FULL SCALE TESTS ON REMOTE HANDLED FFTF FUEL

ASSEMBLY WASTE HANDLING AND PACKAGING

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ABSTRACT

Handling and packaging of remote handled, high activity solid waste fuel assembly hardware components from spent FFTF reactor fuel assemblies have been evaluated using full scale components. The demonstration was performed using FFTF fuel assembly components and simulated components which were handled remotely using electromechanical manipulators, shielding walls, master slave manipulators, specially designed grapples, and remote TV viewing. The testing and evaluation included handling, packaging for current and conceptual shipping containers, and the effects of volume reduction on packing efficiency and shielding requirements. Effects of waste segregation into transuranic (TRU) and non-transuranic fractions also are discussed.

BACKGROUND

HEDL studies on disposal of remote handled breeder fuel assembly wastes for both the Process Facility Modification (PFM) project at PUREX and the Breeder Reprocessing Engineering Test (BRET) at HEDL showed that remote handled waste disposal costs under current concepts could be very expensive. With this in mind, tests were undertaken to evaluate handling and packaging the individual waste components within the cell and to determine the packaged volume of disassembled breeder fuel hardware components. At the same time it was recognized that volume reduction or efficient packaging of these wastes could further increase shielding requirements for an already high activity waste source. The results of these tests and evaluations are presented in the sections which follow.

This report is concerned with handling and packaging of hardware waste components for in-cell, unsealed containers only. Sealing of these containers and subsequent loading into a shipping cask are not a part of the study. Remote handling of radioactive waste components was simulated through use of electromechanical manipulators (EMM), a shielding wall, and remote TV viewing.

TRU AND NON-TRU WASTE CLASSIFICATIONS

One of the particular areas of concern in remote handling and packaging is waste classification as transuranic or non-transuranic. TRU waste must be packaged for certification and ultimate storage in the Waste Isolation Pilot Plant (WIPP) or equivalent. Non-TRU wastes can be packaged for burial at local DOE sites.

If handled carefully, most spent fuel subassembly hardware waste might be classed as non-TRU. Disposal as non-TRU waste by burial is more economical and requires minimum handling compared to TRU waste which must be stored for long periods in special WIPP certified containers. Since DOE has the right to impose stricter rules or regulations,[1] waste management design must provide capability to package either TRU or non-TRU waste. Accordingly, demonstration of handling and packaging remote handled waste considered both TRU and non-TRU categories.

WASTE CONTAINERS

In order to demonstrate packaging of waste for the BRET head end main process cell (MPC), a multi-compartmented, six-position insert and a single-compartment insert were utilized for inner containment. The test procedure was to load hardware waste directly into the inserts. The loaded insert would be transferred to a decontamination cell. At this point, the insert with non-TRU waste would be placed in a disposable solid waste cask (DWSC) shown in Fig. 1 for transfer to burial. TRU waste, on the other hand, must be stored for long periods (up to 18 yrs out of reactor) to reduce surface dose to less than 100 R/hr or else special shielded containers will be required to reduce the dose to less than 100 R/hr for placement in WIPP. The respective containers are described in more detail as follows:

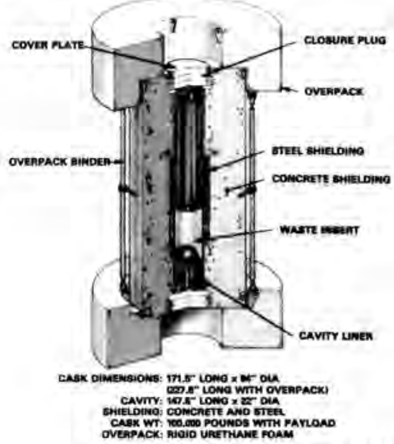

Fig. 1. Disposable Solid Waste Cask.

