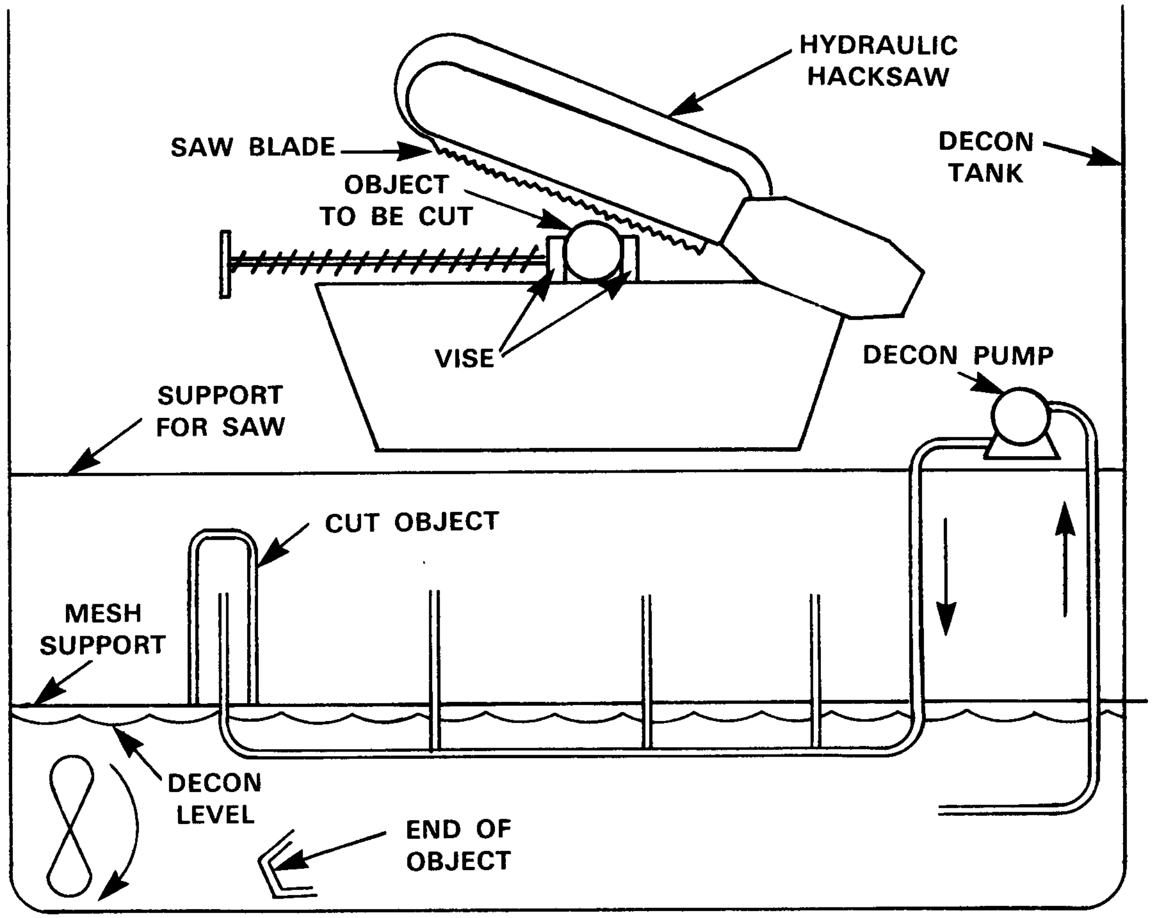

Figure 4C

APPARATUS SCHEMATIC FOR MUNITION DISPOSAL USING A POWERED CUTTING SAW

TABLE I–C
SHAPED CUTTING CHARGES

ADVANTAGES

- OPERATION CONDUCTED AT HOLDING SITE
- RAPID COMPLETION OF PRIORITY DESTRUCTION
- HIGH DEGREE OF SAFETY THROUGH REMOTE ACTIVATION OF SPECIFICALLY–TAILORED SHAPED CUTTING CHARGES
- FAVORABLE ECONOMY OF SCALE IN TERMS OF LOGISTICS, MANPOWER, EQUIPMENT AND PROTECTION
- EQUIPMENT UNDERGOES SELF–DECONTAMINATION
- SIMPLE MONITORING REQUIREMENTS

DISADVANTAGES

- RELATIVELY LARGE AMOUNTS OF DECONTAMINANT USED FOR EACH DISPOSAL EVENT
- PARTIALLY DEPENDENT ON METEOROLOGICAL CONDITIONS

