Repackaging of High Fissile TRU Waste at the Transuranic Waste Processing Center – 13240

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ABSTRACT

Twenty-six drums of high fissile transuranic (TRU) waste from Oak Ridge National Laboratory (ORNL) operations were declared waste in the mid-1980's and placed in storage with the legacy TRU waste inventory for future treatment and disposal at the Waste Isolation Pilot Plant (WIPP). Repackaging and treatment of the waste at the TRU Waste Packaging Center (TWPC) will require the installation of additional equipment and capabilities to address the hazards for handling and repackaging the waste compared to typical Contact Handled (CH) TRU waste that is processed at the TWPC, including potential hydrogen accumulation in legacy 6M/2R packaging configurations, potential presence of reactive plutonium hydrides, and significant low energy gamma radiation dose rates. All of the waste is anticipated to be repackaged at the TWPC and certified for disposal at WIPP.

The waste is currently packaged in multiple layers of containers which presents additional challenges for repackaging activities due to the potential for the accumulation of hydrogen gas in the container headspace in quantities than could exceed the Lower Flammability Limit (LFL). The outer container for each waste package is a stainless steel 0.21 m^3 (55-gal) drum which contains either a 0.04 m^3 or 0.06 m^3 (10-gal or 15-gal) 6M drum. The inner 2R container in each 6M drum is ~12 cm (5 in) outside diameter x 30-36 cm (12-14 in) long and is considered to be a > 4 liter sealed container relative to TRU waste packaging criteria. Inside the 2R containers are multiple configurations of food pack cans, pipe nipples, and welded capsules. The waste contains significant quantities of high burn-up plutonium oxides and metals with a heavy weight percentage of higher atomic mass isotopes and the subsequent in-growth of significant quantities of americium. Significant low energy gamma radiation is expected to be present due to the americium in-growth. Radiation dose rates on inner containers are estimated to be 1–3 mSv/hr (100-300 mrem/hr) with an unshielded dose rate on the waste itself of over 10 mSv/hr (1 rem/hr).

Additional equipment to be installed at the TWPC will include a new perma-con enclosure and a shielded/inert glovebox in the process building to repackage and stabilize the waste. All of the waste will be repackaged into Standard Pipe Overpacks. Most of the waste (21 of the 26 drums) is expected to be repackaged at the food-pack can level (i.e. the food-pack cans will not be opened). Five of the incoming waste containers are expected to be repackaged at the primary waste level. Three of the containers exceed the 200 gram Pu-239 Fissile Gram Equivalent (FGE)

limit for the Standard Pipe Overpack. These three containers will be repackaged down to the primary waste level and divided into eight Standard Pipe Overpacks for shipment to WIPP. Two containers must be stabilized to eliminate any reactive plutonium hydrides that may be present. These containers will be opened in the inert, shielded glovebox, and the remaining corroded plutonium metal converted to a stable oxide form by using a 600 °C tube furnace with controlled oxygen feed in a helium carrier gas. The stabilized waste will then be packaged into two Standard Pipe Overpacks. Design and build out activities for the additional repackaging capabilities at the TWPC are scheduled to begin in Fiscal Year 2013 with repackaging, stabilization, and certification activities scheduled to begin in Fiscal Year 2014.

Following repackaging and stabilization activities, the Standard Pipe Overpacks will be certified for disposal at WIPP utilizing Non-Destructive Examination (NDE) to verify the absence of prohibited items and Non-Destructive Assay (NDA) to verify the isotopic content under the TWPC WIPP certification program implemented by the Central Characterization Project (CCP).

INTRODUCTION

The Transuranic Waste Processing Center (TWPC) is a Department of Energy (DOE) Hazard Category 2 nuclear facility for the repackaging, treatment, certification, and disposal of the Oak Ridge National Laboratory (ORNL) legacy inventory of Contact Handled (CH) and Remote Handled (RH) Transuranic waste as well as the retrieval, treatment, certification, and disposal of RH liquid supernatant and sludge waste stored in the Liquid Low Level Waste (LLLW) system.

