DECONTAMINATION AND VOLUME REDUCTION SYSTEM MASS BALANCE

K. M. Gruetzmacher, S. G. Ferran, S. E. Garner, M. J. Romero, R. M. Bustos
Los Alamos National Laboratory
Los Alamos, NM 87545

ABSTRACT

The Decontamination and Volume Reduction System (DVRS) operated by the Solid Waste Operations (SWO) Group at Los Alamos National Laboratory (LANL) processes large volume, legacy radioactive waste items. The facility is currently classified as a radiological facility. This means that the facility limit for radionuclides important to the operation, such as plutonium and americium, are quite low. The limits are 0.52 Ci for Pu239 (8.4 grams) and Am241 (0.15 grams), and 0.62 Ci (36 milligrams) for Pu238. A great deal of attention is paid to tracking the amount of radioactive material present in the building at any one time. Large waste boxes, up to 10 ft x 12 ft x 40 ft, are assayed prior to entry into the processing building. Inside the building, the waste items are removed from their container, decontaminated and/or size reduced if necessary, and repackaged for shipment to the Waste Isolation Pilot Plant (WIPP) or on-site low-level waste disposal, depending on the final radionuclide assay value of the waste package. Secondary waste produced (e.g., personal protective equipment) is also assayed at the end of the process. A mass balance is done using the incoming and outgoing waste assay values to determine whether there is any significant hold-up material left in the DVRS building.

The large volume of the initial waste packages, the (relatively) small amounts of radioactive material in them, and the tight ceiling on the building inventory require accurate field measurements of the nuclear material. This paper describes the assay techniques, the nuclear material tracking program, and a description of the DVRS process itself. After processing all available low activity legacy oversized waste containers in the DVRS, plans are to upgrade the facility to a Category 2 Radiological Facility, which will increase the threshold limits for radionuclides of interest by a factor of 100. Even with the higher limits, the facility mass balance will remain a critical factor in maintaining the facility within the threshold limits. Other DOE sites across the complex performing decontamination and decommissioning operations face similar challenges related to waste assay and inventory issues. Lessons learned over the life of the project to date are included in this paper.

INTRODUCTION

The Decontamination Volume Reduction System (DVRS) at Los Alamos National Laboratory (LANL) Solid Waste Operations (SWO) facility was set up to process legacy and currently generated oversized transuranic (TRU) waste items. At the start of DVRS operations in 2001, the inventory of existing oversized TRU waste was approximately 2,400 m^3.[1] These oversized waste items come from LANL operations and need to be prepared either for shipment to the Waste Isolation Pilot Plan (WIPP) in standard size containers (normally, 55-gallon drums or standard waste boxes) or for disposal as low-level waste at the LANL low-level waste disposal facility. Some low-level mixed waste will also be generated and sent for treatment and/or disposal off-site. 75% of the materials processed in the DVRS are expected to be low-level, either inherently or through decontamination in the facility. The ability to segregate the waste into TRU and low-level makes this an extremely important facility for reducing the amount of waste that is sent to WIPP and therefore, conserving disposal capacity and costs for the Department of Energy (DOE).

The radionuclide inventory controls on the building are an integral part of the DVRS operation. The radiological facility limit for the building of 0.52 Ci for Pu239 (8.4 grams) and Am241 (0.15 grams), and 0.62 Ci (36 milligrams) for Pu238 are quite restrictive for large waste items whose exact assay value is necessarily uncertain. Non-destructive assay (NDA) equipment is used along with health physics surveys to keep the building compliant with these limits. A database with a near real-time mass balance of incoming and outgoing material is utilized to track the radioactive material inventory.

THE DVRS OPERATION

The DVRS building is a 13,200 ft^2 confinement structure with active ventilation and contamination control. A picture of the DVRS building is shown in Fig. 1. It includes special containment areas for dismantling the large containers, decontaminating metal objects, waste packaging facilities, and a large shear bailer to volume reduce metal to standard size "pucks" for disposal. The pucks are sized to fit within a 55-gallon drum and can also be placed in a standard waste box (SWB).

Fig. 1 The DVRS building at LANL

Historical documentation is used to initially characterize the waste items inside the containers. This documentation may consist of a brief description of the material (e.g., "glovebox"), the radionuclide information available at the time the waste package was sent to LANL's waste facility for storage, the generation site, and the package weight. The first task of DVRS personnel is to get better waste characterization information. Large scale x-ray equipment has been utilized on most packages to get a picture of the package contents. An example of such an x-ray is shown in Fig. 2, which depicts a glovebox housing machining equipment inside a waste container.