TABLE II–C

POWERED CUTTING SAW

ADVANTAGES

- RAPID COMPLETION OF PRIORITY DESTRUCTION
- FUGITIVE EMISSIONS CONTAINED WITHIN THE IMMEDIATE VICINITY OF THE OPENING OPERATION
- CONTROL OVER EACH PROCESS STEP
- ONE BATCH OF DECONTAMINANT USED FOR SUCCESSIVE DISPOSALS
- REMOTE MONITORING OF THE OPENING OPERATION IS POSSIBLE

DISADVANTAGES

- RELATIVELY COMPLEX EQUIPMENT DESIGN
- LOGISTICS BURDEN IN TERMS OF CONTAINER TRANSPORT, SOLUTION STORAGE, SPECIAL PROTECTIVE CLOTHING AND FACILITIES
- SEPARATE CONTAINMENT OF SAW COOLANT FLUID
- FLAMMABILITY OF EXPOSED DECONTAMINANT SOLUTION

ANNEX C
TO SUFFIELD SPECIAL PUBLICATION NO. 125
DATED NOVEMBER 1988

For those agents which come after the first priority chemical destruction process, the following general methods of destruction (in order of disposal priority) are proposed:

G-agents in large containers: Drain fill into KOH/methanol decontaminating solution, add decontaminant to container, destroy all used decontaminating solutions by thermal destruction, destroy decontaminated container by volume reduction and thermal destruction.

Lewisite in large tanks: Same as above.

Neat mustard in large containers: Same as above.

Thickened mustard and mustard residues: Under cold conditions, shred or compact containers in presence of soil, feed mixture of soil, shreddings and solid agent residue directly into thermal destructor system.

In most cases, it is possible to drain containers at the holding sites and transport used decontaminant rather than agent-filled containers to the disposal site.

Scrap metal: Volume reduction at holding site or disposal site, direct thermal destruction.

Soil: Direct thermal destruction.

.../C-7

ANNEX D
TO SUFFIELD SPECIAL PUBLICATION NO. 125
DATED NOVEMBER 1988

DRES WASTE DISPOSAL SYSTEM
SAMPLING/ANALYSIS OPERATION

This operation is carried out in a laboratory located in close proximity to the opening/chemical destruction operation. The laboratory has the following functions:

a. to identify the main toxic ingredient(s) of filled containers for verification and record-keeping purposes;

b. to analyze air samples collected near the opening operations and incinerator sites to verify that agent emissions are absent or meet emission standards for a particular chemical;

c. to analyze decontaminating solutions, when necessary, to ensure completeness of chemical destruction;

d. to perform special analyses on materials such as soil or water, as required.

An on-site location for this operation is recommended to provide timely feed-back on the operating performance of the disposal system and to avoid transporting toxic samples to the DRES base laboratory. The samples (contained in glass vials) along with any sample handling equipment such as pipettes will be destroyed by thermal destruction following analysis.

.../D-2

ANNEX D
TO SUFFIELD SPECIAL PUBLICATION NO. 125
DATED NOVEMBER 1988

Where possible, agent samples will be collected from containers at the holding sites rather than at the disposal site during the final opening operation. Samples of liquids shall be taken by syringe or pipette, placed in glass sample vials in a carrier solvent and transported to the analytical laboratory.

The analytical instrumentation will include a gas chromatograph equipped with flame photometric/flame ionization detectors and a mass selective detector, wide-bore capillary columns with effluent splitter and an automated thermal desorption unit for sample introduction. This latter unit allows direct liquid injection or thermal desorption of miniature solid-sorbent tubes used to collect air samples. These latter samples will be collected continuously and automatically using the DRES Minitube Air Sampling System. Air samplers will be set up at a suitable distance (e.g. 500 m) downwind of the opening/chemical destruction and incineration operations, as indicated in Figure 2, and samples collected continuously over specified time periods. These samples will be analyzed immediately to verify compliance with agent emission standards (8) as listed in Table I-D.

.../D-3

ANNEX D
TO SUFFIELD SPECIAL PUBLICATION NO. 125
DATED NOVEMBER 1988

TABLE I-D

ALLOWABLE LIMITS ($mg\ m^{-3}$) FOR CHEMICAL AGENT EXPOSURE

AGENT	GENERAL POPULATION	WORKERS
Nerve Agents		
GA, GB	3×10^{-6}	1×10^{-4}
VX	3×10^{-6}	1×10^{-5}
Vesicants		
HD, H, HT	1×10^{-4}	3×10^{-3}
L	3×10^{-3}	3×10^{-3}
Averaging Time:	72 hours	8 hours

Devices such as Chemical Agent Monitors (CAM) and MIRAN Infrared Gas Analyzers will be employed specifically near the opening operation as real-time monitors and for site inspections. Possible incinerator effluents such as HCl, SO_2, etc., will be monitored in real time using instrumentation associated with the incinerator(s); this latter type of emissions monitoring will not be the responsibility of the on-site analytical laboratory.