Figure 1 - TRU Waste Processing Center (TWPC)

Through FY12, the TWPC has successfully processed:

- 84% (1,263 m^3) of the ORNL legacy CH TRU inventory with approximately 60% of the waste being characterized and dispositioned as CH TRU and 40% as CH Low Level Waste/Mixed Low Level Waste (LLW/MLLW) with subsequent disposal at WIPP and the Nevada National Security Site NNSS
- 34% (192 m^3) of the ORNL legacy RH TRU inventory with approximately 75% of the waste being characterized and dispositioned as either RH or CH TRU and 25% as CH LLW/MLLW with subsequent disposal at WIPP and NNSS
- 100% (1,550 m^3) of the ORNL legacy RH LLLW supernatant inventory was completed in October 2004 with disposal of the RH liquid waste as solid-fied RH LLW at NNSS
- Currently working conceptual design and planning activities for the design, fabrication, construction, and operations of retrieval and solidification systems for the remaining 2,000

m^3 of ORNL legacy RH LLLW sludge inventory with operations projected to start in FY18

DESCRIPTION OF HIGH FISSILE TRU WASTE

The majority of the ORNL legacy TRU waste inventory was generated by prior isotope production operations and general research activities at ORNL. Twenty-six drums of high fissile TRU waste from ORNL operations were declared waste in the mid-1980's and placed in storage with the legacy TRU waste inventory for future treatment and disposal at WIPP.

The high fissile waste is currently packaged in multiple layers of containers which presents additional challenges for repackaging activities due to the potential for the accumulation of hydrogen gas in the container headspace in quantities than could exceed the lower flammability limit. The outer container for each waste package is a stainless steel 0.21 m^3 (55-gal) drum which contains either a 0.04 m^3 or 0.06 m^3 (10-gal or 15-gal) 6M drum. The inner 2R container in each 6M drum is ~12 cm (5 in) outside diameter x 30-36 cm (12-14 in) long and is considered to be a > 4 liter sealed container relative to TRU waste packaging criteria. Inside the 2R containers are multiple configurations of food pack cans, pipe nipples, and welded capsules. Examples of the inner container configurations are shown in Figure 2.

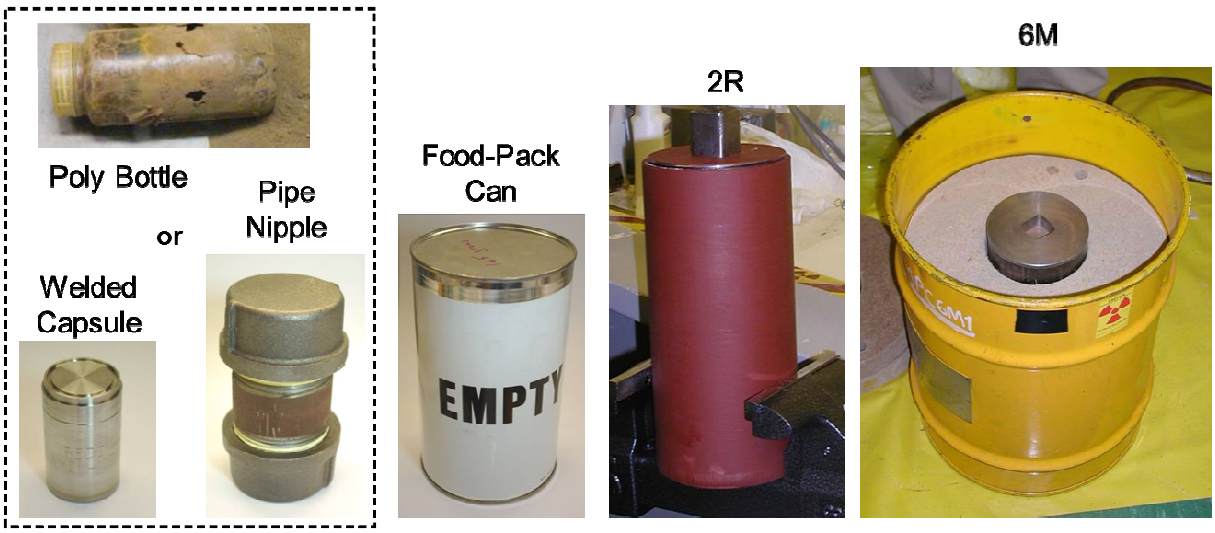

Figure 2 - Waste Package Configurations

The high fissile waste contains significant quantities of high burn-up plutonium oxides and metals, similar to those shown in Figure 3, with a heavy weight percentage of higher atomic mass isotopes and the subsequent in-growth of significant quantities of americium. Significant low energy

