Ontario Hydro

PROPOSED SCOPE FOR DEVELOPMENT OF AUTOMATIC AND REMOTE PROCESSING OF CONTAINERS FOR DISPOSAL OF USED FUEL

Report No 85-8-K

B. Teper
Engineer
Applied Structural and Solid
Mechanics Section
Mechanical Research Department

RESEARCH

91602
new 82-10

ontario hydro
research division

PROPOSED SCOPE FOR DEVELOPMENT OF AUTCMATIC AND REMOTE PROCESSING OF CONTAINERS FOR DISPOSAL OF USED FUEL

Report No 85-8-K

B. Teper
Engineer
Applied Structural and Solid
Mechanics Section
Mechanical Research Department

ABSTRACT

Several containers are being developed for isolation and disposal of used fuel from CANDU reactors. Tests have been conducted to show their satisfactory performance, including structural strength, corrosion resistance and so on. To demonstrate the feasibility of using these containers for disposal, it is necessary to demonstrate that the containers can be assembled remotely, using highly automated equipment (with manual override). Preference will be given to the established technology to limit the amount of developmental work in robotics and to ensure that the proposed system offers a reliable solution. The project has been approved for 1985. A long-term project is being proposed here to demonstrate the viability of the remote handling system. Interim reports will be issued for the engineering assessment and feasibility stages.

job	file	date	report no.
740621-111-461	825.94	April 19, 1985	85-8-K

ontario hydro research division

EXECUTIVE SUMMARY

PROPOSED SCOPE FOR DEVELOPMENT OF AUTOMATIC AND REMOTE PROCESSING OF CONTAINERS FOR DISPOSAL OF USED FUEL

B. Teper
Applied Structural and Solid Mechanics Section
Mechanical Research Department

A large, long-term project is being proposed to demonstrate the viability of remote assembly and handling of various containers for immobilization and disposal of used fuel from CANDU Nuclear Generating Station using automation and robotics. Although the demonstration will be carried out on the thin-walled, particulate-packed container, to allow for a detailed, container-specific study, the concept will be generalized to all other disposal containers. The project will cover handling of the fuel at the disposal site from opening of the transportation overpack through storage, immobilization assembly and storage prior to the final vault emplacement.

The project is large and is expected to continue for several years. Funding for the project has already been approved for 1985. Extension is planned for 1986. Over the full duration, both, engineering study and small scale demonstration are planned. Two interim reports will be issued to communicate the progress on the project in preparation for the engineering assessment and the feasibility stages of the used fuel disposal program.

To minimize the cost of the project, readily available technology will be utilized where possible. For example, hard automation might be given preference over robotics, if it can be shown to fulfill the requirements. Ontario Hydro's and AECL's past experience in the areas of fuel handling and robotics will be utilized to the maximum extent.

job	file	date	report no.
740621-111-461	825.94	April 19, 1985	85-8-K

TABLE OF CONTENTS

NOMENCLATURE

AECB	- Atomic Energy Control Board
Back End of Fuel Cycle	- part of the fuel cycle from the removal of the fuel from a reactor to its disposal or reprocessing.
Bristol Container	- synonymous with particulate-packed, structurally-supported container designed by Bristol Aerospace Limited for AECL
Container	- a receptacle used for the encapsulation of nuclear fuel waste prior to disposal
Disposal Facility	- a facility used to emplace or discharge waste materials with no provision for retrieval (for example an underground disposal vault and its supporting facilities)
Disposal System	- a disposal facility and the transportation facilities needed to bring nuclear fuel wastes from the interim storage sites to final disposal.
Fuel Immobilization	- Placement of used fuel in a sealed container for the purpose of disposal.
Ontario Hydro Container	- synonymous with Thin-Wall Particulate-Packed Container
OHRD	- Ontario Hydro Research Division
TWPP Container	- Thin-Wall, Particulate-Packed Container
Used Fuel	- Fuel extracted from a reactor at the end of its useful cycle.

WRNE - Whiteshell Nuclear Research Establishment, a division of AECL located at Whiteshell Manitoba.

ontario hydro
research division

To Mr. F.J. Kee
Director of Research

PROPOSED SCOPE FOR DEVELOPMENT OF AUTOMATIC AND REMOTE PROCESSING OF CONTAINERS FOR DISPOSAL OF USED FUEL

1.0 INTRODUCTION

From several discussions between WNRE and Ontario Hydro personnel, a new project is being initiated to demonstrate our ability to remotely and safely assemble and handle various containers for immobilization of used fuel from CANDU Nuclear Generating Stations. Effort will be made to determine if technology already exists to perform the required tasks reliably. Certain amount of developmental work is expected to be required. This report proposed the scope of the project for information and further discussion.