ANNEX E
TO SUFFIELD SPECIAL PUBLICATION NO. 125
DATED NOVEMBER 1988

DRES WASTE DISPOSAL SYSTEM
COMPACTOR/SHREDDER UNIT

Many containers and scrap metal pieces which are clean or have been decontaminated may be too large for direct introduction into an incinerator. Normally, most incinerators designed to handle solid waste have an integrated compaction or shredding system to reduce the waste to an appropriate size.

It appears desirable that a stand-alone, transportable compactor/shredder be available for volume reduction of scrap metal at the holding site. That is, transport of shredded material to the disposal site is more efficient in terms of delivered weight versus transporting empty containers. This type of compactor/shredder can be relatively simple compared to a unit which would be integrated with the thermal destructor.

It would be highly desireable in the case of vesicant liquids such as mustard to incinerate the fill and container concurrently, to overcome the disadvantages associated with chemical destruction. This concurrent destruction appears feasible provided safety can be assured for the incinerator operators. For example, shredding by water jet in an integrated shredder/incineration system where the liquid fill is washed into a decontaminant-filled sump is a possibility. Slow speed mechanical slicing combined with mixed metal, solids and liquid feed can be used for thin-walled containers such as 45-gallon drums and this technology could be adapted to meet requirements.

ANNEX E
TO SUFFIELD SPECIAL PUBLICATION NO. 125
DATED NOVEMBER 1988

Perceived requirements for an integrated compactor/shredder unit (CSU), which will be investigated as part of the process of acquiring suitable incineration technology, include the above possibilities.

Some requirements are as follows:

1. The CSU will be a closed unit operating under negative pressure and delivering all air flow directly to the incinerator;

2. It is equipped with a wash-down system capable of utilizing various decontaminating solutions to neutralize liquids and the interior surfaces of the unit. The CSU must be capable of feeding these liquids directly from a sump to the incinerator as an integrated process;

3. The CSU should act as the primary feed mechanism for the incinerator and allow ready introduction of feed stock such as heavy-walled cylinders which have been sized by other methods (e.g., cutting charges);

4. Opening of thin-walled containers should be accomplished by e.g., hydraulic piercing/punching so as not to significantly pressurize any contents during this process;

5. the automated feed system between the CSU and incinerator must have the ability of being cleared and decontaminated

.../E-3

in the event of accidental shut-down;

6. controlled shut-down of the CSU should be automated and all liquids and decontaminating solutions fed to the incinerator or to a designated storage tank prior to subsequent start-up;

7. in the event of accidental shut-down, the unit must be provided with a back up system which will render the unit safe from both liquids and vapours and not allow fugitive releases to the atmosphere;

In the ideal case, the CSU would accept a full 45-gallon drum containing vesicant residues or thickened fill, size the container and feed both solids and liquid directly to the incinerator in an automated, completely safe manner. Current technology which can achieve this goal is under active investigation.

ANNEX F
TO SUFFIELD SPECIAL PUBLICATION NO. 125
DATED NOVEMBER 1988

DRES WASTE DISPOSAL SYSTEM
THERMAL DESTRUCTION OPERATION

Two distinct types of waste are to be destroyed by thermal destruction viz:

a. scrap metal and metal containers, and

b. organic liquids, solutions (organic and aqueous) and solids (organic and inorganic).

For large, empty containers it will be necessary to compact or shred the container to a suitable size for introduction into the incinerator, as described in Annex E.

An incinerator which can destroy both types of waste concurrently is preferred in order to streamline the disposal process and minimize capital expense, labour and operating costs. If this is not possible, then a combination of two separate systems is the next preferrence. In this combination, an incinerator designed for liquid wastes and equipped with required effluent monitoring capability would be used for the thermal destruction of container fills (vesicants only) and decontaminating solutions. A simple compactor/furnace would be used for disposing of scrap metal. The off-gases from this furnace would be fed to the air inlet of the liquid incinerator to take advantage of the effluent monitoring eqipment provided with this latter

ANNEX F
TO SUFFIELD SPECIAL PUBLICATION NO. 125
DATED NOVEMBER 1988

incinerator.