gamma radiation is expected to be present due to the in-growth of Am-241. Radiation dose rates on inner containers are estimated to be 1–3 mSv/hr (100-300 mrem/hr) with an unshielded dose rate on the waste itself of over 10 mSv/hr (1 rem/hr). The americium in-growth also increases the radiotoxicity of the waste with time. Decay corrected to the present, most of the individual waste containers represent greater than three times a Hazard Category 2 quantity of radioactive material.

Figure 3 - Plutonium Oxide and Metal Waste Forms

DESCRIPTION OF ADDITIONAL PROCESSING CAPABILITIES

Repackaging and treatment of the high fissile TRU waste at the TWPC will require the installation of additional equipment and capabilities to address the hazards for handling and repackaging the waste compared to typical CH TRU waste that is processed at the TWPC, including potential hydrogen accumulation in legacy 6M/2R packaging configurations, potential presence of reactive plutonium hydrides, and significant low energy gamma radiation dose rates. All of the waste is anticipated to be repackaged at the TWPC and certified for disposal at WIPP.

Waste Processing Enclosure

Repackaging of the high fissile TRU waste will require the installation of a new process enclosure on the first floor of the TWPC process building. The general design and construction of the process enclosure will match the existing Box Breakdown Area (BBA) on the second floor of the TWPC process building (Figure 4).

The process enclosure will be constructed using stainless steel sheeting attached to carbon steel angle coated with an industrial coating. The panel sections are bolted together and the seams sealed with silicon caulking and a layer of sealing tape. The steel shell incorporates clear transparent polycarbonate panels for lighting. The process enclosure is designed to

Figure 4 - Existing BBA Enclosure

operate under a vacuum up to 7.6 cm (3 inches) of water column. Differential pressure is monitored by the use of vacuum gauges. Ventilation dampers are provided between each section to maintain inlet airflow. Figure 5 shows a schematic of the process enclosure layout.

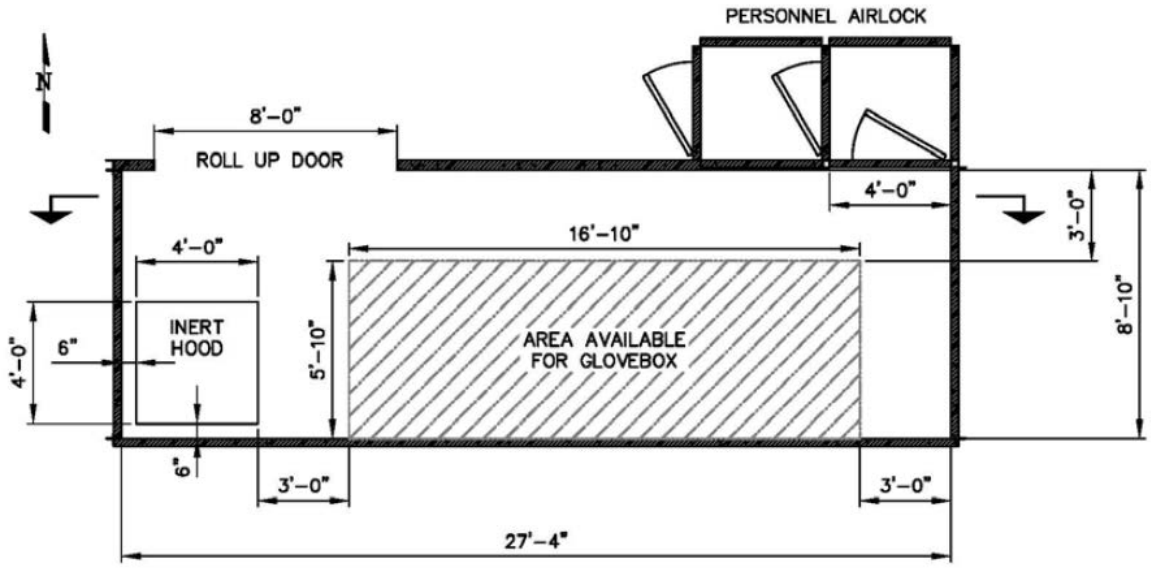

Figure 5 - Waste Processing Enclosure

Metal Oxidation Process Glovebox

Repackaging and treatment of the high fissile TRU waste will require the installation of a metal oxidation process glovebox inside the previously described process enclosure. The glovebox will be fabricated of stainless steel (304L), and will be capable of operating under either an inert environment or a standard negative pressure ambient atmosphere. Approximately one inch of external shielding will be required to mitigate the low energy gamma radiation that is expected to be present in the waste. The glovebox will consist of multiple functional operating areas:

- TC-1, Process Transfer Chamber
- GB-1, Inert Atmosphere Glovebox
- TC-2, Furnace Vessel Transfer Chamber
- GB-2, Process Glovebox (ambient atmosphere)

A schematic of the metal oxidation process glovebox is shown in Figure 6.

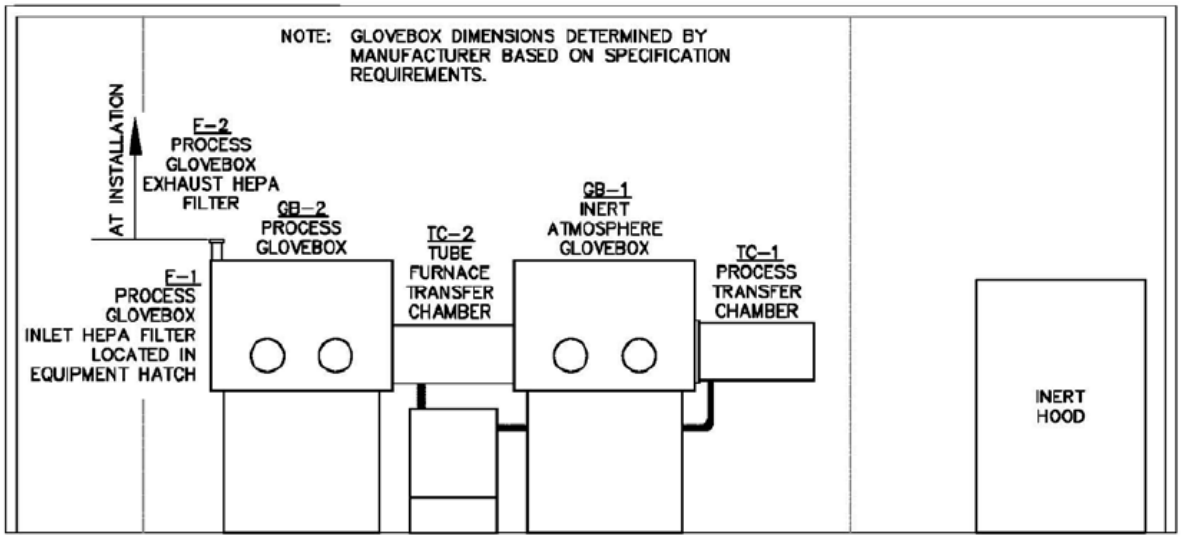

Figure 6 - Metal Oxidation Process Glovebox

The metal oxidation process glovebox will contain the necessary equipment required to stabilize plutonium metal components in the high fissile TRU waste. The oxidation process is based on the following process parameters.

Oxygen Deficient Direct MetOx Process Parameters

- Material: Plutonium Metal Specimens
- Batch Size Basis: 300g
- Reaction: $Pu + O_2 \rightarrow PuO_2$
- Carrier Gas: He_2
- Oxidizing Gas: 20% O_2 in He_2 (volumetric basis)
- Total Processing Gas Feed Flowrate: 2 liters per minute
- Humidity (H_2O) in Inlet Gas: <3 ppm H_2O, approximately (-)70^{o}C dew point
- O_2 required for complete oxidation: ~30 liters at ambient conditions per batch

Figure 7 - Metal Oxidation Tube Furnace

The process approach used to oxidize metal components includes four stages with varying temperatures and oxygen concentrations.

