SAVANNAH RIVER SITE TRU SOLUTIONS - 9513

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ABSTRACT

In May 2001, the Savannah River Site (SRS) started shipping transuranic (TRU) wastes to the Waste Isolation Pilot Plant (WIPP) at the rate of one shipment per month. With close to 30,000 drums of waste, it was expected to take many years to accomplish. An acceleration program was proposed and Washington TRU Solution's Central Characterization Project's (CCP's) first major deployment was made to assist SRS. Maximum throughput saw over 240 drums per week entering the characterization program and five shipments of 150 drums leaving the site each week. Eight years later, SRS will finish the legacy TRU drum program. How did this happen and what was learned during the process?

INTRODUCTION

The Savannah River Site, located near Aiken, South Carolina, is managed by the United States Department of Energy (DOE) and operated by Savannah River Nuclear Solutions (SRNS). SRS began operation in the 1950s to produce radioactive materials for defense and other purposes. With the opening of the WIPP site in March 1999, SRS began developing a program to certify and dispose of approximately 30,000 drums of legacy TRU waste and 6,000 cubic meters of non-drummed waste. TRU waste is defined as alpha-emitting radionuclides with atomic numbers greater than that of uranium (>92), with more than 20 years half-life, and with activity concentrations greater than 3700 Bq/g (100 nCi/g). This waste had been stored both above ground and buried under earthen covers since its generation starting in the early 1970s. Wastes generated prior to 1973 were disposed of according to the orders in effect at the time.

DISCUSSION

SRS TRU drummed waste could be split into two types: mixed and non-mixed. Mixed TRU storage and disposal must meet additional requirements based on the application of the Resource Conservation and Recovery Act (RCRA). RCRA, enacted in 1976, is a federal law that regulates the disposal of solid and hazardous wastes. For SRS this meant that most of the TRU waste was confined to storage that was permitted by the South Carolina Department of Health and Environmental Control (SCDHEC). Empty storage space meeting these requirements was almost nonexistent. This limited the space available for sorting and processing the drums. The first waste stream to be characterized was chosen based on storage access. To dispose of TRU wastes at WIPP, the first step is to develop an Acceptable Knowledge (AK) report. AK is used in TRU waste characterization activities in five ways:

1. To delineate TRU waste streams
2. To assess whether TRU mixed wastes comply with the waste acceptance criteria
3. To assess whether TRU wastes exhibit a hazardous characteristic (ignitability, corrosivity, reactivity, toxicity)
4. To assess whether TRU wastes are listed (on one of the Environmental Protection Agency (EPA) lists of hazardous chemicals)
5. To estimate waste material parameter weights

AK had described the first waste stream chosen for characterization as having a single isotopic distribution, minimal hazardous waste components, and low radioactivity. Characterization was to be performed using nondestructive examination (NDE) and nondestructive assay (NDA) equipment built in the 1960s as laboratory instruments. Only headspace gas (HSG) analysis was to be performed using new equipment. Issues with legacy wastes were quickly encountered. Drums with prohibited items (PI), container integrity issues, and NDA results less than the WIPP minimum of 3700 Bq/g (100 nCi/g) were being identified faster than were acceptable drums. During the earlier days of TRU waste generation, the waste acceptance criteria had not been defined completely. Aerosol cans, liquids, and other prohibited items and conditions were not restricted. A TRU activity concentration lower limit of 370 Bq/g (10 nCi/g) was used, rather than the defined lower limit of 3700 Bq/g (100 nCi/g). Drums identified with WIPP-prohibited items were set aside, as there was no facility available to perform remediation. Drums identified as <3700 Bq/g (<100 nCi/g) were either disposed of as non-mixed Low Level Waste (LLW) at SRS or, if the waste was mixed, sent back to storage with no path to disposal.

