RECYCLING AND BENEFICIAL REUSE OF CONTAMINATED LEAD FOR SHIELDED IP-1 CONTAINERS

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ABSTRACT

The West Valley Demonstration Project (WVDP) has initiated the reuse of contaminated lead generated across the U.S. Department of Energy (DOE) Complex for manufacturing into shielded containers. The 110-gallon (416-liter) overpack drums contain two inches (5.1 centimeters) of smelt-refined lead. The goals of contractor West Valley Nuclear Service Company's (WVNSCO) Waste Management Services group were to shield remote handled transuranic waste generated from decontamination and decommissioning, and provide an economical storage option for the waste pending acceptance at the Waste Isolation Pilot Plant (WIPP). To support accomplishment of these goals, this unique shielded container design was developed to shield 55-gallon (208-liter) drums with dose rates up to 50 R/hr, to meet on-site waste acceptance storage criteria for less than 200 mR/hr, and to eliminate the need for further reprocessing or repackaging operations pending disposal.

Implementation of the project included the development and use of a 110-gallon (416-liter) drum with an insert designed to accept a nominal two inches (5.1 centimeters) of poured, decontaminated lead along with a vented, shielded cap. As part of this technology deployment, the Oak Ridge Institute for Science and Education (ORISE) certifies the lead as recyclable based on sample analysis. The final product was offered for sale by Duratek Inc.

This paper will discuss the packaging challenges presented as a result of decomissioning efforts of two of the most highly contaminated cells along with the economics and challenges associated with design, fabrication, handling, and use of these shielded overpacks. The effort was coordinated with three commercial vendors, DOE-ORISE, DOE-WVDP, and WVNSCO.

BACKGROUND

Cleanup efforts at the West Valley Demonstration Project (WVDP) have shifted from the focus on high-level radioactive waste processing to decontamination and dismantlement (D&D) of the former nuclear fuel reprocessing plant. A portion of these D&D efforts are being focused on cleanup of the Head End Cells (HECs).

The HECs were originally used between 1966 and 1972 to mechanically prepare spent nuclear fuel (SNF) for chemical processing to recover uranium and plutonium. They are heavily shielded hot cells. Decontaminating these facilities required the repair and replacement of failed equipment, and retrieving, characterizing, processing, packaging, and storing loose debris.

The Head End Cells consist of two main cells: the Process Mechanical Cell (PMC) and General Purpose Cell (GPC). The mechanical process used in these cells involved receiving spent fuel from the Fuel Receiving and Storage Pool (FSP) and placing it on the PMC's size reduction tables. Pieces of spent fuel dropped through a chute into critically safe baskets in the GPC. The empty fuel hulls were then brought back into the GPC from the Chemical Process Cell and placed into a sorting hopper where samples were obtained. The empty hulls were moved up through a shielded hatch opening to the Scrap Removal Room (SRR), a buffer cell that allowed for personnel entry and removal of the hulls.

Through historical reports and upon an initial radiological survey of the cell, it was found that the HECs contain a significant quantity of loose debris generated during SNF recovery operations. As a result, the HECs were heavily contaminated with spent fuel, activation products, and fission product radio nuclides. Radiation levels in the HECs range from general area dose rates of 100 R/hr to hot spots of 2,000 R/hr. Both alpha and beta/gamma removable contamination levels are on the order of billions of disintegrations per minute. Therefore, all the cleanup work in the HECs must be performed remotely. The significant amount of loose debris discovered in the PMC and GPC consisted of general contaminated equipment and scrap from fuel and waste handling, fuel assembly hardware, leached fuel hulls, fine particles, miscellaneous fuel-bearing objects, and waste from the Analytical Cells. In addition to debris, water had infiltrated the GPC due to its below-grade location and created further damage to the cell and its equipment.

WASTE MANAGEMENT BASIS

In addition to the characterization and packaging issues for highly radioactive waste common throughout the DOE Complex, the WVDP also is not currently scheduled to ship TRU waste to WIPP. However because WIPP is the only facility in the nation licensed to receive TRU waste, the WVDP has prepared its waste to meet WIPP's Waste Acceptance Criteria (WAC).

Thirty-gallon (114-liter) containers were selected for packaging debris based on the size constraints of the HECs. The hatches between the hot cells had been sized to accommodate the transfer of 30-gallon (114-liter) containers, which are essentially the same as the scrap drums used during spent fuel reprocessing operations. The 30-gallon container offered the greatest degree of flexibility for over-packing into 55-gallon (208-liter) drums which could later be placed readily into the proposed RH-TRU 72B waste canister, or 10-160B cask for shipment.

As the cell cleanup efforts progressed, the dose rates of the packages began to increase. Initial drums were loaded with general combustible waste using the small tooling that was readily available. These drums were low dose (<500mR/hour) and could be placed in outer shipping containers using hands-on methods. One of the chief considerations for safe completion of cleanup work was limiting radiological exposure to workers. It was important to evaluate the criticality potential of the spent fuel-related debris and arrive at the most effective and efficient way to collect and package it. As a result of the dose rates, special shield containers were needed to remove the waste from the cells for placement into storage.