<u>DSWC Twenty-Six Inch Diameter, Six-Position Insert</u>

The DSWC[2] used for disposal of FFTF reflector assemblies and IEM cell wastes was considered for disposal of BRET non-TRU wastes for burial at Hanford. This cask has a 22-inch diameter cavity. Modification of the cavity diameter to 26.75 inches was recommended for two reasons:

1. To accommodate wastes in 55 gallon (200 liter) drums.

2. To accept a remote handled (RH) WIPP certified container[3] up to 26 inches in diameter and up to 8000 lb. gross weight for transfer to interim storage. In this case, the WIPP container would be stored at Hanford, and the DSWC returned to BRET for reuse. The cavity ID for a WIPP container (Fig. 2) can be variable as long as the container OD and surface dose rate do not exceed 26 inches and 100R/hr respectively. A cavity ID slightly greater than 8 inches would be required for TRU transfer cans for BRET operations.

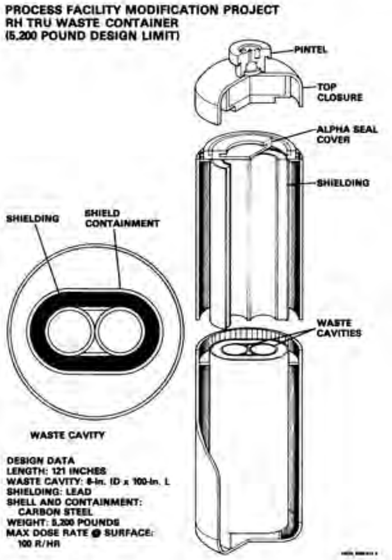

Fig. 2. RH TRU Waste Container.

The special 26-inch diameter, six-position insert shown in Fig. 3 was designed and constructed for demonstration of remote handling and packaging using a modified DSWC with a 26.75-inch diameter cavity (not yet designed).

Fig. 3. Demonstration 26-Inch Diameter DSWC Six Position Insert

Each wedge-shaped sector of the 26-inch diameter insert can easily accommodate all of the hardware waste including hulls from a spent FFTF fuel subassembly.

DSWC Single-Position Insert

Remote handling and packaging tests were also performed with a 19-inch diameter single-position insert (Fig. 4).

This closed, single-position DSWC insert was fabricated from drawings of the current design. The container is 140 inches long and 19 5/8 inches I.D. (Fig. 4). The insert is closed at the top with a bolted cover aligned with two guide pins. A handling socket type opening in the cover is used for transport. The container is prototypic except for ears welded to the side for support in the deck penetration.

Tests were carried out with a single, large-compartment insert to identify advantages and disadvantages compared to a multi-compartmented insert occupying essentially the same volume.

Fig. 4. Demonstration 19-Inch Diameter DSWC Single-Compartment Insert Packed with Slit Duct Sections

A principal disadvantage of a large-compartment, single position insert would be a tendency toward non-uniform loading since the waste components would not be as restricted in movement during the loading process. Non-uniform loading may possibly result in "hot spot" cask surface dose rates exceeding allowable limits.

TEST PROCEDURE

Station Arrangement

The waste containers described earlier were fabricated for remote handling and packaging tests. All packaging tests were performed at one of the remote test stations located in the Hot Cell Verification Facility at HEDL. These stations allow remote maintenance evaluations to be performed from behind a four foot thick simulated hot cell wall. The station is equipped with a prototype viewing angle window and a pair of master/slave manipulators.

Remote loading of waste components was performed with a bridge mounted electro-mechanical manipulator (EMM) as indicated by Fig. 5. A floor mounted television camera was used to provide a visual assist during the remote loading.

Both waste containers were provided with a 2.9 inch I.D. handling socket type opening for handling and transport. The handling socket design is compatible with the current fuel grapple.

Waste Components

Simulated Driver Fuel Assembly (DFA) waste components were fabricated for use during remote handling and packaging tests (Fig. 6). The waste components simulated mill and laser[4] dismantling scenarios. Mill dismantling resulted in two full-length, half-duct sections, an inlet shield assembly, a handling socket, and hulls. Laser dismantled waste consisted of three short, one-third duct sections, an inlet shield assembly, hulls and a handling socket with four feet of flattened attached duct.

