PACKAGING AND TRANSPORTATION OF DEPLETED, NATURAL, AND LOW ENRICHED URANIUM FOR DISPOSITION FROM THE SAVANNAH RIVER SITE

D. L. Gillas
U. S. Department of Energy, Savannah River Operations Office
P. O. Box A, Aiken, SC 29802

ABSTRACT

The Savannah River Site (SRS) has several inventories of depleted, natural, and low enriched uranium (DU/NU/LEU) that require final disposition. Fiscal Year 2003 (FY03) saw the beginning of disposition actions for these inventories. This paper will describe these inventories and the thought process behind determining the appropriate packaging and transportation (P&T) of each material stream. It will also discuss the material streams that are still in the planning phase.

In FY03, SRS completed a pilot project that disposed of 3,270 drums of depleted uranium oxide (DUO) between May and July 2003. The shipping method was 110-ton mill gondola rail cars with a coated polypropylene fabric liner ("wrapper") as the DOT "strong, tight" package. These rail cars were shipped to Envirocare of Utah for final disposition of the DUO as low level waste. This paper describes the loading, packaging methods, the issues related to these methods, transportation mode, the remedies attempted to correct issues, and the lessons learned during this pilot. The disposition project for the remaining inventory has begun and uses different P&T methods than were used in the pilot.

The SRS inventories of DU and NU metal were also dispositioned in FY03. These inventories were shipped by commercial tractor/trailer truck to Envirocare of Utah.

Many universities have inventories of NU metal that are on loan from DOE. Several of these universities have requested that these inventories be returned. Through September 2003, SR shipped the material from five universities directly to the Nevada Test Site for disposal. The material was never physically returned to SRS thus saving a shipping step. These five universities provided the pilot to develop this program that is planned to continue until the material from all of the universities is dispositioned.

Depleted uranyl nitrate (DUN) is being shipped as a radioactive acid solution and is being treated before disposal. P&T issues have been numerous and will be discussed. The low enriched uranium oxide (LEUO) seems to be the stream with the least P&T issues but has yet to be shipped. Plans are to ship this material by commercial tractor/trailer truck to NTS for disposal.

INTRODUCTION

SRS began dispositioning excess materials including large inventories of DU/NU/LEU. The DU/NU/LEU streams include trioxide, metal, and solutions with varying concentrations of contaminants including, in one case, hazardous constituents. The packaging varies, from the

original packaging, to individual overpacks, to large overpacks, to tankers depending on the material stream and the destination. Transportation modes include truck and train depending on the stream and destination. The disposal methods will only be briefly discussed in this paper since the focus is P&T; however, the disposal site for each stream strongly influences the P&T methods and, conversely, the desired P&T method strongly influences the decision on which disposal site to select.

The material streams involved have historically been managed as nuclear materials with the hope of finding reuse applications. However, cost-effective reuses have not been identified to date and, since these material streams are the responsibility of DOE Environmental Management (EM), these materials have been defined as excess and must be dispositioned in accordance with EM-1 guidance. Actions to prepare for disposition actually began in FY02 for the DU trioxide (DUO) and the first material was disposed in FY03. The disposal actions for the DU/NU metal began and were completed in FY03. The disposal planning, as well as initial activities, for the LEU trioxide (LEUO) and the DUN began in FY03. The disposal actions for the NU on loan to universities also began in FY03.

The materials that will be covered in this paper include: DUO, DU/NU metal, LEUO, DUN, and university NU metal.

BACKGROUND

The DU/NU/LEU inventories at SRS were accumulated during the decades of nuclear weapons production and are a direct result of weapons production activities. These inventories were stored in any available space on site and have been, and continue to be, managed as accountable nuclear material. All of these inventories have served some purpose in the past and, technically, could have future uses. However, no such future uses are currently available and as such, the inventories are planned to be disposed as waste.

DEPLETED URANIUM OXIDE (DUO)

DUO Background

The DUO inventory consisted of ~36,000 55-gallon (212 liter) drums, a significant portion (<30%) of which were overpacked into 85-gallon (327 liter) drums. This inventory was stored in seven facilities at SRS. The inventory is a byproduct from weapons production activities and was accumulated from the early 1970's through 1989. The facility that converted the byproduct stream from a uranyl nitrate acid solution into trioxide was shut down in 1989.

In FY02, two of the storage facilities were determined to be in sufficiently poor condition such that the decision was made to disposition these drums as waste as opposed to upgrading the facilities for continued storage. A sample plan was developed and samples were pulled in FY02. The final characterization was completed in early FY03. Extremely low detection limits were needed to discern the parts-per-trillion levels of plutonium contamination. This information combined with the remaining results of the characterization showed that the material could be disposed at either the Nevada Test Site (NTS) or Envirocare as low level waste. It also showed

that the DUO met the Department of Transportation (DOT) definition of Low Specific Activity (LSA) 1, unirradiated material; thus it could be shipped in a "strong, tight" container.