DECIDING THE PATH FORWARD

The criteria for packaging the highly contaminated waste consisted of two primary criteria. The first was to package the waste to meet WIPP's established contact-handled (CH) criteria and proposed remote-handled (RH) criteria. The second was to meet the WVDP's on-site waste storage criteria of <200mr/hr for waste containers stored in facilities for future off-site shipment.

Traditional lead or steel shield containers were initially considered and used at the start of the project. These costs ranged from $7,000 to $10,000. Due to the length of the cleanup efforts and volume of waste to be generated, this was an expensive undertaking to complete the project.

Subsequent searches led us to a program sponsored by the Department of Energy - Oak Ridge Institute of Science and Education (ORISE) for directed reuse of lead in shielding products.
The program was developed to find a use for the DOE Complex's hundreds of thousands of pounds of contaminated lead.

Duratek Inc. was selected as the vendor to provide the means of developing a container with shielding made of smelt-refined lead and to provide the finished product at a significantly reduced cost.

The container selected by WVNSCO for use was a 110-gallon (416-liter), 1A2/Y409/S, drum. The overpack drum would need to package and shield DOT 7A, Type A 55-gallon (208-liter) drums containing transuranic and/or high-activity waste.

Fig. 1

DESIGN BASIS

A purchase order and specification were prepared by WVNSCO and placed with GTS Duratek Inc. to fabricate 10, two-inch (5.1-centimeter) lead-lined drums. Duratek selected Skolnik Industries to manufacture the 110-gallon (416-liter) drums and Bull Run Metal Fabricators to perform the modifications to the drum for the shielding. Duratek would perform the smelting operations for placement of the lead in the drum as shielding.

The inner cavity or space was set at 25.75 inches [diameter] by 35.50 inches [height] usable space (66 centimeters by 91 centimeters) in order to accommodate a UN 1A2, 55-gallon (208-liter) drum with headroom for a Nucfil filter centered in a Rieke flange on top of a 55-gallon (208-liter) drum. The inner control liner wall is 10 gauge carbon steel.

CAVITY

The interstitial space between the inner control liner wall and the inside of the drum wall was set at a two-inch [nominal] cavity (5.1 centimeter). This space is then filled with poured-in-place molten lead. In order to minimize void spaces during the pouring process, a target weight (of lead) was established based on the internal volume of the cavity. This target weight, along with probing and agitating the lead to release trapped gases, ensured that a 90 percent lead fill was achieved between pouring campaigns and shrinking of the lead as it cooled.

The lead was poured through three access ports in the bottom of the 110-gallon (416-liter) drum. The inner control liner was designed and fabricated to prevent radiological contamination of the lead. Once the pouring process was completed, the three access ports on the bottom of the drum were sealed in place with metal caps welded over the openings. This also prevented re-contamination of the lead.

SHIELD CAP

The shield cap consists of two-inch-thick (5.1-centimeter) lead encapsulated in carbon steel. The shield wall/cap interface was labyrinthined to minimize radioactive shine. External lifting eyes/D-rings were supplied on the shield plug. The shield cap can than be bolted in place, with a means of venting the internal cavity that holds the vented 55-gallon (208-liter) drum. In order to avoid damage or destruction of a neoprene or rubber gasket and to facilitate venting the inner cavity, a rolled Z-bar was developed to form the mating surface between the drum shield body and the shield cap. This consisted of two pieces of 3/16-inch or 1/4-inch-diameter by 39-3/4-inch-long (bar stock welded to the inner liner. When welded in this position, these two 'beads' of metal leave two approximately one-inch gaps, located 180 degrees from each other, to act as vent paths from the inner storage area to the area between the shield cap and the 110-gallon (416-liter) drum lid. Once sealed in place the outer lid of the 110-gallon drum is bolted in place as originally designed. The 110-gallon (416-liter) drum lid also contains a 3/4-inch NPT Rieke flange that will accept a Nucfil filter.

The final product was certified as an Industrial Package 1 container by GTS Duratek.
For DOE-ORISE’s portion of this project, a certification letter from the DOE is provided for the drums. DOE’s basis for this is lead released by the DOE for “directed reuse” (e.g., determined to meet authorized surface release limits as defined in DOE Order 5400.5, “Radiation Protection of the Public” or as augmented by ORNL/TM-2001/36, “Supplemental Limits for the Directed Reuse of Lead in Shielding Products by the Department of Energy”) shall be employed in pouring the lead. Lead recycled in this manner is not considered in violation of the Department of Energy’s moratorium on contaminated metals, since it is returned to a licensed facility. Duratek performs sampling of the lead during pouring operations, performs preliminary analysis, and then provides these wafer coupons to ORISE for their certification analysis. ORISE performs the additional analysis, which is funded by DOE Oak Ridge Operations and typically costs between $1400 to $1800 per drum. Table I below contains typical gamma spectroscopy values of the wafer coupons.

