Load Planning in the Dark: RH-TRU Waste Container Load Planning at Sandia National Laboratories/New Mexico-15116

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ABSTRACT

Sandia National Laboratories (Sandia) performed several sets of experiments during the 1970s and 1980s with fresh and irradiated mixed oxide (MOX) and uranium oxide (UO_2) materials designed to simulate various fuel responses under varying reactor conditions. These research materials were from light water and breeder mixed oxide reactors. The experimental vessels and extraneous piece parts resulting from the experiments were identified as eligible for disposal at the Waste Isolation Pilot Plant (WIPP) as remote-handled (RH) transuranic (TRU) waste. Once Sandia received the approval to dispose at WIPP, discussions began with the Carlsbad Field Office (CBFO) and Nuclear Waste Partnerships, LLC (NWP) to provide Central Characterization Program (CCP) support for certified acceptable knowledge, visual examination, and dose-to-curie for the repackaging effort. In addition to the WIPP support, Sandia was required to prepare a load plan describing the configuration of the parent containers and how they could be repackaged to meet WIPP and other regulatory requirements. However, all of these containers were packaged as material twenty (20) or thirty (30) years ago and the records of the packaging process and configuration were not documented as waste. Therefore, it seemed that the load plans were prepared with limited information regarding parent container configuration, hence in the dark.

The design of the Auxiliary Hot Cell Facility (AHCF) in technical area (TA) V, where the repackaging was to take place, along with the shipping requirements for the RH 72-B cask, limited the options for repackaging. This configuration required that 0.114 m^3 (30-gallon) containers be packaged in the hot cell, removed and placed into 0.208 m^3 (55-gallon) containers to mitigate contamination issues. The material had been tracked as accountable nuclear material and Sandia had verified Material Control and Accountability (MC&A) data on each parent container. Based on the MC&A data, scaling factors could be determined and sampling and analysis was not required. However, it meant that parent containers could not be split into two daughter containers, though two or more parent containers could be combined into one daughter.

INTRODUCTION

In February 2014, Sandia National Laboratories (Sandia) began processing materials for disposal at WIPP as part of their RH TRU waste stream. These materials were the result of experiments conducted during the late 1970s and throughout the 1980s. The materials were packaged in various Sandia-fabricated casks and included

- Experimental vessels from 0.5 to 3 meters long and 0.25 meters in diameter,
- Small material pieces and kerf, and
- Experimental debris

The RH TRU material in this waste stream is primarily sampled MOX material which was fabricated at the Hanford Engineering Development Laboratory (HEDL) and irradiated in Experimental Breeder Reactor (EBR)-II. In addition to the irradiated MOX material, was lesser amounts of irradiated uranium oxide material fabricated from US materials and irradiated in the Belgium Reactor-3 (BR3). To ensure compliance with the facilities technical safety requirements (TSR) the radiological conditions that were expected during processing and the calculated quantities of material needed to be determined. This information was also needed to prepare the load plans for packaging.

In the early phases of the load plan development and based on limited packaging information it was assumed the load plan would be simple and consist of a one-to-one; one parent container to one daughter container resulting in thirty seven (37) daughter containers. Due to the length of a few of the experimental vessels, it was not clear at that time if an entire experimental vessel would fit in a 0.114 m^3 (30-gallon) drum. However, once it was determined that Sandia needed to store the containers on site much longer than initially planned due to the WIPP shutdown, there was an increased incentive to minimize the number of daughter containers.

DISCUSSION

At the AHCF, campaign plans and associated procedures are required to be developed and approved before repackaging can begin. The campaign plans are developed and approved first and then the procedures are written based on the activities described in the campaign plans. After review of source documents, MC&A data, and interviews with Sandia technical staff, the parent containers were divided into three campaigns that enabled containers with similar material types to be combined and/or sorted.

Campaign plans are required to document several pieces of information on each container to ensure compliance with the TSR and Radiological Protection (RP) requirements. A report, *Analysis of Materials to be Processed in the Auxiliary Hot Cell Facility (AHCF),* was prepared to determine and document the required parameters.

As indicated above, the materials used in the experiments were MOX and UO_2, with various burn-up rates and uranium enrichments. For MOX, the burn-up ranged from 4.5% to 11% with uranium enrichment from <1% to 93%.The burn-up for UO_2 averaged 4.5% with uranium enrichment at 8.3%. Mass data was primarily obtained from the MC&A database of record, Materials Accounting Records System (MARS).