Several container conceptual designs have been proposed by AECL for the immobilization and disposal of used fuel from CANDU Nuclear Generating Stations. The following concepts are being developed.

1. Stressed shell - a thick, metallic, corrosion resistant container.

2. Metal matrix - a thin-wall, metallic, corrosion resistant container, filled with cast metal (such as lead) for support.

3. Thin-wall, particulate-packed container (TWC) - a thin-wall, metallic container, filled with a granular material for support.

4. Structurally supported, Particulate-Packed Container - a thin-walled metallic container filled with a granular material which transfers external loads from the shell to a strong basket.

5. An additional container having thin, corrosion protective shell supported by a thick, steel canister is also being considered, as an alternative to the stressed shell design.

These containers are illustrated in Figures 1 through 5.

All of the above container concepts are being studied for the Concept Assessment Phase of the Canadian Nuclear Fuel Waste Management Program. The development effort includes welding and weld inspection programs, corrosion studies, stress analysis and a prototype test program. Prototypes of the first four containers were built, assembled (without fuel or using simulated bundles) and hydrostatically tested. The hydrostatic tests showed that all containers have an adequate short-term, mechanical strength.

When used fuel is introduced, the containers will have to be assembled and handled remotely. A technical and economic evaluation of the automatic equipment and operations is needed for each of these concepts in preparation for the Concept Assessment and Feasibility Assessment Stages.

The project discussed in this report will address the problems of remotely handling the used fuel, assembling and handling the containers. A comprehensive project on remote handling could not be completed in time for the Concept Assessment stage, given the currently available resources. To allow for a reasonable engineering judgement to be made regarding the viability of the remote handling system during the assessment stage, the project will be divided into several stages, as discussed in Section 6.

It is proposed that the project be conducted under the technical coordination of the Mechanical Research Department.

2.0 AIM AND SCOPE OF THE PROJECT

The proposed project is aimed at demonstrating a methodology for assembling and handling each of the above five containers. The project will be conducted in three stages. The first two will be engineering studies aimed at determining whether technology already exists, or could be developed, to successfully assemble and handle the containers. These stages are scheduled to be completed by March 1987. In the third stage, construction of a scaled demonstration facility is being considered, either for a few more complex operations or for the complete assembly line.

Mechanical Research intends to conduct a conceptual study only. Our role in the project will likely be to determine what equipment is required and how it could be integrated into a smooth, safe and reliable assembly line. Close contact will be established with potential equipment suppliers during the early stages of the project. It is anticipated that all or most of the required equipment will be purchased externally, for the demonstration phase and/or the full scale disposal operation.

Fuel handling will be considered from the moment when transportation vehicle arrives at the disposal site to the storage of fully assembled containers. The following steps will be included:

- Operation of the front-end fuel consolidation facility.
- Maintaining records of the processed fuel including determination of bundle serial numbers.
- Placement of fuel in containers
- Assembly of containers, including welding
- Decontamination and inspection of containers
- Processing of containers failing manufacturing inspection
- Operation of the storage facility for assembled containers.

3.0 MAIN STEPS

The feasibility of the automated, remote assembly and handling of containers will be illustrated for a single container design: the thin-walled particulate-packed container. Automation needed for other container designs will be implied by comparison and by limited engineering studies. The main steps in the container assembly are similar for all containers. Many of those steps were outlined in Mr. L. Crosthwaite's letter to Mr. B. Teper, enclosed in Appendix A. These steps consist of:

1. Reception and unloading of used fuel modules from transportation casks.
2. Storage of modules containing fuel in front-end storage facility.
3. Recording of each bundle manufacturer, ID number, and γ radiation level, for inventory control (tentative).
4. Loading of the bundles into baskets.
5. Placing loaded baskets into containers.
6. Filling containers with the structurally supportive material, eg, granular material, plugs or molten metal (depending on container design).
7. Installing containers' lids.
8. Closure welding.
9. Ultrasonic and helium leak inspections.
10. Decontamination
11. Handling outside the hot-cell to interim (back-end) storage.
12. Repair or reopening of containers which have failed inspection, including retrieval of bundles and replacement in new containers.