At this same time, the Mound Site in Ohio was going through closure. DOE decided that efficiencies could be realized if the waste was sent to SRS. Using the already certified SRS program, the Mound wastes would be characterized and shipped to WIPP. The South Carolina Department of Health and Environmental Control agreed, but required a two for one (SRS to Mound) volume disposal commitment. For every cubic meter of waste from the Mound site to come to SRS, two cubic meters of waste had to be shipped to WIPP. Thus the acceleration program was born.

To meet the ‘Mound’ commitment, CCP was brought to SRS. Their equipment was newer and set up for more of a production process versus the laboratory equipment being used by SRS. CCP quickly proved that they could easily characterize waste at a rate that exceeded what was anticipated. A very important role change for SRS and its program took place at this time. SRS would focus on feeding the characterization process line operated by CCP. The SRS characterization process was shut down and CCP became the sole characterization member of the team. Looking back, this allowed each organization to focus on functions that they were best qualified to perform. SRS was to utilize its resources to maintain the authorization basis, deal with prohibited items, control container movement to and from characterization, and control shipping activities.

To improve the efficiency of the CCP process, SRS used its equipment to prescreen the drummed waste. Utilizing Real Time Radiography (RTR) minimized the number of rejected drums found by CCP by segregating drums with prohibited items from the characterization stream. It also reduced the amount of time CCP needlessly expended on characterizing drums with prohibited items (because these drums would have to be re-characterized anyway after PI removal.) These drums were categorized based on the identified reject conditions. To keep all of this expanding information straight and available to multiple planning people, a Microsoft Access database was developed.

The SRS database has kept track of the following information independent of the CCP database:

- Location within storage arrays
- AK information – waste stream, waste type, special considerations
- Prescreen data – prohibited items, Visual Examination (VE) requirements
- Characterization status
- Non-conformance Report (NCR) data generated as a result of characterization
- WIPP Waste Information System (WWIS) approval

Using this information, SRS has been able to manage the day-to-day movement of the containers and verify CCP data accuracy. Errors made during the transcription of drum identification numbers were the most frequent errors throughout the characterization process. By sharing data, a comparison of the two databases allowed SRS to assist CCP by keeping these and other errors to a minimum.

At the height of the SRS program, drums were being fed into the characterization process at a rate of 240 drums per week. SRS was making five shipments per week totaling 30 drums per shipment. Three factors had a significant effect on the processing at this time:

1. Due to age and drum corrosion, many of the SRS containers could not meet the 7A Type A packaging requirements
2. No DOE facility was available for mixed low level waste disposal
3. SRS was the only large site able to feed WIPP with a significant number of shipments per week.

Therefore, DOE authorized SRS to ship to WIPP waste that historically had been managed as TRU waste in load-managed ten-drum overpacks, as long as the overpack container met the >3700 Bq/g (>100 nCi/g) limit. This would allow SRS to dispose of the mixed-TRU waste that otherwise would have been held with no path to disposal. SRS took advantage of its unique position and shipped over 12,200 drums in this fashion during the 2003/2004 time frame.

It is important to note that each TRU waste stream that was load-managed in this way met the TRU activity concentration criterion (>3700 Bq/g, >100 nCi/g) as a waste stream in its entirety. Each had been managed as TRU waste in storage for decades. DOE's logic (with EPA concurrence) was that each met the intent behind the decision to retrievably store TRU waste at generator sites in the 1970s until disposal capacity at WIPP was licensed. Just because a modern container-based NDA analysis indicated an activity concentration less than the TRU criterion in a particular drum, that didn't change the fact that the overall waste stream characteristics met the criterion.

By October 2003, approximately 4,700 drums had been identified as containing prohibited items. Over the next five years, SRS would utilize five different remediation facilities to open and repackage over 10,200 drums.