Each container was analyzed for the following parameters:

- Amount of uranium oxide
- Radionuclide quantitative composition
- Unshielded dose rates
- Hazard category fraction
- Radionuclide mass
- Criticality safety threshold mass fraction and U-235 fissile equivalent mass (FEM)
- Plutonium equivalent curies (PE-Ci), fissile gram equivalent (FGE), decay heat

After the above data was determined for each parent container, three campaign plans were prepared, Campaigns 11, 12, and 14. Each campaign plan included parent containers with similar radiological, physical, and packaging properties. The campaign plans were the key to creating load plans that allowed for ensuring the safety requirements were met, reducing the number of RCRA containers, maximizing the use of shield pots, and minimizing the overall number of daughter containers.

LOAD PLANS

A load plan was developed for each set of parent containers in each campaign plan. Each load plan used the estimated dose rates and the physical configuration of the material to be repackaged to combine material in as few daughter containers as possible. For the high dose rate material, the use of the Argonne National Laboratory (ANL) shield pot systems was identified as the preferred packaging configuration. A shield pot is a small, shielded container, centered in a 0.026 m^3 (7-gallon) bucket, two of which can be loaded in a 0.114 m^3 (30-gallon) drum. Detailed drawings can be obtained from ANL. If shield pots could not be used because of the size of the contents in the parent containers, then dose rates of the daughter containers was a determining factor to keep the dose As Low As Reasonably Achievable (ALARA) because operators will handle these daughter containers when they are removed from the hot cell.

Storage of the daughter containers was a major concern because Sandia has very limited RCRA permitted, Hazard Category (HC)-3 Nuclear Facilities space. Most of the daughter containers were to be co-located near the hot cell operations in a criticality safety index (CSI) array so final shielded dose rates were considered when creating the load plans.

An additional constraint was the need to keep similar materials together. As discussed earlier, accurate mass data for the material was available from the MC&A database. Since this - mass data comes from the MC&A database, only the accountable items were described. Therefore, the load plans had to account for material size, dose rates, types of material, shielding, sorting of contents to reduce both the number of RCRA containers, and total number of daughter containers.

MicroShield models were used to estimate the dose rates. Several assumptions were made including:

- Cs-137 was assumed to be responsible for the vast majority of the dose

- Source dimensions, volume, and density were assumed to provide a conservative dose estimate
- Source is unshielded or centered in the container for CSI array dose rates

Campaign 11 Load Plan

Campaign 11 consisted of eighteen (18) experimental vessels and one (1) smaller container with experimental material pieces. These vessels had an uncontaminated outer container with a smaller experimental vessel inside which contained the experimental material. Figure 1 is an example of these vessels.

Figure 1. Small Experimental Vessel

Initially, before visually observing the physical configuration, the load plan estimated up to six vessels could be packaged in a 0.114 m^3 (30-gallon drum). By removing the uncontaminated outer container and hardware from each vessel, the 19 parent containers were direct loaded into three (3) daughter containers. These daughter drums are all mixed and are stored in a HC-3, RCRA permitted, CSI array at Sandia.

Campaign 12 Load Plan

Campaign 12 consisted of eleven (11) containers with excess experimental material pieces, pellets, kerf, and small amounts of experimental hardware debris. The initial load plan suggested five (5) daughter containers would be required for repackaging, four of them using shield pots and one being a direct load. This configuration ensured that each daughter container would meet the > 2 mSv/hr (200 mrem/hr) RH requirement, provide shielding for the largest dose items, and reduce the number of daughter containers. When the parent containers were opened in the hot cell, it was determined that some of the debris would not fit into shield pots. Therefore, the load plan was updated resulting in these 11 parent containers being reduced to four daughter containers, two with shield pots and two direct loaded.

In addition, all of the RCRA items could be included in one direct load 0.114 m^3 (30-gallon) drum which reduced the needed RCRA storage space. Figure 2 is an example of experimental pins and pieces.