Table I

RADIONUCLIDE	**Activity Bq/gm**
Ag-110M	5.552E-02
Co-58	6.202E-02
Co-60	7.912E-02
Cs-134	5.245E-02
Cs-137	6.940E-02
Eu-152	5.397E-01
Eu-154	2.089E-01
Fe-59	1.194E-01
Mn-54	5.788E-02
Nb-94	6.214E-02
Nb-95	5.463E-02
Ru-103	5.492E-02
Ru-106	5.897E-02
Sn-113	7.865E-02
Sb-125	1.719E-01
Zn-65	1.323E-01
Zr-95	1.228E-01

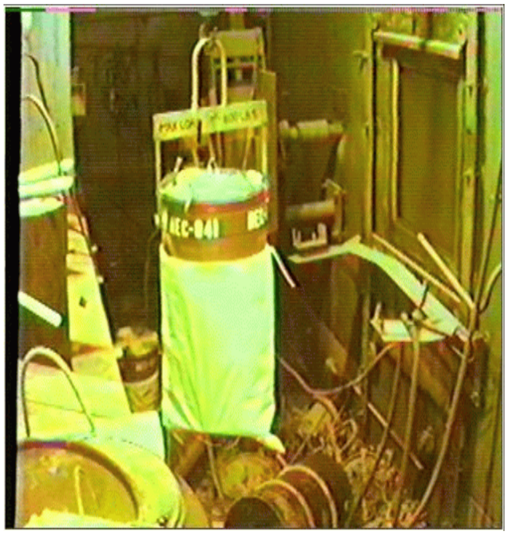

Fig. 2

PRODUCT IN USE

Engineers developed methods to minimize contamination by covering the initial waste packages (30-gallon drums [114-liter]) with a remotely removable covering. When it was time to bring the package out, the covering was removed while the drum was suspended in the air, and the drum was then immediately removed. The drums were being removed from areas where contamination levels are in the billions of counts per minute (cpm) and the resulting contamination levels on the packages was generally less than 1000 disintegrations per minute (dpm).

Additional efforts to allow for overall dose reduction ALARA strategy were investigated in the area where the drums were weighed, measured for radiation dose, and overpacked in 55-gallon (208-liter) drums into shielded containers. The Scrap Removal Room (SRR) was refurbished and allowed for drums to be brought out in a lower background radiation level area. This allowed waste drums to be lifted from the GPC through the hatchway, where their contamination covers were removed. Then the waste drums were placed in the radiation drum counter where weight and dose readings were transmitted to an indicator panel outside the cell. The drum was then placed in the lead-shielded, 110-gallon (416-liter) drums without exposing the operators to unnecessary radiation. The workers now only had to enter a low-dose, low-contamination zone and bolt the shield cap in place and the final lids on the 110-gallon (416-liter) drums to remove them to storage.

Fig. 3

Once this was completed, the Herculite® was removed from the shield drums, and survey readings were taken to verify the drum was <200 mR/hr on contact and the outer surface of the drum was free from contamination. Based on measurements taken on the drum counter, additional shielding could be placed between the 30-gallon (114-liter) drum and the 55-gallon (208-liter) drum. This typically consisted of a ½-inch steel cylinder. Once the final packaging was assembled, 30-gallon (114-liter) drums reading approximately 70 R/hr could be shielded down to less than 200 mR/hr. For temporary waste storage of higher-dose waste drums, the unused canister racks installed in the Chemical Process Cell (CPC) for the high-level waste vitrification project were used pending final disposal path.

Since the tare weight of the drum empty is approximately 3,800 pounds (1,724 kilograms), additional handling features were added. D-rings were placed at 180 degrees on the drum to allow lifting with cranes and/or slings. Two of the filled shield drums are lifted onto 4 foot by 6 foot steel pallets, and transported to the waste management storage facilities.

LESSONS LEARNED

During the initial design and development phase, the first completed drums were noticed to rock on the pouring flanges on the bottom of the drum. Duratek developed a jig fixture to hold the bottom of the drum in place to prevent the expansion during pouring operations.

Fig. 4.

Additionally, the bolt holes on the shield cap needed to be carefully positioned in order to align all of them with the bolt holes on the liner. If the holes were off center, proper closure could be a tedious task. To simplify bolting the shield cap in place, the bolt holes on the shield cap were slotted to make alignment easier.

The IP-1 design has proved to function very well. However, based on information provided by WIPP and other DOE Complex personnel, a DOT 7A Type A design should be pursued as a new shield container. Efforts are under way to have the new TYPE A 7A design submitted to WIPP for review and approval as a qualified disposal container. Additionally, if approved, the package could then be used to transport and dispose of previously characterized RH TRU waste as CH TRU.

SUMMARY

The 110-gallon (416-liter) 2-inch (0.6 meter) lead shield drum has proven to be a very economical and reliable package to both shield and store high-activity, high dose rate waste. New shielded containers would have cost between $7,000 to 10,000. Efforts between commercial vendors and the DOE have paid off to provide a suitable reuse for smelt-refined lead.

FOOTNOTE

The views expressed by the authors are their own and do not necessarily represent the views of the U.S. Government, the U.S. Department of Energy, the State of New York, or any of its agencies. This document has undergone Export Control Review and has been approved for general release.