Addressing Challenging Materials at Oak Ridge National Laboratory – 10248

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ABSTRACT

Since the Manhattan Project, Oak Ridge National Laboratory (ORNL) has been engaged in developing processes for implementation in the U.S. Department of Energy (DOE) production facilities and in producing radioisotopes for medical and industrial applications. These activities have resulted in a large variety of unique remote-handled legacy waste and contaminated hot cell facilities. DOE has established a project to dispose of the ORNL legacy waste and to deactivate, decontaminate, and decommission facilities at ORNL no longer needed for the mission. Capabilities are needed to characterize, treat, package, and dispose of various remote-handled solid waste streams for which no treatment capability currently exists at ORNL. This paper describes the approaches under consideration for addressing a range of these challenging materials.

INTRODUCTION

The DOE Environmental Management (EM) cleanup mission at ORNL includes dispositioning of facilities, contaminated legacy materials/waste, and contamination sources; and remediation of soil under facilities, groundwater, and surface water to support final Records of Decision. Capabilities do not exist at ORNL in a single facility or combination of existing facilities to process all remote-handled solid waste streams that will be addressed by the EM cleanup activities. These waste streams cannot be dispositioned unless facilities are available to process the materials for disposal. If they are not processed in a timely manner, new storage facilities and multiple handlings of materials will be required. Some materials are presently located in areas scheduled for decontamination and decommissioning (D&D) and remediation. Existing facilities containing these materials cannot be decommissioned and remediation of the underlying groundwater and soils cannot be completed until the materials are removed. Evaluations are under way to identify cost-effective and timely options for disposition of ORNL's challenging materials.

INVENTORY OF REMOTE-HANDLED SOLID MATERIALS

The remote-handled solid waste streams requiring treatment prior to disposal will be a small subset of the waste streams generated by EM cleanup efforts. It is estimated that more than 90% of this waste can be packaged at the site of generation and shipped directly to off-site disposal facilities and that less than 10% will require additional treatment prior to disposal as remote-handled low level or transuranic waste. The latter volume is addressed in this paper.

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The challenging remote-handled materials that would require treatment prior to disposal at Nevada Test Site (NTS) and Waste Isolation Pilot Plant (WIPP) include

- Transuranic high-efficiency particulate air filters,
- Other large contaminated equipment items removed from facilities prior to D&D by the Integrated Facilities Disposition Program,
- Legacy materials stored in hot cells,
- Activated reactor components in reactors slated for D&D,
- Legacy activated reactor components currently stored on-site or in reactor pools,
- Legacy radioisotope thermoelectric generators (RTGs),
- Other orphan legacy waste,
- Waste from D&D of facilities requiring additional treatment and processing,
- High alpha legacy material and waste,
- Spent fuel and activated metals, and
- Waste generated from ongoing operations requiring additional treatment and processing.

The legacy waste materials described above are expected to bound the treatment and facility design requirements based on physical size, radionuclide content, dose rates, etc. These materials contain approximately 1.85×10^{15} Bq (50,000 Ci) of Pu-238 and Cm-244. Dose rates exceed 1 million R/h at 1 foot for some materials. The materials that must be handled range from less than a couple of centimeters (less than an inch) in all dimensions to extremely large components; the largest identified to date are 30.84 metric ton (34 ton) casks measuring ~3.35 × 3.35 × 2.74 m (~11 × 11 × 9 ft). Included in this list are a number of RTGs containing 10^{14} to ~10^{16} Bq (10^4 to ~10^6 Ci) of cesium or strontium and hazardous components (e.g., mercury)

TREATMENT REQUIREMENTS

Material handling capabilities will be required to receive shielded containers of radioactive materials; open the containers; and then examine, characterize, segregate, size reduce, and process the materials before packaging them for disposal. Capabilities will be provided in the facility to package materials for off-site transport to waste repositories. The capability is needed to load and unload a wide variety of on-site packages, including those used for on-site shipments as well as DOE/Department of Transportation certified shipping packages. These on-site packages include, but are not limited to, the Sugarman ND S-10-13 Model 1 transfer cask, the MK-42 transfer cask, shielded B-25 boxes, and concrete storage casks measuring 2.74 m (9 ft) high with a maximum diameter of 3.25 m (10 ft, 8 in.). A number of the large storage casks have been backfilled with grout that must be mechanically removed in a shielded area to allow recovery of the contents for characterization and repackaging in appropriate disposal containers. Some legacy materials will require special high-alpha processing capabilities to process materials into a solid waste form suitable for disposal.