4.0 HOT-CELL AND EQUIPMENT DESIGN

A detailed hot-cell layout will be prepared including proposed positioning of equipment, as a part of the project. An effort will be made to design the hot-cell to be as small as possible, to minimize cost. However, the size of the hot-cell will be determined by the size of the containers and by the space required for: container assembly, equipment used in assembly and for equipment maintenance.

Two types of automatic or robotic equipment will be investigated:

(a) dedicated equipment designed to perform specific operations.

(b) secondary equipment used to monitor and maintain the facility including clean-ups and carry video cameras to required locations. This equipment will also assist in treatment of containers which failed inspection and in equipment repairs.

The function of primary, dedicated equipment will be determined from the detailed analysis of activities (motion studies). Its operation will be automated to the fullest extend needed or possible (computerized). Manual override will be provided on all automated operations. The equipment will have a modular design. This will allow for easy disassembly for maintenance or replacement.

The maintenance (secondary) equipment is expected to consist of mobile, remotely controlled robots or manual equipment which prime function will be to maintain the hot cell. Certain, repetitious operations of this equipment will likely be computerized. Most secondary operations will be performed by remote manual control.

5.0 PERSONNEL INVOLVEMENT

The project will be administered jointly by:

(a) Nuclear Materials Management Department in project administration, monitoring, funding and technical assistance.

(b) Mechanical Research Department in technical coordination and technical responsibility.

(c) The progress on the project will be monitored by AECL.

Ontario Hydro and AECL expertise in the area of robotics and handling of nuclear materials will be reviewed. The most suitable and available personnel will be consulted in the following areas:

- remote manipulator design
- computer hardware
- software development
- feedback and control
- hot-cell design
- interim storage design
- decontamination
- radiation protection
- remote welding and weld inspection.

and so on, to assist us in this project.

6.0 PROPOSED SCHEDULE AND BUDGET

The proposed project is large and highly diversified. The schedule for this project will consist of three stages (time intervals). For the purpose of this proposal, the project is subdivided into ten groups of activities:

Stage 1 - Engineering Assessment - to be completed by April 1, 1986.

1. Project initiation - allows for the development of ideas on the scope, the requirements and the available expertise, for the project.

2. Equipment evaluation - all processes (tasks) associated with assembly and/or handling of bundles, containers and associated equipment (eg, particulate or basket) will be identified. The equipment required to perform the tasks will be conceptualized including the initial hot cell layout.

An interim report will be issued for this stage.

Estimated cost of this stage is $70,000. Funding of $50,000 has already been approved.

Stage 2 - Feasibility Assessment - to be completed by April 1, 1987.

3. Hot-cell design - a detailed evaluation of the quality and the quantity of the primary equipment required to facilitate the prespecified production rate of containers efficiently. Some consideration will be made to determine the range of the cost for the automated system.

An interim report will be issued for this stage.

Estimated cost of this stage is expected to reach $90,000.

Stage 3 - Demonstration Facility - long-term project proposed to start in 1986.

4. Hot-cell, back-up facilities and secondary, maintenance equipment will be proposed including facilities for inspection, decontamination and storage for defective equipment.

5. Remote operation and control will be maintained by a computer controlled operating system..

6. Economic studies - a proposal will be prepared including estimates of equipment costs.

7. System demonstration - small scale laboratory simulation. The extent of the demonstration facility will be determined later.

8. System optimization for the full scale operation.

9. System reliability - define: maintenance requirements, both periodic and unscheduled; spare parts inventory; estimate of frequency and duration of outages.

10. Quality Control - set up procedures for equipment performance parameters, equipment inspections, monitoring equipment, material accounting, etc.

11. Summary Report.

Funding for Stage 3, will be determined later, depending on the detailed scope of this stage.

Figure 6 lists all presently planned activities for stages 1 through 3 and their proposed time of execution. Many of the activities can be conducted simultaneously.

The project will be conducted in two separate phases:

(a) Engineering study consisting of activities 1.1 through 4.5 inclusive. This phase will be conducted between November 1984 and March 1987.

(b) Construction of the demonstration facility will start in January 1986 and will consist of activities 5.1 through 10.1.

The funding for years 1985 and 1986 could be obtained from two sources:

(a) Ontario Hydro (NMMD) funds under TAP: about $70,000.

(b) Ontario Hydro Research Division funds: about $50,000.

Source b is anticipated because of the innovative nature of the project and because of its possible other benefits to Ontario Hydro.