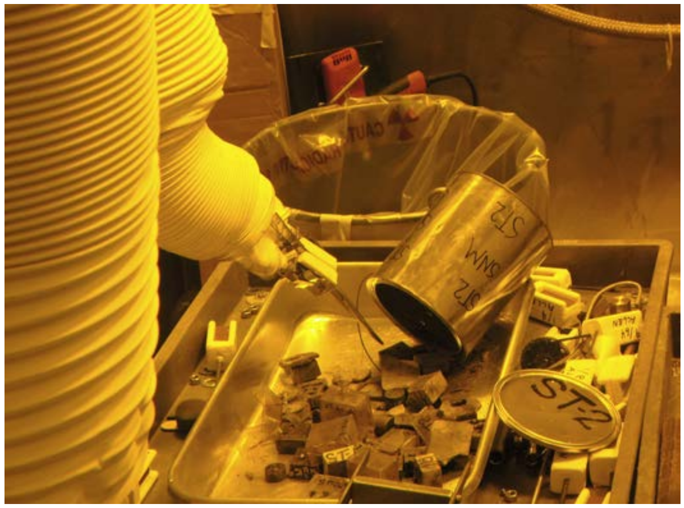

Figure 2. Pins and Pieces

Campaign 14 Load Plan

Campaign 14 consisted of five (5) large experimental vessels and two (2) smaller ones, all having high dose rates. The initial load plan for this campaign was very optimistic. In the original configuration of these experimental vessels, the experimental material pieces were located in quartz tubes which would undergo performance evaluation under a variety of conditions. Due to the large size of these vessels, it was hoped that the quartz tubes were not fractured and the fuel remained confined. If that was the case, the accountable radiological material could be separated and packaged as RH TRU in shield pots, and the large vessels could be disposed of as low level waste. The load plan was designed as follows:

- Daughter container 1 would contain experimental material pieces from two of the large vessels and be placed in two shield pots inside a 0.114 m^3 (30-gallon) drum
- Daughter container 2 would contain experimental material pieces from two additional large vessels and be placed in two shield pots inside a 0.114 m^3 (30-gallon) drum
- Daughter container 3 would contain the experimental material pieces from the two smaller vessels and from the remaining large vessel direct loaded into a 0.114 m^3 (30-gallon) drum

When the parent containers were disassembled, the quartz tubes were not intact and experimental material pieces were scattered throughout the inner container. Therefore, the inner containers had to be size reduced and the load plan had to be revised.

The final load plan for Campaign 14 did not minimize the number of daughter containers as originally envisioned. Six (6) daughter drums resulted from the seven (7) original containers. Figure 3 shows one of those large vessels as it was being removed from Dense Pack, storage silos.

Figure 3. Large Experimental Vessel

SCALING FACTORS

As discussed earlier, sampling was not required for this portion of the RH TRU waste stream. The approach used by WIPP to characterize the radiological properties is dose-to-curie. A dose rate is measured at several locations for each daughter container and the average used to determine the quantity of Cs-137. Using the Cs-137 average, the scaling factors are used to calculate the mass and activity of the radionuclides to be reported.

The scaling factors for this portion of the waste stream were determined differently than for the previous drums that were characterized in 2011. In the previous campaigns, statistical sampling of the debris waste was required and based on the laboratory data, three scaling factors were developed based on similar radionuclide amounts. However, in the current campaigns, Sandia was able to characterize the radionuclide contents of each container by using the MC&A mass data, enrichment, burn-up, and other information on the experimental material pieces in each parent container. Therefore, scaling factors for Campaigns 11, 12, and 14 were developed for each individual daughter container based on the material from parent containers which was packaged into each daughter drum.

Identification of the experimental materials was provided by Sandia to the WIPP radiological engineers with the pre-irradiation composition and the post-irradiation burn-up data. ORIGEN2.2 computer runs were made for each experimental material. Then the sums of the activities of each radionuclide from all of the parent containers were used to develop the scaling factors. MicroShield is used to calculate the dose-to-curie correlation factors for Cs-137.

CONCLUSIONS

The experiments that generated this waste were conducted 30-40 years ago and originally were identified as material. The thought was that additional evaluation of the materials may be required by researchers. Packaging records were not readily available because they were not identified as waste at the time of generation. While accurate mass information was available from the MC&A database, information regarding the physical configuration was limited. Published reports had drawings of limited detail, and survey reports were only available for the outer portion of the container. Sandia did not want to introduce any more items into the hot cell than were absolutely necessary, as that would result in additional RH TRU waste. Hence, a comprehensive examination of the data available was necessary to develop load plans that would

- meet safety and WIPP requirements
- reduce the number of final containers
- reduce the dose to the hot cell operators, and
- limit the number of RCRA daughter containers

Due to a great deal of up-front planning, discussions with the WIPP radiological engineers, the WIPP acceptable knowledge experts, and using modeling, the initial load plans were close to the final packaging configurations.

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