The drums were typically stacked three high in the storage facilities. The two facilities in question allowed rain water and mud to accumulate on the floors such that the bottom layer of drums was standing in water during portions of the three-decade storage period. This caused significant corrosion in some of the drums in the bottom tier bringing into question the integrity of the drums. Drums in the other two tiers also exhibited significant surface corrosion but drum integrity was not generally in question. Because the drums averaged ~1,650 pounds (750 kg) each, coupled with the degraded integrity, the drums could not be used as the "strong, tight" container. For these reasons, the drums could not be used as the shipping containers for this waste stream and actions were taken to determine the least expensive and compliant packaging method.

DUO Disposition Pilot

The drums in these two facilities were ~9% of the entire DUO inventory and were representative of the worst case condition for the entire inventory. Therefore, since the decision was made to dispose of the entire inventory, this 9% was used as a pilot project to determine the appropriate P&T methods, and the disposal site and method.

A transportation study was performed to determine options for P&T including a comparative cost analysis. The study concluded that transportation by rail was significantly less expensive than shipping by truck since the volume and density were so high. However, the life cycle cost for disposition included the disposal cost as well. The NTS cost per cubic foot for disposal was significantly lower than the alternative of disposal at Envirocare so that transportation by truck became favorable. However, SRS was able to negotiate a lower price for disposal at Envirocare that was higher than that of NTS but reduced the life cycle cost such that transportation by rail for disposal at became slightly more cost effective. Envirocare requested that the drums be placed four on a pallet and banded together to reduce the amount of handling at their site. It would also reduce the amount of handling of individual drums since the integrity of the drums was in question.

The next step was to determine the packaging method for the palletized drums. A Request For Proposals (RFP) was released that specified that the drums were not to be considered the shipping package and that the palletized drums required a compliant package that would be shipped. The chosen method was to use a 66-foot (~20 m) long, 110-ton (100 MT) mill gondola car with a tarp rain cover as the conveyance and line the car with a polypropylene-coated fabric liner ("wrapper") as the strong, tight package. Compliant and functional blocking and bracing (B&B) was developed which included modifications to the gondola car to allow for straps to be attached to the car.

The original packaging method included: 1) lining the entire rail car with a single wrapper, 2) lifting the palletized drums (~7,000 pounds (~3,200 kg) per pallet) by crane and placing them into the rail car, 3) ratchet binding sixteen drums (four pallets) together with two two-inch-wide (5 cm) nylon straps just below each ring, 4) closing the wrapper by folding the excess material of

the wrapper over the drums to allow a double layer of the wrapper over the drums, 5) tying the wrapper, 6) placing four-foot (1.2 m) by eight-foot (2.4 m) sheets of plywood over each set of two pallets, 7) placing ratchet binder straps, that are connected to the rail car, over the plywood, 8) installing bows over the top rail of the car, and 9) placing a tarp over the bows as a rain cover. Figure 1 shows a gondola car that is loaded and ready to close. Figure 2 shows the gondola car closed and ready to ship.

Fig. 1 Loaded gondola car that is ready to close

Fig. 2 Gondola car loaded and closed, ready to ship

Seven gondola cars were loaded and shipped with this method before the first car arrived at Envirocare and was unloaded. Inspection of this first car showed that there were holes in the bottom of the wrapper from abrasion between the very heavy pallets and the bottom of the car. No drums breached so that no material was released. Shipping was stopped until an alternative packaging method could be determined and implemented.

The revised method included adding a layer of roofing felt under the wrapper and a cushion material (Geotex™ fabric) between the wrapper and the pallets. The intent was to protect the wrapper from abrasion. With the idea that this would correct the problem, loading and shipping continued. Eleven more cars were loaded and shipped before the first of these arrived and was unloaded at Envirocare. Inspection of the first car showed that the interaction between the abrasive roofing felt and the smooth cushion fabric caused high friction on the wrapper and melted large (~ one foot square) sections of the wrapper (see Fig. 3). Loading was once again halted until yet another packaging method could be determined and implemented.

Fig. 3 Damage to the wrapper is shown. The bottom of the rail car shows through the damaged area.

The third method discarded the use of the roofing felt and added two layers of the cushion fabric under two layers of wrappers and an additional two layers of cushion fabric on which the drums

were placed. This method proved functional as the strong, tight package but was not cost effective (material and labor) for the long term.