7.0 CONCLUSIONS AND RECOMMENDATIONS

A large project is being proposed with the intention of demonstrating the viability of remotely and automatically assembling and handling the containers for disposal of used fuel bundles. The project is proposed in two distinct phases: demonstration by engineering study and construction of a limited scale demonstration system. The first phase will be largely completed for the concept assessment stage in 1987. The second phase is longer and more expensive. Both phases are seen as necessary for the full demonstration because of the high level of complexity of the assembly process.

The project proposed in this report and the proposed robotics laboratory will have additional benefits to Ontario Hydro in terms of spin-off applications to other activities within Ontario Hydro.

We recommend that the project should be approved as defined in this report. Since the project was started late in comparison with all other aspects of the used fuel disposal program, we recommend that the project should be given high priority, appropriate funding and technical support (manpower) to ensure its expedient progress.

ACKNOWLEDGEMENTS

This report was prepared as a result of the author's discussions with Mr. L. Crosthwaite of AECL, Mr. J.M. Cipolla and Dr. J.D. Tulk of Ontario Hydro. Messrs J.L. Crosthwaite, L.J. Hosaluk

and J.A. Chadha provided detailed review and critique of the report. The author acknowledges and thanks them for their contribution.

Approved:

G.J. Clarke
Manager
Mechanical Research Dept

Submitted:

B. Teper
Engineer
Applied Structural and
Solid Mechanics Section

Reviewed by:

J.A. Chadha
Section Head
Applied Structural and
Solid Mechanics Section

BT:ljh

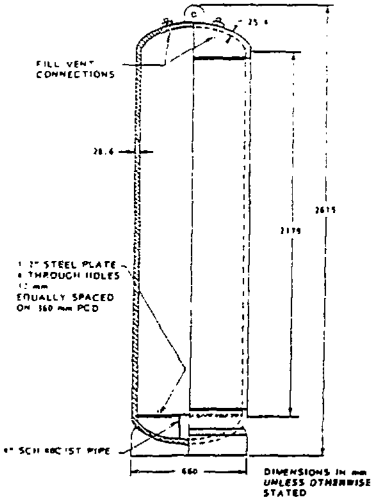


FIGURE 1

DESIGN DETAILS OF THE STRESSED SHELL PROTOTYPE CONTAINER

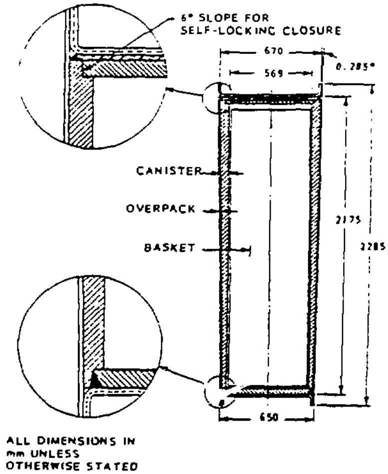


FIGURE 2

ONE OF SEVERAL ALTERNATIVE STRESS SHELL DESIGNS

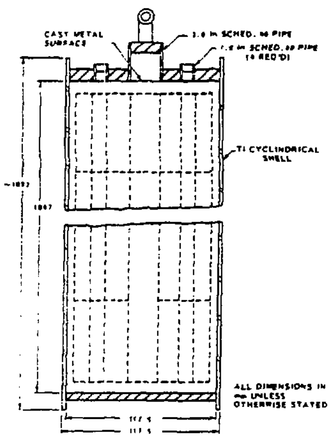


FIGURE 3

METAL INVESTED CONTAINER

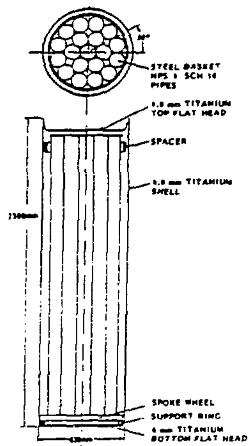


FIGURE 4

PARTICULATE-PACKED THIN WALL CONTAINER

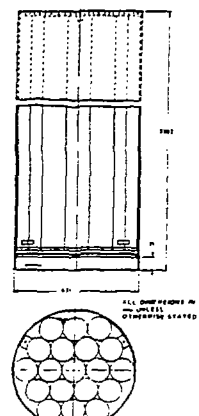
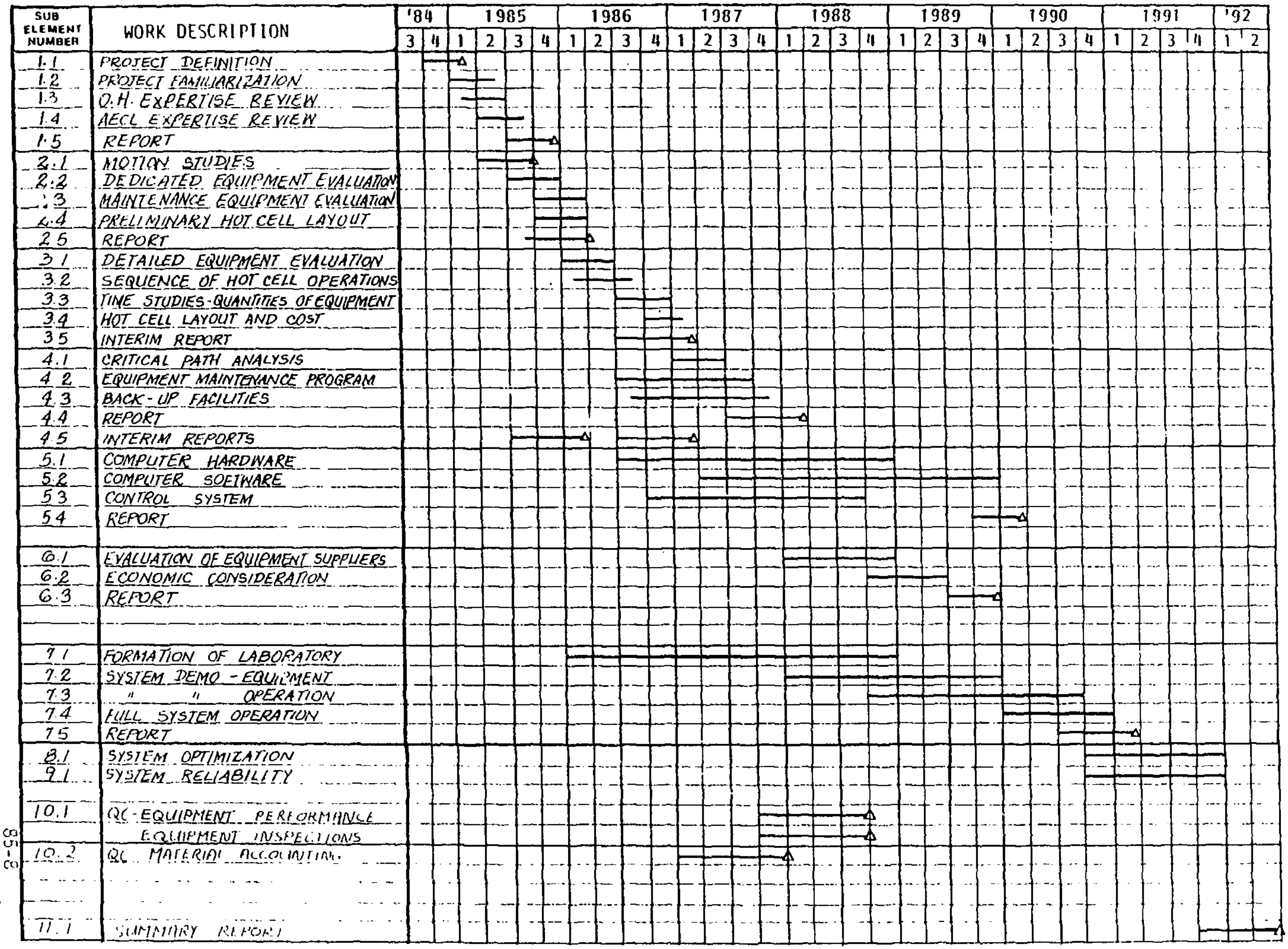


FIGURE 5

STRUCTURALLY SUPPORTED CONTAINER

FIGURE 6

PROPOSED PROJECT SCHEDULE



Δ Report

85-8
166749 RD

Atomic Energy of Canada Limited
Nuclear Fuel Waste Management
Whiteshell Nuclear Research Establishment

L'Energie Atomique du Canada Limitée
Gestion des Déchets de Combustible Nucléaire
Etablissement de Recherches Nucléaires de Whiteshell

Pinawa Manitoba
R0E 1L0
Ph(204)753-2311

APPENDIX

FWTB-84-447
1984 November 06

Mr. B. Teper
Ontario Hydro
R289
800 Kipling Avenue
TORONTO, Ontario
M3Z 5S4

Remote Handling, Fabrication and Inspection of Fuel Isolation Containers

- Potential for an OH-TAP Contribution in 1985

Dear Bernie:

As I indicated I would, during our recent conversations in Toronto at the Conference on Remote Handling in the Nuclear Industry, I am writing to outline my ideas for a potential contribution by OH to identify and evaluate various methods for remote loading, assembly, handling and inspection of fuel isolation containers, in particular the packed-particulate concept developed by Ontario Hydro. I can identify, now, several distinct areas that will require remote capabilities and have itemized them here for your consideration.