Two levels of treatment are normally considered in the thermal destruction of wastes. For example, most municipal wastes are burned with a destruction removal efficiency (DRE) of 99.99%, whereas hazardous wastes that are considered carcinogenic, teratogenic or mutagenic must be destroyed with a DRE of 99.9999%. For thermal destruction of chemical warfare agents, the incinerator DRE must be even higher. The DRE for three agents are listed in Tabld I-F.

TABLE I-F

AGENT INCINERATION DESTRUCTION REMOVAL EFFICIENCY REQUIREMENTS (4)

Agent	DISCHARGE STANDARD (mg m-3)	REQUIRED DESTRUCTION EFFICIENCY (%)
GB	0.0003	99.999999
VX	0.00003	99.9999999
H	0.03	99.99995

For Operation Swiftsure, nerve agents will be chemically destroyed and all non-DND contract personnel who will operate the compactor/incinerator equipment will not be allowed to work with these agents (or explosives) to ensure maximum safety.

ANNEX F
TO SUFFIELD SPECIAL PUBLICATION NO. 125
DATED NOVEMBER 1988

Generally, transportable incinerators capable of attaining the high DRE required for hazardous waste destruction are modular in nature and are composed of three parts: a furnace, a post-combustion chamber (PCC) and an air pollution control (APC) system.

The furnace, or kiln, is normally designed to accept both solids and liquids. Typical parameters are:

solids residence time:	approx. 30 minutes
vapour/gas residence time:	approx. 2 seconds
temperature:	minimum of 1000°C

Depending on the operating temperature, the incineration in this step will be performed in either the ashing or slagging mode, whether the solids are melted or not.

The post-combustion chamber is used to complete the oxidation of the gases. The temperature in the PCC is typically held at about 1250°C. This step may not be essential if the residence times and temperatures in the furnace are very much higher, but is essential if there is an oxygen deficiency in the furnace, i.e., the furnace operates in a reduction or pyrolysis mode, for example.

An APC system is necessary to remove the acid gases and particulates generated in the combustion process. The APC normally consists of:

.../F-4

a. a quench procedure to lower the gas temperature,

b. a packed tower or equivalent to remove the acid gases such as HCl, NOx, SOx, etc., or a scrubber, precipitator or baghouse to remove particulates, and

c. a stack for releasing the purified air stream.

A wide variety of incinerators are available which potentially can meet requirements for destruction of the types of waste stored on the DRES EPG (9,10). Special incinerators have been designed for large scale thermal destruction of chemical-filled munitions (4,5). Several North American companies sell appropriate systems or lease the treatment service by installing their units on-site. Prominent companies in this field include Ogden Environmental, Detoxco, Westinghouse, Ensco, Cominco, Combustion Engineering, Sanexen and O.H. Materials. Typical types of incinerators for various categories of waste (11) are listed in Table II-F. A concept drawing (11) of a transportable rotary kiln for disposal of hazardous wastes is shown in Figure 1F.

The incinerator(s) for the DRES Waste Disposal System will be selected to meet criteria which, amongst others, include the following:

1. A real-time effluent monitoring capability will be incorporated to ensure proper operation of the incineration process and that environmental air quality standards are met;

.../F-5

TABLE II-F

MATRIX FOR MATCHING WASTE TYPE WITH INCINERATION PROCESSES

Waste Type	INCINERATION PROCESS: Rotary Kiln*	Multiple Hearth	Fluidized Bed	Stationary Liquid Incinerator*	Multiple-Chamber Incinerator	Molten-Salt Incinerator*	Plasma** Arc
SOLIDS							
Granular homogeneous	x	x	x				x
Irregular & bulky (pellets, etc.)	x				x		shredded
(drums, etc.)							shredded
Low melting point (tars, etc.)	x			If material can be melted and pumped			x
Organic compounds with fusible ash constituents	x	x				x	x
GASES							
Organic vapour laden	x	x	x	x			x
LIQUIDS							
High organic strength aqueous wastes,	If equipped with auxiliary liquid injection nozzles.	x	x	x	x		x
Organic Liquids	If equipped with auxiliary liquid injection nozzles.		x	x	x		x
SOLIDS/LIQUIDS							
Waste containing halogenated aromatic compounds (1200° C. min. temp.)	x		x	If liquid	x	x	x
Aqueous organic sludges	Provided waste does not become sticky upon drying	x	x				x

* Also suitable for pyrolysis operation

** This is a developing technology

x Indicates suitable waste type for incineration process identified

Source: Hitchock, D.A., 1979 cited in Reid Crowther, 1980b v. 2 revised.