REMEDIATION OF PROHIBITED ITEMS

The first remediation facility, a glove box housed in a Perma-Con® structure, was limited to 56 Plutonium Equivalent Curies (PEC) due to a Hazard Category 3 facility classification per DOE Standard 1027. (PEC is a normalization of all of the radionuclides contained in a defined volume to a common radiotoxic hazard index based on Pu-239.) The TRU Visual Examination Facility (TVEF) was used to remove aerosol cans, open >4 liter sealed containers that contained no liquids and perform the Visual Examination as a quality control check for NDE. This facility processed close to 5,100 drums during its four year life. The primary facility process restriction was that aerosol cans had to be removed rather than punctured. This resulted in numerous 55-gallon drums filled with nothing but aerosol cans. As the number of rejected drums grew, additional facilities were brought on line. In October 2005, a glove bag facility was constructed in the F-Area laboratory and in June 2006 a glovebox facility was constructed at the Savannah River National Laboratory (SRNL.) Both facilities had the ability to process liquids by absorption. In February 2006 DOE deployed the Modular Remediation System (MRS) which had a nitrogen-inerted atmosphere. And finally, the truck well and the warm crane maintenance areas within the F-Canyon facility were brought on line in September 2006. Each facility had its own limitations. Drum characteristics determined which facility was used. Typical remediation costs ranged anywhere from \$3,000 – \$7,000 per drum.

Before any remediation process began, a diagram generated via RTR showed the location(s) of the identified prohibited item(s). It also provided an estimate of the liquid quantity. This "Fastscan" sheet was the road map used by the remediation facility to find the prohibited items or know what to expect in the case of significant quantities of liquid. Most remediation processes were straight forward: remove the aerosol cans, open the >4 liter sealed containers, and absorb the liquids. Absorption of liquids proved to be the most difficult. Many of the drums contained lab waste with small vials or test tubes, some with small quantities of liquid. As part of the initial packaging and disposal process, the vials were wrapped with several layers of plastic. Due to age and radiation, the plastic had discolored. For the operators performing remediation, it was virtually impossible to tell which bundle contained the identified liquid or even if all of the prohibited items had been found. This resulted in 100% inspection of the contents. For this reason, CCP's Visual Examination process, which allows remediation of prohibited items, was used in many cases for the laboratory waste. When VE was utilized, it met the NDE certification requirement.

Small quantities of free liquid, usually water, proved to be difficult to find and absorb. A plugged drainage culvert during a heavy thunderstorm resulted in a large number of submerged drums. During remediation a "dewatering" program was used to remove water found between the drum wall and the often-used polyethylene drum liner. This was not always successful and in most cases water made its way inside the liner. Small quantities, less than ten milliliters in most cases, were found by RTR in the folds of plastic waste bags. When these drums were opened, water formed a thin sheet or broke up into smaller quantities that dispersed throughout the waste and could not be found. Even though absorbent was added to the drum, the water could collect in another plastic fold and the drum was again rejected by RTR. Repeated remediation became the only answer. Very substantial time and cost was invested to remove these small amounts of water from drums simply to meet the WIPP waste acceptance criteria which prohibited free liquids.

SRS also has identified a population of drums that require content division. A drum's contents must be split if it exceeds:

- the calibration limit of the NDA equipment
- the shipping wattage limit
- a total material content limit.

SRS has not yet found a good method to perform the splitting of the drum's activity.

NONDESTRUCTIVE EXAMINATION

NDE, better known as Real Time Radiography (RTR), is the first step in the actual characterization process. The characteristics of the X-Ray unit are the most important. If the radiographic power is too low, dense collections of objects become impenetrable. This is particularly the case with lead-lined gloves. Sometimes, the historical practice at SRS was that the facilities would change out all of the gloves in a particular glovebox line at the same time. These often ended up in the same waste drum and bunched at the same level or location within the drum. With adequate radiographic power, most identification issues can be resolved to the point of eliminating potential prohibited items. The rest made their way to a remediation facility where VE was performed. If the radiographic power is too high, the fine details of the waste matrix can be "blown through". Most systems can vary the intensity of the X-Ray beam. This is important when discerning punctured aerosol cans and small quantities of liquid. SRS's RTR unit could also tilt the image intensifier and the X-Ray head. By utilizing this tilt function, the operator was able to determine if there was a hole in the liner lid and also see around some impenetrable objects. RTR, compared to the other two characterization steps, identified the largest number of containers requiring further processing by SRS before characterization could be completed.