1. Receipt of Used Fuel - Beginning at the head end, we will be required, of course, to receive fuel in a shielded flask and to remove it from the flask for loading into the container. If we assume the OH 96-bundle module will be used for shipping, then a remote operation to transfer from the 96-bundle rectangular configuration to the 72-bundle circular array within the immobilization container is required. At the same time, we may be required, for inventory control and IAEA Safeguards purposes, to identify all fuel bundles and the container identity into which they are being transferred. The following remote equipment would therefore be required for the receipt/loading operations:

a) Devices to remove the modules from the flask,
b) Devices to transfer from the 96-bundle configuration to the 72-bundle configuration,
c) A "reader" or character recognition device to recognize the fuel bundle end plate serial no. and manufacturer's logo, if the bundle is not already prior-identified by number and position in the shipping module. If it is prior-identified, a system to transfer this information

to the Fuel Immobilization Centre would be needed for feeding into a data base and accounting system. If the information must be read off a bundle end plate, then a device to clean the end plate of crud to make the identity visible may be required. If the identity is stamped on one end plate only, a device to recognize and present the bundle's identified end to the character-reading device would be needed.

2. Packaging of Used Fuel - Once the bundles have been identified and loaded into the pre-fabricated shell, devices to fill the container with particulate, vibratory compact it and to determine (by a weight check?) the degree of compaction would be required. As I will discuss later, a small helium source for a subsequent leak test may have to be inserted into the vibratory-compacted container prior to its final closure.

3. Container Closure - Once the container has been vibratory-compacted, the top lid must be fitted remotely and a remote closure weld performed. The type of closure weld selected will, of course, dictate the remote welding device configuration. TIG or similar type welds may require seam-tracking capability, multiple-pass welds may require inter-pass cleanups. A diffusion bond type weld may be simpler in that an edge roll-around device might be used, eliminating the seam-tracking requirement.

4. Container Inspection - The most probable inspection technique envisioned now is ultrasonic. This would require movement of ultrasonic probe and detection equipment around the weld, or moving the weld in front of the probe/detector system.

A final leak check will likely be required. It seems probable that a helium leak detection device may be selected as the most sensitive for our requirements. One concept could be to emplace a helium source device into the container, prior to fitting the lid and performing the final closure weld. This could be a small cartridge of helium with a pre-timed device designed to open it inside the closed container, at the same time emitting a signal that the cartridge had indeed opened. Such a signal could possibly be audible (say, a beeper), detected by a sensitive microphone near the container. Once the helium was known to have been released into the container, a He leak detection device could be moved around the closure welds to determine if any were seeping from manufacturing flaws that had gone undetected by the ultrasonic procedure.

5. Container Rejection & Repair - Some containers will fail inspection and will either have to be repaired or the fuel removed for re-canning. Devices to remove and repair all, or portions of the closure weld will be required. In extreme cases, the entire fuel and particulate load may have to be removed and installed in a new container and the procudures from that point repeated.

6. Final Handling/Dispatch - Once a container has passed inspection, it must be transported to a buffer storage facility from where it will be further handled for transportation to the disposal site. Heavy-duty remote operations equipment will be required for these functions.

...3

As I foresee this study, it could form a basis for identifying, for a particular container design (in this case, the packed-particulate type), the existing remote technology that could be adapted for the various functions required or, if the technology does not currently exist specifically, those developments necessary to accomplish such remote operations. Although the study will be oriented toward a specific container design, reference could be made to those remote operations common o other designs (eg: structurally supported, metal matrix) and how such operations might be adapted to these other designs.

In a broader sense, a case-specific study, such as you outlined in your work package proposal, is ideal in that it would provide a firm example of the requirements and status of remote handling, fabrication and inspection equipment, nto which a wider-ranging discussion of the topic could be based. To this end, I would propose that your final report on the study be used as both a reference and a part of a broader-range document discussing the whole question of remote technologies required for fuel waste immobilization.

I trust this will provide you with an indication of my perceptions of the scope and necessity of the proposed study and I look forward to a further collaboration with you in the future.

J.L. Crosthwaite
Fuel Waste Technology Branch

/lm

cc: K. Nuttall
L. Hosaluk