- Stage 1:
  - Inlet gas feed at 5 vol% O_2 at ambient temperature for 1 hour, utilizes 6 liters O_2
  - This stage is designed to oxidize fines in a controlled fashion.
- Stage 2:
  - Inlet gas feed remains at 5 vol% O_2 but temperature ramped up to 400^{o}C over 1 hour, utilizes 6 liters O_2
  - This stage completes oxidation of fines and small pieces.
- Stage 3:
  - Inlet gas feed remains at 5 vol% O_2 with furnace temperature at 400^{o}C for 5 hours, utilizes 30 liters O_2
- Stage 4:
  - Inlet gas feed ramped up to 10 vol% O_2 and temperature ramped up to 600^{o}C for 2.5 hours, utilizes 30 liters O_2
  - This stage ensures completion of the oxidation process and satisfies the WIPP oxide temperature requirement of 600^{o}C.
  - Cool down of material, Inlet gas feed 100 vol% He_2 for approximately 3 hours at 1 liter per minute
  - Total Process Time (including cool down): 12.5 hours
  - Total liters O_2 fed: 72 liters (~150% stoichiometric excess)

DESCRIPTION OF TWPC PROCESSING

All of the high fissile TRU waste is anticipated to be repackaged into Standard Pipe Overpack containers (Figure 8) at the TWPC prior to certification and disposal at WIPP. Planned waste processing activities are divided into three categories:

- Direct repackaging
- Repackaging into multiple outgoing packages
- Repackaging with stabilization

The use of Standard Pipe Overpack containers are required in order to meet both the Plutonium Equivalent Curie (PE-Ci) loading and external dose rate requirements for transportation in TRU PACT-II Type B packages to WIPP. Standard Pipe Overpack containers are approved for up to 1,800 PE-Ci and 200 grams Pu-239 Fissile Gram Equivalents (FGE).

Figure 8 - Standard Pipe Overpack Container

Direct Repackaging

Most of the high fissile TRU waste is expected to be repackaged at the food-pack can level (i.e. the food-pack cans will not be opened). These waste drums will be opened inside the new waste processing enclosure. The 0.04 m^3 or 0.06 m^3 (10-gal or 15-gal) 6M inner drums will be removed the outer drum and opened. The inner 2R container will be removed from the 6M drum, and vented/opened in an inert hood due to the potential accumulation of hydrogen in the headspace above the LFL. Once the 2R container has been opened, the inner food pack cans will be loaded into a Standard Pipe Overpack container.

Repackaging into Multiple Outgoing Packages

Three of the high fissile TRU waste containers are known to exceed the 200 gram Pu-239 FGE limit for the Standard Pipe Overpack. These containers will be repackaged down to the primary waste level and divided into multiple Standard Pipe Overpacks for shipment to WIPP. The repackaging steps for these containers will be similar to the steps for direct repackaging described above with the exception that the food pack cans will be transferred to the metal oxidation process glovebox where the contents will be subdivided into multiple outgoing containers based on mass prior to loading into Standard Pipe Overpack containers.

Repackaging with Stabilization

Two high fissile TRU waste containers are known to contain plutonium metal that must be stabilized to eliminate any reactive plutonium hydrides that may be present. The repackaging steps for these containers will be similar to the steps for direct repackaging described above with the exception that the food pack cans will be transferred to the metal oxidation process glovebox where any remaining corroded plutonium metal will be converted to a stable oxide form utilizing the oxygen deficient direct MetOx process described above. The stabilized waste will then be packaged into two Standard Pipe Overpacks.

Figure 9 - TRU PACT II Loading

TRU Waste Certification and Disposal

Following repackaging and stabilization activities, the Standard Pipe Overpacks will be certified for disposal at WIPP utilizing Non-Destructive Examination (NDE) to verify the absence of prohibited items and Non-Destructive Assay (NDA) to verify the isotopic content under the TWPC WIPP certification program implemented by the Central Characterization Project (CCP). Following certification the waste will be shipped to WIPP for disposal as TRU waste utilizing TRU PACT-II Type B packages for

transportation (Figure 9).

CONCLUSION

With the installation of additional equipment and capabilities to address the hazards for handling and repackaging, the TWPC will be able to safely repackage and stabilize the high fissile TRU waste from the ORNL legacy TRU waste inventory. Design and build out activities for the additional repackaging capabilities at the TWPC are being initiated in Fiscal Year 2013 with repackaging, stabilization, and certification activities scheduled to begin in Fiscal Year 2014.