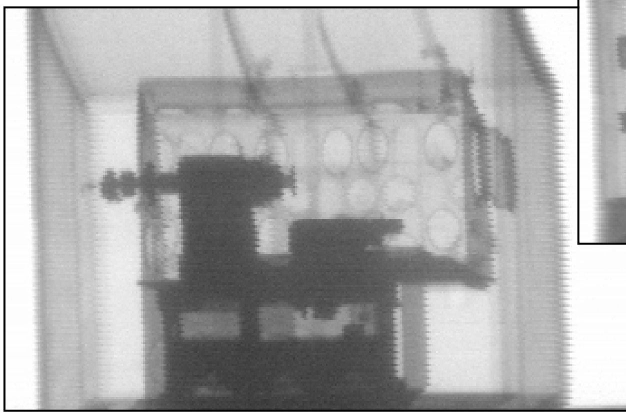
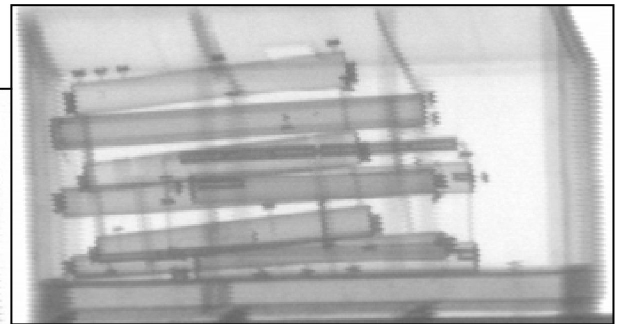

Fig. 2 X-ray of a waste box containing a machining glovebox and one containing pencil tanks

The legacy waste items are as much as 40 years old, and some were determined to be TRU based on generator knowledge rather than actual radioassay measurements. Some items were assayed many years ago on equipment available at the time. Prior to taking an oversized waste box into the DVRS facility, a current waste assay is performed using modern NDA equipment, such as the Large Item Neutron Counter (LINC) and high purity germanium (HPGe) detectors. A sodium iodide (NaI) detector, one of the new generation of hand-held surveillance instruments, is also being incorporated into the process to use as a quick in-process indicator of whether waste is TRU or low-level.

The first stages of processing in the DVRS emphasized simple recharacterization of TRU to low-level waste and repackaging of items such as large high efficiency particulate air (HEPA) filters into acceptable WIPP packages [2]. As of October 1, 2003, 86 m^3 of oversized waste, consisting largely of HEPA filters and combustible trash, have been processed in the DVRS facility, resulting in a 55 m^3 reduction in TRU inventory. This reduction was mainly due to TRU/LLW segregation. Figure 3 depicts a fiberglass reinforced plywood (FRP) box which has been opened for repackaging of the contents into an SWB. During the first two phases of processing, techniques were developed and perfected to perform the standard operations at the DVRS - gas sampling, assay of nuclear materials, opening boxes, segregating and repackaging waste. The DVRS is currently in the process of gearing up to concentrate on two activities, decontamination of metallic TRU waste to low-level, and repackaging of suspect (for prohibited materials) waste. At the same time, ventilation, more sophisticated engineering controls, and process improvements are underway to move the facility into final phase 2 operations. Phase 3, with nuclear facility radioactive material limits (Hazard Category 3), will begin when the revised safety analysis report for TA-54 is approved. This phase will allow for processing of the remaining oversized waste.

Fig. 3 Repackaging oversized waste containers

RADIOACTIVE WASTE ASSAY TECHNIQUES

Waste boxes destined for the DVRS are assayed to determine their radioactive constituents prior to taking the boxes into the facility. After processing, the original waste items and any secondary waste generated during the waste processing are re-assayed using the same technique. This second assay assures a mass balance of nuclear materials entering and leaving the facility and also allows personnel to segregate TRU from LLW items.

The basic NDA techniques in the DVRS process utilize high purity germanium (HPGe) detectors in a far field geometry and the Large Item Neutron Counter (LINC), which is used for items with adequate amounts of TRU radionuclides to make a large item neutron count of practical use. The HPGe system is very versatile and requires an experienced gamma spectroscopist to set up the measurement parameters. The detector is highly shielded from background radiation and can be placed in the best possible position relative to the waste. The length of the waste measurement varies depending on the container type and the waste matrix. The spectroscopist watches the spectrum develop on a laptop computer and changes the parameters and restarts the measurement if necessary. An example of an HPGe measurement setup for DVRS secondary waste assay is shown in Fig. 4.