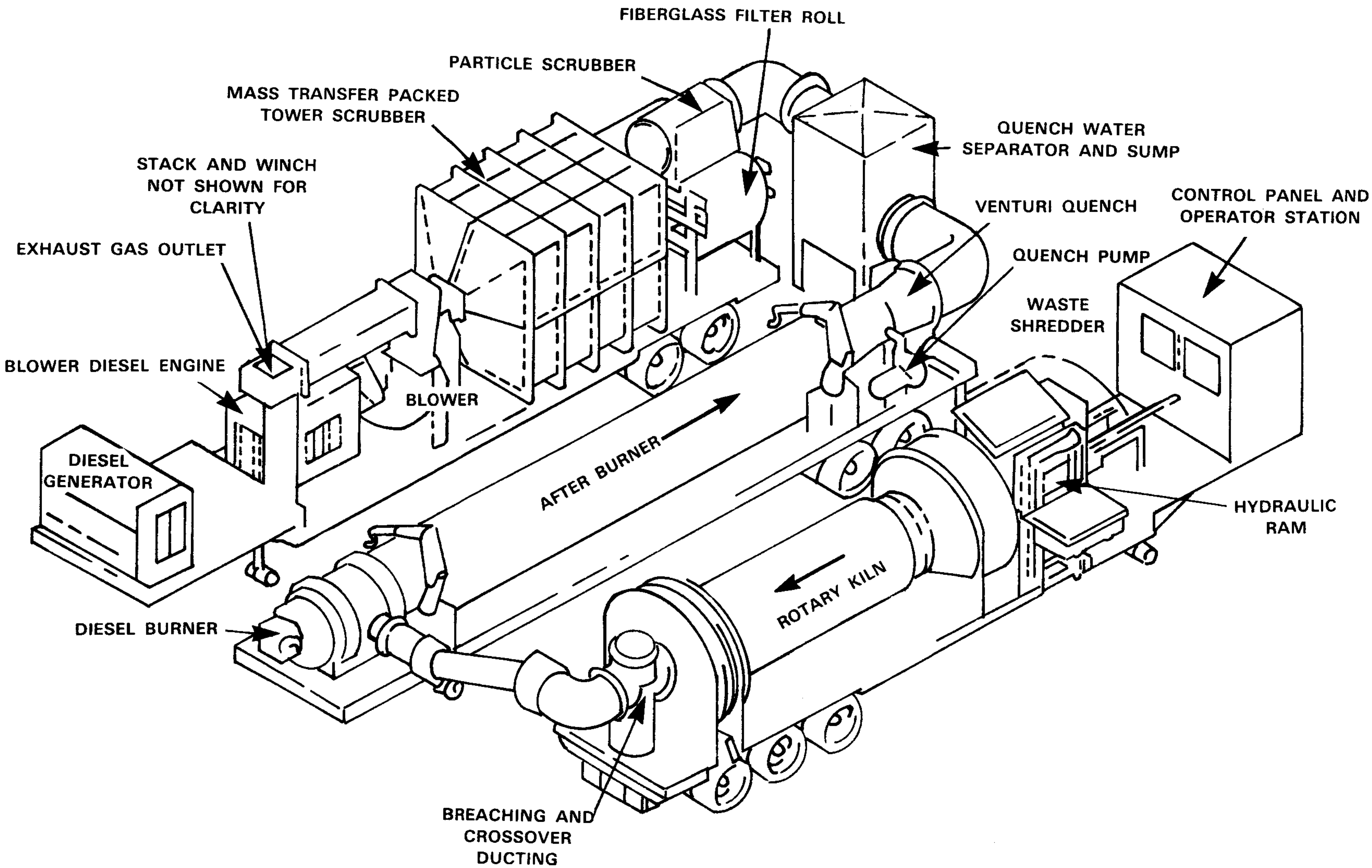

Figure 1 F

AN ARTIST'S CONCEPT OF MOBILE ROTARY KILN FOR DISPOSAL OF HAZARDOUS WASTES (Source: Tenzer (1978))

ANNEX F
TO SUFFIELD SPECIAL PUBLICATION NO. 125
DATED NOVEMBER 1988

2. Metal will be melted to produce acceptable residue such as pellets, ingots or slag;

3. If possible, the unit(s) will operate on a batch-mode principle and not require a continuous feed to maintain the incinerator operation beyond a normal 8-hour working period.