During all of the changes to the packaging method, no drums breached so that no material was ever released. The major conclusions from the pilot project were: 1) this wrapper was not an appropriate package for this specific waste form, 2) shipping by rail is appropriate and cost effective, and 3) disposal at Envirocare is appropriate and cost effective assuming shipment by rail.

Based on this experience in the pilot project, a Request For Proposals was released that specified the use of gondola cars with hard tops that will be used for both the packaging and the conveyance for the remaining 55-gallon (212 liter) drums. Bid packages were received and a contract was signed. However, this contract also includes shipping the overpacked drums (see below) which began in FY04 so that the shipment of 55-gallon drums will not continue until FY05.

DUO Drums in Overpacks

Of the ~33,000 remaining DUO drums, ~10,000 (or less) were historically overpacked (overpacked because of storage and drum condition issues not related to P&T of the drums) into 85-gallon (327 liter) drums. These drums are wider than the 55-gallon drums such that four overpacks would not fit across the width of a standard railcar. Therefore, other options were needed. The overpacks are relatively new and in excellent condition but the weight exceeds the DOT limits for a non-bulk, strong, tight package. Since there is a significant quantity of drums, SRS decided to perform a drop test to qualify the drums as Industrial Package 1 (IP-1) packages. The drums passed the test and thus do not require additional packaging. SRS has begun to ship these drums in wider-than-standard boxcars to Envirocare with the drum as the shipping package and the boxcar as the conveyance. As stated above, a single shipping contract covers both the shipping of the overpacks and the 55-gallon (212 liter) drums. Shipping of the overpacks began in February 2004.

DEPLETED AND NATURAL URANIUM METAL

DU/NU Metal Background

Historically, DU metal was provided by Fernald in the form of solid and hollow right cylinders (depending on design requirements) weighing between six and 14 kg each (commonly referred to as "slugs"). These slugs were assembled into target assemblies at SRS and used in the reactors to produce weapons materials. When the last of the reactors were shut down in the late 1980's, target production halted with slugs still in the target fabrication process. The slugs still in process were removed from the process lines and stored on site. The process started with bare uranium slugs, then plated them with nickel, then canned them in aluminum. When production stopped, the slugs were in all stages of the process. Approximately 35% of the remaining slug inventory was bare (never entered the process) and ~65% of the slugs were processed to some extent. The process did not change the chemical form or nucleonics of the uranium, only the nickel and aluminum were added to the exterior of the slugs. Therefore, the waste profile was

able to be consistent for the entire inventory. Also, Fernald had already shipped a significant quantity of bare slugs to NTS for disposal so SRS was able to use their characterization without repeating the analyses.

DU/NU Metal Disposal

In early FY03, the decision was made to dismantle the buildings in which the DU/NU metal was stored. As a byproduct of this decision, the material needed to be dispositioned. A P&T study had been performed in FY02 that showed similar results as that of the DUO in that rail shipment was preferred. However, when the rail infrastructure was reviewed, the upgrades needed to use the rail spur made this option cost and time prohibitive. Also, the volume (weight) of the material was relatively small (2,700 MTU) so that truck transportation was used. Four trucks per day were loaded and shipped, four days per week from mid-March through May 2003.

The portion of the material (~35%) that never entered the process remained in storage in the original wooden crates that Fernald used to ship them to SRS. These crates were lined with aluminum sheeting and were determined to be acceptable packages for the material form (metal slugs). The remaining material (~65%) that came out of the process was stored in various containers. Some was stored in reused wooden crates, some in metal boxes, and a large portion was stored in fiberboard containers. The fiberboard containers presented a problem in that they were not entirely closed. However, since the material was in the form of metal slugs that were very difficult to disperse, wrapping the containers in heavy plastic solved the problem and they were accepted as the shipping packages.

Since the decision was made to use truck transportation, disposal at NTS would have been the most cost effective. However, this inventory was not included in SRS's forecast for disposal at NTS and, even though the volume was small relative to other uranium inventories, it was too large for NTS to add to the forecast. Envirocare was willing and able to take the inventory within the time constraints and thus this inventory was shipped by tractor/trailer (see Figure 4) to Envirocare for disposal. However, because of operational constraints at Envirocare, the truck was not allowed to be used as the strong, tight container which was the reason to assure each of the container types were acceptable shipping packages.

Fig. 4. Trailer loaded with DU metal. Very dense material met truck weight limits long before the volume would be filled.