Fig. 5. Remote Loading of Waste Components by Electro-Mechanical Manipulator

Fig. 6. Inlet Nozzle Waste Component and Simulated Component

No attempt was made to simulate any anticipated bow or twist in the duct section nor were leached hulls fabricated. When loading the waste from one complete assembly, the calculated hull volume of 0.47 cu. ft. was considered in determining container capacity.

Test Results

All remote loadings were performed with the EMM (Fig. 5). Loading tests were simplified by locating the insert vertically in a floor recess with the top of the insert at floor level.

Non-TRU Waste Loading Sequences

The manual insertion of mill generated DFA waste into the 26-inch diameter DSWC insert determined that one disassembled DFA would easily fit into each position of the insert. If loading were to be carried out during the disassembly sequence, waste from two DFA's plus one additional duct section could be loaded into each position. An alternate sequence of first loading all the duct sections from several disassembly operations followed by inlet shield assemblies and handling sockets allowed four complete assemblies to be loaded into one position of the container, including space for hulls.

It was found that ten duct sections followed by three shield assemblies and three handling sockets could be loaded remotely into one position of the 26-inch diameter, six-position insert.

Six complete assemblies were remotely loaded into the 19-inch diameter container leaving some space still available for additional waste. Load capacity of the single-position container is very dependent upon the sequence and orientation of components as they are dropped into the container. Smaller containers or containers with dividers allow better loading methods and inventory control.

Volume Reduction Packaging Tests

Loading was conducted to determine the container capacity for a specific waste component. Manual loading into one position of the 26-inch diameter container allowed as many as 22 disassembled duct sections to be loaded.

Six dummy inlet shield assemblies were loaded into a single storage position with space clearly available for at least four more. It was also found that 30 to 45 handling sockets could be accommodated. The number of inlet shield assemblies and handling sockets will vary considerably depending on the amount of duct still attached and their orientation after being dropped into the container.

Remote loading with the EMM allowed as many as 18 duct sections to be loaded into the bottom of a single storage position of the container.

Remote loading of the 19-inch diameter DSWC closed container determined that at least fifty duct sections could be loaded in the bottom. In addition, eight inlet shield assemblies or six shield assemblies and ten handling sockets could be added above the duct sections (See Fig. 7). As with the 26-inch diameter insert a four foot drop was required when loading the ducts.

In many instances during remote duct loading sequences, additional ducts could be inserted. However, as the containers approached capacity, more time was expended locating sufficient space to start an insertion. When the time became excessive it was then determined that the container was full and loading was terminated.

Some loading inconsistencies appeared during performance of the packaging tests. Because of fabrication inaccuracies caused by bowing of the position dividers and an out-of-round container barrel, some of the positions were larger than others. This difference in volume caused some differences in waste storage capability. It was also found during the manual and remote duct loading portions that more duct pieces could be loaded with the EMM than by hand. The weight of the EMM forcing the duct into a nearly full container tended to push the lower portions of the ducts apart allowing another to be inserted.

Fig. 7. Demonstration of Waste Packaging in DSWC Single Compartment Insert

Leached Hulls Packaging

A sufficient quantity of leached hulls were not available to allow filling of each container under test. However, the hulls from at least twelve assemblies will fit into one position of the 26-inch diameter container.

Dose Rates and Shielding

Surface gamma dose rates and shielding requirements were calculated for a modified FFTF Disposable Solid Waste Cask (DSWC) using the computer code QAD-P5A[5] for six DFAs, without fuel or pin hulls. The hardware sections from the DFAs were restacked vertically in their original sequence with the bottom of the DFA at the bottom of the cask. Axial distribution of the source term was divided into five major source segments. For waste packaging efficiency, the DSWC cavity inside diameter was increased to 26.75 inches to accommodate 55 gallon drums. Shielding requirements were calculated to reduce surface dose rates to less than the 200 mrem/hr surface dose rate design level. Calculations were completed for 5, 6, 7, 8, 9 and 10 cycle exposures with decay times of 1 and 1.5 years. (A cycle is defined as 30 days shutdown and 100 days at 400 MW). All source terms were based on hardware for the original type DFA.