4. The unit assigned to organic waste disposal will be capable of handling methanol/aqueous solutions directly or in slurry form using available adsorbents such as coal dust or soil;

5. the unit(s) will accept containers in size up to and including 45-gallon drums when combined with a suitable compactor. The container orientation will not be a critical factor during addition to the compactor/incinerator;

6. The unit(s) will not require elaborate site preparation and housing and will utilize readily-available electrical and natural gas utilities;

7. Operation will not be labour intensive, with the commercial supplier providing personnel under contract to operate the unit(s);

8. Scrubbing sytems utilizing water will not have a daily consumption rate exceeding 5000 gallons per day;

.../F-6

9. Auxillary units such as contained water jet cutting systems and air ducts from the opening operations area should be readily interfaced with one incinerator unit;

10. Incinerator power consumption should not exceed 500 kW h^{-1};

11. Natural gas consumption should not exceed 1700 cu. ft h^{-1};

ANNEX G
SUFFIELD SPECIAL PUBLICATION NO. 125
DATED NOVEMBER 1988

DRES WASTE DISPOSAL SYSTEM
CRITICAL ALTERNATIVE METHODS

The proposed waste disposal system can dispose of the bulk of the stored waste in a safe manner. The following items require handling and disposal using special methods:

a. explosive munitions, with or without a chemical fill, and

b. large or fragile containers which contain chemical fill and which cannot be handled and transported safely.

These types of items are relatively small in number and can be dealt with in situ according to the following procedures:

1. High Explosive Munitions Without Chemical Fill

These devices are extremely dangerous to handle, especially when rusted or in fragile condition. Generally, they must be destroyed in situ by EOD experts. For example, the device may be exploded or rendered inoperative and harmless by bursting/rupturing using a remotely-activated shaped charge which is placed close to the device. When ruptured, the fragments and solids can be incinerated directly as the explosive material when uncontained will ignite in a non-destructive fashion.

.../G-2

ANNEX G
TO SUFFIELD SPECIAL PUBLICATION NO. 125
DATED NOVEMBER 1988

2. Low Explosive Munitions with Chemical Fill

For items in good condition which may be handled, the following techniques are possible:

a. the device may be defused by EOD experts before removing the chemical fill into decontaminating solution, or

b. the device may be burst with shaped cutting charges inside a portable, reinforced container filled with decontaminating solution, as described in Annex C. By mounting the device on a pedestal surrounded by a blast shield, extra protection is provided against the possibility of rupturing the reinforced container.

When the munition is considered too dangerous to handle, in situ explosion/rupturing using removely-activated shaped charges is necessary. In this case, release of agent vapour to the atmosphere is likely and downwind safety templates would be established to accommodate the "worst case" scenario (i.e., instantaneous release of the entire fill as vapour). The ground surrounding the munition is pre-soaked with decontaminating solution to neutralize expelled liquid drops. The ruptured munition must then be soaked in decontaminant and subjected to open air burning (if allowed) to complete the process. The metal fragments will be subjected to thermal destruction using the waste disposal system incinerator.

.../G-3

3. Large Containers With Chemical Fill

The fill will be drained into containers holding an appropriate volume of decontaminating solution. Decontaminating solution will then be added to the large container to destroy toxic residue before moving/dismantling/compacting and incineration.

4. Fragile Containers With Chemical Fill

For certain fills, e.g., mustard, it may be possible to handle and transport the container under cold ambient temperatures (e.g., below 5°C) when the liquid fill is in a solid state. It may then be possible to compact/shred and incinerate the fill and container directly, depending on container size and incinerator technology available. Otherwise, the fill can be re-liquified by warming and pumped or drained into a vat containing decontaminating solution. Other methods which will have to be investigated on a case-by-case basis include, for example:

a. in situ draining the fill into other containers;

b. reinforcing the container by e.g., applying solidifying foam and placing the item in a second container for transport to the disposal site.

ANNEX H
TO SUFFIELD SPECIAL PUBLICATION NO. 125
DATED NOVEMBER 1988

DRES WASTE DISPOSAL SYSTEM
ENVIRONMENTAL IMPACT FROM SYSTEM OPERATION

Certain operations of the waste disposal system have a potential impact on the surrounding environment. Effects could arise from emissions to the atmosphere or from byproducts of the chemical destruction operation. Methods to minimize any such environmental effects are described as follows:

1. Releases to the Atmosphere

a. Agent Vapours

There is potential for release of small quantities of agent vapour during the opening and chemical destruction operations. These operations will usually be conducted in an isolated building on the disposal site. This building will be equipped with a recirculating fume hood and, if possible, an air duct which is integrated into the air inlet system of the incinerator, located nearby. In this latter case, all air in the building is drawn through the fume hood and into the incinerator before release to the atmosphere. This will create a slight negative pressure in the building to further prevent vapour from escaping. Usually, the opening/chemical destruction operations would be conducted concurrently with thermal destruction operations. The recirculating filter installed in the fume hood will permit some opening operations to be conducted before the incinerator is installed or when it is not operating. Both the filter element and the incinerator have a capacity which far exceeds that required to contain any agent vapour which would be released should an accidental spill occur while opening a container. The floor of the chemical destruction building will be lined with impermeable chemical resistant plastic to which decontaminant can be poured should such a spill occur.