LOW ENRICHED URANIUM OXIDE

LEUO Background

The LEUO resulted from one experimental reactor core that was used at SRS in the mid-1980's. The resultant solutions from this core averaged ~1% enrichment. The solutions were then processed through the same process used to reduce the DU solutions to trioxide. The process tanks had been full of DU solutions so that when the LEU solutions were added to the process, the enrichment of the resulting oxide actually varied from ~0.24% up to just over 1% as the enriched solutions were processed. The first 33 drums produced each had a different enrichment, while the remaining drums are relatively consistent at ~1% enrichment. When all drums were averaged by weight (including the drums that were at or below 0.711%), the average enrichment was ~0.94%.

LEUO Disposition

The LEUO was packaged with future shipment in mind. Galvanized steel drums were filled so that they met the requirements for a non-bulk, strong, tight package for LSA-1 material as defined by DOT. Since there are only 381 drums, shipment by rail is not necessary or desirable. Envirocare's Waste Acceptance Criteria will not allow material over 0.711% enrichment so that NTS became the only disposal option. Since NTS does not have rail capabilities, truck shipment was required. This material is planned to be shipped by truck to NTS in FY04.

DEPLETED URANYL NITRATE SOLUTIONS

DUN Background

The DUN is the result of the same process that generated the DUO except that the last step, reduction to oxide, was not performed. The facility that was used to reduce the solutions to oxide was shut down in 1989 for operational issues. Additional DU was generated at SRS but there was no operational process to convert it to a solid. The uranyl nitrate has been stored at SRS since it was produced. A portion of this material has been used from time to time for operational purposes but SRS expects to dispose of a large portion of this inventory.

The DUN concentration is in the range of 350 to 400 grams of uranium per liter of solution and the average uranium enrichment is ~0.25%. The DUN also contains mercury and chromium above Resource Conservation and Recovery Act (RCRA) limits for land disposal so that it requires treatment to meet Land Disposal Restrictions (LRD). A feasibility study has verified the feasibility of treating this material such that it meets LDR.

DUN Planning

Many options were studied for the final disposition of the DUN. The chosen option was to treat the material at an off-site vendor and dispose as low level waste (since the only RCRA constituents are characteristic, the treated waste form has been shown to meet all LDRs so that the final waste form will only be low level waste and not mixed waste). The final waste form

may meet the Envirocare WAC (but would still be required to be disposed in their mixed waste cell because of their license requirements) and will meet the NTS WAC.

The solutions are being transported in IP-2 containers because of contaminant levels. SRS purchased six 4,600-gallon (17,700 liter) IP-2 intermodal tankers from a foreign source. Significant effort was applied to find a domestic source for these tankers without success. Three of these tankers are being used to transport the solutions to the treatment facility. Transport of the solutions to the treatment vendor began in January, 2004. The treated material will be shipped by truck to NTS for disposal.

NATURAL URANIUM METAL FROM UNIVERSITIES

University NU Background

From the late 1950's and into the 1960's, DOE's predecessor, the Atomic Energy Commission (AEC), loaned NU to universities for teaching nuclear physics and engineering. The NU originated as rejected fuel slugs from the SRS reactor fuel fabrication processes. The slugs were similar in form to the DU metal slugs in that they were solid or hollow, right cylinders of uranium metal that were clad in aluminum. The slugs were arranged in subcritical arrays and neutron sources were used to create a measurable neutron flux. Many arrays have not been used since the 1970's – very few are still in use. The loans were agreements directly between the universities and the government (vs. through a contractor) and thus were never the responsibility for the operating contractors to manage. In FY03, DOE Savannah River Operations Office (DOE/SR) began a pilot program to collect and disposition a portion of this material. Five universities had, within the previous year, indicated that they would like to have the material removed from their site. The loan agreements state that the university can keep the material as long as they would like and then AEC (or now DOE) would take it back upon request of the university. The university is responsible to package and ship the material to a DOE designated location.

University NU Disposition

The NU metal was characterized using dose-to-Curie calculations. The dose ranged between one and five millirems on contact. The universities' inventories averaged ~2.5 MTU each. The decision was made to package the material at the university for direct shipment to the NTS thus saving a shipping step and saving both DOE and the universities money. DOE provided the drums to the universities due to the NTS packaging requirements being more stringent than DOT's. SRS personnel who are NTS Waste Certification Officials traveled to each university to actually package and ship the material. Standard tractor/trailer trucks were used as the strong, tight packaging and the conveyance. All five universities scheduled for the pilot were successfully completed in FY03. The program will continue with seven universities scheduled for FY04. As many as seventy universities have loan agreements through DOE/SR.

SUMMARY

SRS has initiated disposition plans or activities for all of the legacy inventories of DU/NU/LEU at SRS. Per EM-1 guidance, the disposition actions for all of these inventories will be completed by November 2006. No issues are expected to prevent the accomplishment of this goal.