Fig. 4 HPGe measurement of secondary DVRS waste

The gamma ray spectra collected during the measurement along with the physical parameters of the measurement are used to determine the radionuclide content of the waste. Usually, the spectra are collected utilizing Ortec®'s Isocart system with Maestro®-32 MCA Emulator, pictured in Fig. 4. The spectra are analyzed using Eberline Services Spectral Nondestructive Assay Platform (SNAP™) analysis code. A review of this characterization methodology is included in the DVRS Phase 1 Technical Defense Report [3].

MASS BALANCE

Phase 1 and 2 operations are limited to less than 85% of the hazard category 3 (HC-3) threshold limits on radioactive material (RAM) [4]. Phase 3 allows operation of the DVRS as a HC-3 facility. In order to determine whether a container or a group of containers plus the facility hold-up and radiological standards/sources meet the building RAM limits for phases 1 and 2, an equation that determines the sum of the fractions of all radiological components is used (a similar equation will be used in phase 3):

$$\sum_{n=1}^{m} RAM_n / RAM_{nlimit} \leq 0.85 \qquad \text{(Eq. 1)}$$

Where

RAM_n = the measured activity level plus the uncertainty of each radionuclide

RAM_{nlimit} = currently, the HC-3 threshold limit for each radionuclide

m = the total number of radionuclides

This calculation is performed on a near real-time basis by characterizing the waste, coming into and leaving the facility. Hold-up in the facility is determined based on the inventory difference between the facility input and output values for each container or group of containers. Radiological standards and sources in the building are also counted in the inventory. The four components, the running sum of the input, output (negative), hold-up, and standards/sources together make up the building inventory of RAM. All of this information is tracked on a daily basis using the DVRS Radionuclide Inventory Database.

At the end of Phase 1, the RAM hold-up calculated from the input and output characterization was determined to be minimal. A comprehensive radiation survey of the building, including the HEPA ventilation units indicated that no detectable activity remained in the building. If there had been any positive smear results, they would have been converted to potential total contamination and added to the information in the Inventory Database. Phase 1 consisted of low activity 4 ft x 4 ft x 7 ft boxes of HEPA filters, with a total HC-3 threshold limit fraction for all of the boxes of less than 0.85 required. Figure 5 shows that for all isotopes the activity of the outgoing material was within the 2-sigma error bounds of the activity of the incoming material

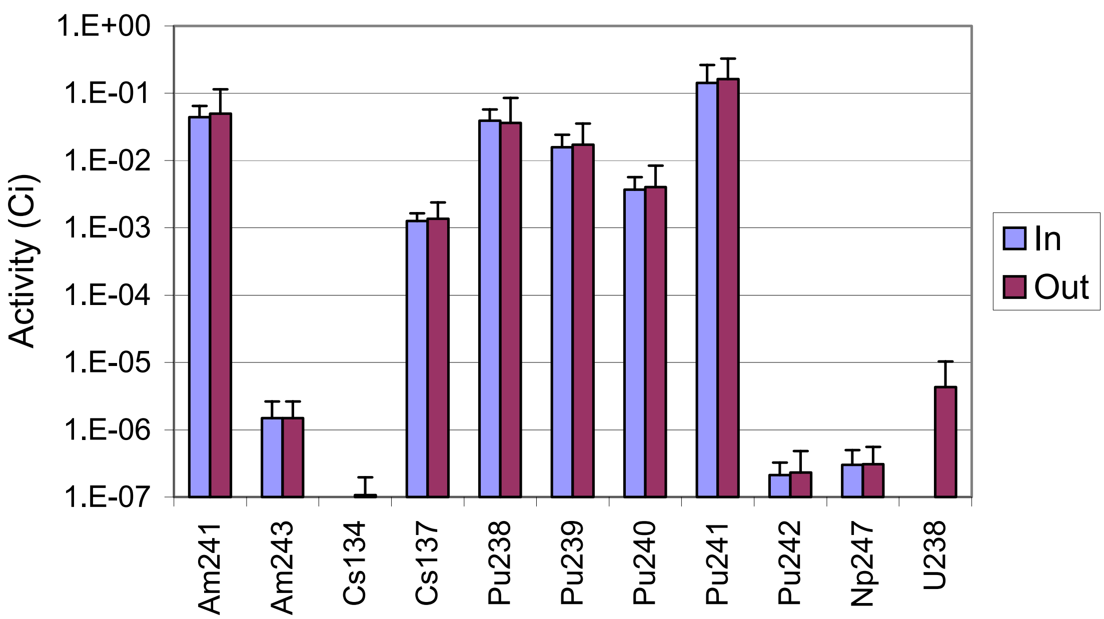

Fig. 5 DVRS Phase 1 mass balance

The database estimates the amount of hold-up in the facility based on the difference between entering and exiting waste. Hold-up is an ever changing number and is created by two processes. The first is a real value caused by the loss of radioactive material from the waste items during processing – onto containment walls and floors, tools, equipment, PPE, filters, etc. The second is an artificial value created by the inherent differences in the gamma spectroscopy or neutron assay results between the container entering the facility and the primary and secondary waste leaving the facility. This difference arises for several reasons and is accounted for in the assay uncertainty.