HEADSPACE GAS ANALYSIS

SRS has always assumed that an unvented drum would have a potentially explosive atmosphere before venting. For this reason, all drums retrieved were vented using a semiautomatic drill head enclosed in a blast-chamber. A high efficiency particulate air (HEPA) filter vent was installed and simultaneously a headspace gas (HSG) sample was obtained. This gas sample was analyzed for hydrogen, methane and flammable volatile organic compounds (VOCs). Based on these results, precautions were taken during the storage of the drums to allow a non-flammable equilibrium to be reached in the drum's atmosphere.

Headspace gas analysis was usually performed as the second step of the three-part characterization process and has proven to be the least problematic of the WIPP requirements. Of the 30,000 drums characterized, CCP has identified fewer than 100 with HSG issues. In most cases, if HSG showed an elevated VOC level, allowing the drum to vent for an additional six months seemed to resolve the issue. Isopropyl alcohol (IPA) has been the one VOC most troublesome. SRS has been moderately successful by taking the drums with elevated VOCs into a glovebox environment, pulling all of the waste out of the drum, exposing the actual waste materials by opening the plastic layers, and allowing the VOCs to escape through evaporation.

NONDESTRUCTIVE ASSAY

NDA has been one of the more difficult characterization activities to accomplish. SRS is working to certify its fourth NDA unit and has over 600 drums that are presenting assay challenges. Unlike RTR failures, there are no simple remediation facilities to remove the prohibited item(s) when NDA identifies an issue. AK has proven to be an important factor in resolving many of our NDA issues. Waste generated in the labs or as a result of a "special" program would many times have a non-standard isotopic distribution. This meant that using a standard isotopic ratio for heat- or weapons-grade plutonium waste contents was impossible. Utilizing the AK report often was the key. Knowing when and where the process actually took place, as well as in what part of the process, often provided enough information to understand the spectrum obtained. Expert analysis was then able to apply a correct isotopic distribution. If it was determined that the "special" program involved neptunium then allowances could be made by the Expert Analysis (EA). Over the past 50 years, SRS also has made a number of special products for DOE ranging from Cf-252 to various medical isotopes. Fortunately, these programs were heavily documented. This AK method has been used for much of the waste generated by those programs.

The first waste streams to be characterized at SRS contained weapons-grade plutonium isotopes. An Imaging Passive Active Neutron / Gamma Energy Analysis (IPAN/GEA®) instrument was used initially for NDA characterization. Using the gamma analysis, the isotopic distribution could be verified and the neutron results utilized to quantify the amounts of materials. This worked well for most of the drums and very well for drums with low quantities of fissile weapons-grade plutonium. But every so often a measurement would seemingly result in an excessive quantity of material being measured. Criticality became a concern. The gamma spectrum showed the waste to contain a standard weapons isotopic distribution material. However neutron-based assay provided a count that was too high to be practical. Based on historical assay analysis and AK of this particular waste stream, (alpha, n) reactions were suspected. (Alpha, n) reactions are well documented in the literature. For this discussion, alpha-emitting isotopes in close proximity to certain fluoride or oxygen isotopes can result in a many-fold increase in the release of neutrons (n), causing the inaccuracies. After review of the AK, fluoride compounds were suspected. Applying a correction factor allowed the waste to be characterized.