During priority chemical destruction operations, such as the Shaped Charge Method (Annex C) agent liquid/vapour will normally contact decontaminating solution before any release to the atmosphere occurs. In-container incineration of this solution will produce CO_2, H_2O and some acid gas releases in small quantities for each disposal event. For operations involving pumping or siphoning, decontaminating solution is utilized to react with the liquid stream and to destroy toxic residue in the container. This solution will be immediately available in the vicinity of the liquid transfer equipment should a leak occur.

For containers where fill identification is required, the sample acquisition hole will be immediately fitted with a plug to prevent agent vapour release.

Instrumentation such as the Chemical Agent Monitor and MIRAN Gas Analyzers will be employed to continuously monitor the air

ANNEX H
TO SUFFIELD SPECIAL PUBLICATION NO. 125
DATED NOVEMBER 1988

in close proximity to the opening/chemical destruction operations. As a final measurement, air samples will be continuously and automatically collected and analyzed around (downwind) of these operations and the incinerator(s) during disposal operations.

To further enhance personnel safety and reduce the possibilities of agent release, all operations including agent destruction will be conducted during daylight hours only, with maximum allowable temperatures and windspeeds of 35°C and 30 km h^{-1}, respectively. These conditions and the wind direction will be monitored continuously using a portable, automatic recording meteorological station.

During agent transport from waste holding sites, a number of safety precautions are observed, including the following:

i. agent-filled containers, especially those which might conceivably develop leaks during transport, are secured in a second container;

ii. EPG road closures are instituted and enforced near and along the route;

iii. vehicle escort is provided, normally with medical assistance/ambulance included.

.../H-4

ANNEX H
TO SUFFIELD SPECIAL PUBLICATION NO. 125
DATED NOVEMBER 1988

During transport, accidental spills from sealed containers are highly unlikely. However, should a primary container rupture (leak), due to, e.g. a vehicle crash, agent vapour would be released and dispersed downwind. The downwind dosage at a 10 km distance will be below the "no effects" level for nerve agents and mustard (8) (assuming "worst case" instantaneous release of approximately 0.5 kg of agent) if the following additional conditions are observed during transport operations:

i. atmospheric lapse condition of −1°C or greater measured at 0.5 and 4.0 m heights,

ii. wind in excess of 3 m sec^{-1} (10 km h^{-1}).

b. Incinerator Emissions

Incinerator emissions such as HCl, SOx, NOx, CO, etc., as well as steam opacity and particulate matter will be within regulatory guidelines. Adherence to the regulations will be the responsibility of the company which supplies and operates the incinerator(s).

2. Liquid Wastes from Operations

Where chemical destruction is used, the agents will be decontaminated using alkaline hydrolysis methods (alcoholysis). The amount of decontaminating solution required for each agent and the reaction time have been determined (1,7).

The used solutions are not potable due to the salts and other products present. These solutions will not be discharged to any body of water, land-filled or re-used. Waste solutions will be temporarily stored in containers or in a large holding tank.

Incinerators which utilize wet-scrubbing techniques for emissions control may produce large quantities of acidified salt water unless a recycling method is incorporated into the system to reduce the water content. This effluent will be contained in a holding pond where water will be returned to the atmosphere by evaporation. The residual salts and acids are compatible with the alkaline soil prevalent in the area and could be re-introduced into the thermal destructor for slagging with the metal waste.

3. Solid Wastes From Operations

Waste material such as used drill bits, siphon tubes, pipettes, rubber gloves etc., will be placed in suitable containers for disposal by incineration. The scrap metal thermal destruction will produce metal pellets or slag which is acceptable for land-filling either at DRES or a commerical land-fill site. This metal residue may contain small amounts of arsenic or other metallic elements in alloy form with iron; these alloys are safe to handle and dispose of by land-filling. The metal slag may also be suitable as feedstock for steel mills or metal refining operations.