Initial calculations showed surface dose rates to be excessive at the sides of the DSWC (Fig. 1). DSWC shielding was then modified to include a 3-inch thick full-length steel shield wrapped around the inner steel cavity plus a concentric outer shell of 23.67 inches of ordinary concrete and a protective 1/4-inch thick steel covering (total O.D. of cask = 84 inches). Top and bottom plugs of 12 inches of steel extend slightly beyond the 3-inch thick steel cavity shield (see Fig. 8).

All calculated gamma surface dose rates for the modified DSWC were below the 200 mrem/hr surface dose rate design level. The maximum calculated dose rate outside the DSWC with hardware from 6 DFAS (10 cycle burnup, cooled 1 year) was 114.9 mrem/hr at dose point 10 (height of 60 inches from the bottom of the cask). This is a reasonably conservative model which should allow some rearrangement of DFA components without exceeding the design level guideline. The extent of allowable rearrangements, however, would have to be determined.

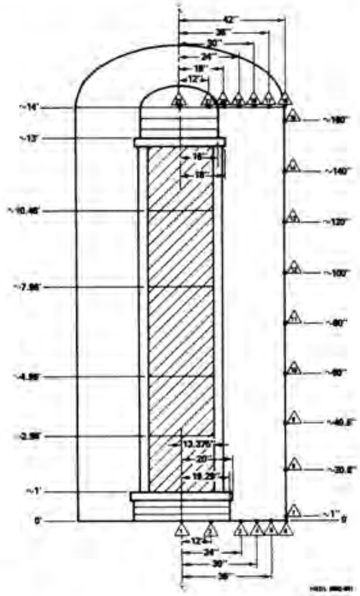

Fig. 8. Cross Section of Modified DSWC Showing 5 Segment Source Regions and 22 Surface Dose Points

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The following conclusions resulted from these tests and studies:

- A multi-compartmented waste container enables more uniform loading than a single, large compartment container. This type container will contain fewer "hot spots" and thus permits higher waste loadings without exceeding allowable surface dose rate limits.
- More waste can be stored in a divided container if the same type waste is stored together in each section.
- Increasing the DSWC diameter from 22 inches to 26 inches will provide a significant cost/unit volume advantage and will permit use of standard 55 gallon drums as inner containers for small components.
- The multi-component container costs slightly more to fabricate but it allows more waste in a given size container and better control of waste inven tory. It also reduces the time required for remote handling operations.
- The DSWC heat rating of 1500W should be adequate for multiple FFTF fuel assembly components provided sufficient decay period is allowed. For example

18 months to 2 years for 70,000 MWD/MTHM exposure fuel.

- Fuel disassembly techniques which maintain the assembly hardware as non-transuranic would save significant container, storage and shipping costs.

- Shielding modifications are required for the current DSWC design in order to keep surface dose reading below 200 mR/hr.

- Waste component positioning within the waste container and the DSWC shielding design both need to be optimized if maximum waste loadings are to be attained for very high activity waste.

Recommendations

- Consideration should be given to shorter inserts and associated DSWC's to accommodate such inserts when stacked one upon another. Waste components do not exceed 8 ft. and must be dropped into 12 ft. high inserts (or stand offs provided on the bottom to limit physical stress on the insert from loading). Some loading visibility is lost when positioning components several feet below the top of the insert.

- Volume reduction packaging tests showed that large quantities of the same waste component can be loaded into inner containers. It is recommended that cask surface dose rate studies be continued to optimize waste loadings without exceeding cask surface dose rate limits.

REFERENCES

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