A significant portion of the SRS TRU waste contained heat-source plutonium (Pu-238). For these waste streams a gamma instrument, Canberra's IQ3® system, was brought to SRS. This instrument proved to be well-suited to this type of waste and the quantifiable distributions allowed certification of most Pu-238 waste. Again AK played an important part in the analysis of the various waste streams. Waste could be directed to either IQ3® or IPAN/GEA® based on expected isotopics. Some waste proved difficult for either system. Drums contaminated with neptunium created problems for both NDA systems. AK analysis was able to determine time frames for the processing, and product specifications set limits for quantities of material. To fully characterize the waste with neptunium, one of its daughter isotopes, protactinium, had to be measured in addition to the neptunium due to interferences from other daughter activities. Based on decay calculations, the balance of neptunium in the waste was determined.

As characterization proceeded, a growing group of NDA failures collected. These containers generally had increased dose rates anywhere from a few tens of microSievert/hr (mrem/hr) to over 1 mSv/hr (100 mrem/hr) at contact. The IQ3® was recalibrated using attenuators made of cadmium to filter out the lower-energy gamma rays. This method provided some success. A third NDA instrument was brought to SRS, a Canberra Segmented Gamma Scanning System (SGS). This system provided the advantage of increased distance between the detectors and the waste material. This system has been able to characterize many of the containers that were rejected by the IPAN/GEA® and the IQ3®.

As can be seen, NDA of legacy waste materials is not a simple task. Waste generation was not guided by the need to characterize the waste for eventual shipment to WIPP, but rather by a “cold war” mentality of ‘move forward as quickly as possible’. Waste was an unavoidable byproduct and the primary concern was with the amount of usable product being discarded. Many of the standard NDA assumptions are not always true, as implied from the following list:

- Non-standard isotopic distributions
- Non-homogeneous matrices and source distributions
  - Lumped
  - Pancaked at the bottom of a container
- Interfering isotopes and fission products
- Chemical form (alpha, n)
- Background effects (effects of container movement near the measurement system).

FUTURE PLANS FOR TRU WASTE REMOVAL AT SRS

During 2009, SRS will take a critical look at the Site’s remaining TRU waste. This is comprised of five major groups of waste:

1. HEPA Filters
2. Large Boxes
3. Miscellaneous Packaging
4. Problem 55-Gallon Drums
5. Mound/Los Alamos National Laboratory (LANL) Wastes

Already in place, an SRS program is overpacking 3 HEPA filters into a Standard Waste Box (SWB). These containers will be characterized using a newly installed CCP RTR unit and, once certified, the Large Container NDA system. After characterization, these SWBs will be shipped using the Transuranic Package Transporter Model 2 (TRUPACT-II) transportation container. This will supplement the drum program during the second half of 2009.

To avoid size reduction of TRU wastes, DOE has developed two new assay systems and two new shipping components for the TRU program. The Large Container NDA system, already discussed, and a new Large Container NDE system will allow the characterization of large component, high-density wastes. The Large Container NDE system is completing design tests and is expected to be certified during 2009. These two large container systems will support the packaging of waste into a new shipping container, the Standard Large Box 2 (SLB2). The SLB2 is designed to be direct-loaded with TRU waste or to overpack one nominally sized 1.5m x 1.5m x 2.4m (5ft x 5ft x 8ft) box. SRS has repackaged a portion of its large bulk waste into approximately 200 SLB2s already. A new transportation container, the TRUPACT-III, completes the developments. The TRUPACT-III will finish required testing this year; DOE expects certification by the U.S. Nuclear Regulatory Commission (NRC) with shipping to commence in 2010. The TRUPACT-III can hold one SLB2.

To complete the disposal of SRS TRU wastes, a remediation/repackaging facility will be required. High PEC levels in the remaining waste materials will demand a hardened facility with robust ventilation. It is expected that one of the two canyon facilities will be utilized. Personnel exposure concerns, waste isotopic content and physical characteristics will influence the design.

SRS worked to take advantage of opportunities. No new major facilities have been built. While the program has evolved over the past eight years, objectively looking at options and understanding the Ship-to-WIPP requirements have proven to be instrumental to our success. The partnership formed with CCP early-on and the two distinct but complementary roles have resulted in an extremely successful program.