One reason for differences in assay measurements is the differing properties of the entering and exiting containers. The FRP boxes are made up of plywood that has fiberglass secured to the outside of the container with epoxy-like material. These boxes have a somewhat varying wall thickness. Attenuation of gamma rays in the container walls is therefore not entirely consistent from one box to another, or even on different sides of the same box. The primary waste exits the facility in TRU SWB containers, which have metal walls. The secondary waste is generally only wrapped in thick plastic when it is assayed.

An even larger difference can be created by the waste items themselves. Both their density and their position in relation to other items in a container entering or exiting the facility can be factors in the assay uncertainty. Here again, attenuation of gamma rays makes a difference in the gamma assay. The position of the RAM contamination in relation to the detector contributes to the uncertainty in the results - that is, is it localized on a side, on top of or on the bottom of an item, are other items between the RAM and the detector, etc. Since the configuration of the waste items changes in processing, the assay results for the entering and exiting materials will be somewhat different. In fact, the exiting material will most certainly have a more accurate assay because the composition and position of the waste items is well-known. Similarly, for neutron assay results, while the location of the RAM is not a factor in many cases, the count rate is affected if there is hydrogenous material in the container (e.g., plastics). Neutron assays of plutonium contaminated material depend on knowing the isotopic composition of the RAM. If this is not well-known, the assay results will be incorrect. Neutron assays are also affected by items which may contain contaminants like plutonium fluoride, or certain non-plutonium radionuclides that spontaneously emit neutrons. In addition, neutron assays are not effective for small amounts of plutonium.

Background radiation can affect the assay results. Background radiation rates vary with the amount of nuclear material (natural or man-made) in the vicinity of the counting equipment, the shielding around the equipment, and in the case of neutron detectors, cosmic ray events. The personnel operating the equipment must remain aware of changing conditions in the background rate and assure that the assay results are not affected.

Finally, all assay calculations are based on counting statistics. Good statistics (i.e., large numbers of counts) produce good results. Longer count times produce better statistics. If count times vary between the entering and exiting waste, the results will vary.

Periodically, the real RAM hold-up in the facility is checked to cancel out these artificial hold-up values. This is accomplished by first removing all known radioactive material from the facility, and adjusting the database for these removals. The pre-filters and roughing filters in the fixed and portable HEPA filter systems and the sawdust generated during container cutting operations are removed and assayed separately. This RAM is also accounted for in the database. Then the facility is radiologically surveyed to determine if actual RAM hold-up exists. If RAM is detected, either the surface will be decontaminated, or the actual hold-up amount will be entered into the database. To be conservative, the database assumes that all gross activity detected is Np237, the radionuclide with the lowest HC-3 threshold value. If no activity is detected in the facility survey, it is assumed that the hold-up indicated by the database is artificial and attributed to assay differences. The RAM inventory is re-aligned to initial conditions and the facility is considered free of hold-up. Three of these surveys have been conducted to date, one at the end of Phase 1 processing, one following the processing of the first six containers in Phase 2, and one after processing the second six containers in Phase 2. All surveys have shown no detectable activity in the building.

CONCLUSION

Tight controls are required to meet the DOE requirements for the various phases of container processing in the DVRS building. The Radionuclide Inventory Database is an effective, near real-time method of controlling the inventory of RAM in the DVRS facility. To date, the three comprehensive RAM surveys have shown that there is no hold-up in the building and that the assay results including uncertainty can be reconciled with the "no hold-up" determination based on the survey results.

REFERENCES

1 Romero, M.J., "Decontamination and Volume Reduction System Operation at Los Alamos National Laboratory," presented at the 2003 ANS Annual Meeting, San Diego, CA, June 1-5, 2003.

2 Gruetzmacher, K.M., et al., "Waste Assay and Mass Balance for the Decontamination and Volume Reduction System at LANL," presented at the 44th Institute of Nuclear Materials Management Annual Meeting, Phoenix, AZ, July 13-17, 2003.

3 "DVRS Phase 1 Technical Defense Report," Los Alamos National Laboratory Report, REPORT-SWO-008, February, 2002.

4 DOE Standard 1027 (DOE-STD-1027-92), "Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports Standard 1027," U.S. Department of Energy, December, 1992.