.../H-6

ANNEX H
TO SUFFIELD SPECIAL PUBLICATION NO. 125
DATED NOVEMBER 1988

Contaminated soil destroyed by incineration will be in the form of silicate residue (glassy sand) which can be safely land-filled or spread on the surface of the ground.

SECURITY CLASSIFICATION OF FORM
(highest classification of Title, Abstract, Keywords)

DOCUMENT CONTROL DATA

(Security classification of title, body of abstract and indexing annotation must be entered when the overall document is classified)

1. ORIGINATOR (the name and address of the organization preparing the document. Organizations for whom the document was prepared, e.g. Establishment sponsoring a contractor's report, or tasking agency, are entered in section 8.)

Defence Research Establishment Suffield
Ralston, Alberta, Canada, TOJ 2NO

2. SECURITY CLASSIFICATION (overall security classification of the document including special warning terms if applicable)

3. TITLE (the complete document title as indicated on the title page. Its classification should be indicated by the appropriate abbreviation (S,C,R or U) in parentheses after the title.)

Operation SWIFTSURE. A Plan for disposal of waste held on the experimental Proving Ground(U)

4. AUTHORS (Last name, first name, middle initial. If military, show rank, e.g. Doe, Maj. John E.)

McAndless, John M.
Gray, Alan H.
Coffey, Clayton G.

5. DATE OF PUBLICATION (month and year of publication of document)

December 1988

6a. NO. OF PAGES (total containing information. Include Annexes, Appendices, etc.)

66

6b. NO. OF REFS (total cited in document)

11

6. DESCRIPTIVE NOTES (the category of the document, e.g. technical report, technical note or memorandum. If appropriate, enter the type of report, e.g. interim, progress, summary, annual or final. Give the inclusive dates when a specific reporting period is covered.)

Suffield Special Publication

8. SPONSORING ACTIVITY (the name of the department project office or laboratory sponsoring the research and development. Include the address.)

9a. PROJECT OR GRANT NO. (if appropriate, the applicable research and development project or grant number under which the document was written. Please specify whether project or grant)

Project SWIFTSURE

9b. CONTRACT NO. (if appropriate, the applicable number under which the document was written)

10a. ORIGINATOR'S DOCUMENT NUMBER (the official document number by which the document is identified by the originating activity. This number must be unique to this document.)

SSP NO. 125

10b. OTHER DOCUMENT NOS. (Any other numbers which may be assigned this document either by the originator or by the sponsor)

11. DOCUMENT AVAILABILITY (any limitations on further dissemination of the document, other than those imposed by security classification)

(X) Unlimited distribution
( ) Distribution limited to defence departments and defence contractors; further distribution only as approved
( ) Distribution limited to defence departments and Canadian defence contractors; further distribution only as approved
( ) Distribution limited to government departments and agencies; further distribution only as approved
( ) Distribution limited to defence departments; further distribution only as approved
) Other (please specify):

12. DOCUMENT ANNOUNCEMENT (any limitation to the bibliographic announcement of this document. This will normally correspond to the Document Availabilty (11). However, where further distribution (beyond the audience specified in 11) is possible, a wider announcement audience may be selected.)

Unlimited

13. ABSTRACT (a brief and factual summary of the document. It may also appear elsewhere in the body of the document itself. It is highly desirable that the abstract of classified documents be unclassified. Each paragraph of the abstract shall begin with an indication of the security classification of the information in the paragraph (unless the document itself is unclassified) represented as (S), (C), (R), or (U). It is not necessary to include here abstracts in both offical languages unless the text is bilingual).

(U) A plan is described for the disposal of waste materials currently held at protected sites on the DRES Experimental Proving Ground. The plan is based upon a disposal system which utilizes both chemical and thermal destruction technology.

(C) Chemical destruction will be employed for the disposal of highly toxic chemical warfare agents while all other materials, including the detoxified waste from the chemical destruction operation, will be subjected to thermal destruction (incineration). With certain incineration technologies available, it may be possible to dispose of vesicant chemical agents by direct incineration. Critical altarnative methods will be employed to deal with small numbers of explosive-containing items which present an extreme safety hazard. //

14. KEYWORDS, DESCRIPTORS or IDENTIFIERS (technically meaningful terms or short phrases that characterize a document and could be helpful in cataloguing the document. They should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location may also be included. If possible keywords should be selected from a published thesaurus. e.g. Thesaurus of Engineering and Scientific Terms (TEST) and that thesaurus-identified. If it is not possible to select indexing terms which are Unclassified, the classification of each should be indicated as with the title.)

Chemical warfare agents
Chemical destruction
Thermal destruction
Demilitarization
Defence Research Establishment Suffield