EVALUATION OF TREATMENT ALTERNATIVES

A bounding case has been developed for characterizing, treating, and packaging for disposal the various remote-handled solid waste streams in a single, new on-site facility [1]. A detailed engineering study is now under way for selection of the low cost option for challenging materials management while minimizing impact on the site D&D schedule. The ultimate goal of this initiative is to address the technical risks, uncertainties, and data gaps associated with the identified disposition options such that the most cost-effective and optimized approach can be implemented for conditioning the target inventories for disposition. The study will compare the baseline single facility with a multiple-technology flowsheet that includes process capabilities such as immobilization, decontamination, shredding, compaction, repackaging, etc. to multiple facilities with simpler flowsheets that include only one or two process capabilities. Likewise, the evaluation will include off-site treatment and/or direct disposal options through more comprehensive application of the performance assessment bounds at the disposal sites.

The initial steps in this process include refining the waste generation estimates and identifying and obtaining additional data needed to support the alternatives evaluations. Enhanced waste stream characteristics and volume estimates are being developed. The original legacy waste volumes used for planning were "in-situ" values based on an estimate of the "as-generated" volumes of the waste in their present configurations—i.e., primarily being stored in facilities slated for D&D. Estimates of the volume of waste after packaging in shielded B-25 boxes, 208.2 L (55 gal) drum overpacks, and/or other specially designed on-site shielded shipping containers for shipment to a storage, treatment, or disposal facility are now being estimated. They are on average approximately 40% higher than the original "as-generated" volumes. Initial D&D waste estimates were obtained by assuming that 10% of the volume of the hot cells subject to D&D would require treatment and/or disposal as remote-handled waste. Actual equipment volumes are now being estimated, and it is being assumed that equipment and 2.54 cm (1 in.) of the surface of the hot cell walls will be removed for disposal as remote-handled waste. The original estimates appear to be fairly consistent with the more detailed "in-situ" volumes presently being developed for hot cell facilities. Similar volume estimates for reactor and waste processing facilities must be developed and converted into packaged volumes for transport, storage, and disposal.

The next step in the engineering evaluation process will be to evaluate individual waste streams for treatment and disposition options. Examples of challenging ORNL materials that will be considered for processing as individual waste streams are described below.

Activated Reactor Components

Beryllium is used as reflector material in the ORNL High Flux Isotope Reactor. The reflectors must be replaced periodically. Natural uranium in the beryllium is transmuted to plutonium through years of neutron capture while in the reactor. Additionally, the beryllium reflectors contain on the order of 10^{15}–10^{16} Bq (hundreds of thousands of curies) of tritium, as well as high levels of carbon-14 and cobalt-60, which restrict disposal options. These 1.22 × 0.61 m (4 × 2 ft) reflectors and other activated metal items (Fig. 1), such as control plates reading 1 million R, components measuring 1.52 × 1.52 × 1.83 m (5 × 5 × 6 ft), bearings, etc., require unique conditioning and packaging for disposition. Additional characterization data is needed to determine the limiting factors for meeting disposal site waste acceptance criteria, and size reduction options, such as underwater cutting, could be required for packaging for disposal.

Fig. 1. Activated reactor components.

Fig. 2. Curium capsule.

High-Alpha Americium–Curium Capsules

Some legacy materials, such as the curium capsules (Fig. 2) used to fabricate targets that are irradiated for isotope production and Mark 42 targets that are the source of heavy elements used for research and isotope production, will require special high-alpha processing capabilities. These high-alpha solids will be received into a facility in shielded casks, removed from containers, examined and characterized (as necessary), dissolved, and then mixed with a dry grout mix (as necessary) to form a solid waste form suitable for disposal. The packaging materials will be cleaned to the extent possible, volume reduced, and then packaged into drums for disposal. Alternative options for disposal for the materials include transport to other DOE facilities for co-processing with other waste streams, upgrading of existing ORNL hot cell facilities, and construction of a new facility on the ORNL site.

High Activity Radioisotope Thermoelectric Generators

A number of RTGs (Fig. 3) containing 10^{14} to ~10^{16} Bq (10^4 to ~10^6 Ci) of cesium or strontium and hazardous components (e.g., mercury and other heat transfer and heat-sensing materials) must be dismantled to allow recovery and segregation of the radioisotope from the hazardous materials and repackaging of the materials to meet waste acceptance criteria and shipping cask limits.

Fig. 3. Radioisotope thermoelectric generator.

Large Concrete Vaults

Oak Ridge has thirty 30.84 metric ton (34 ton) casks (Fig. 4) containing remote-handled waste that must be dispositioned. The casks measure ~3.35 × 3.35 × 2.74 m (~11 × 11 × 9 ft). The waste is heterogeneous in nature, including lab equipment; metal, plastic, and glass containers; personal protective equipment; rags; sand; gravel; tools; sorbents; filters; fission chambers; ion exchange resins; etc. Eighty percent of the waste is greater than Class C, and the waste has been grouted in place in three of the vaults. The waste in these vaults must be characterized, possibly repackaged, and transported to a disposal site. The current baseline calls for opening the vaults to characterize and repackage the waste. However, the current on-site hot cell facilities cannot handle vaults of this size, and the vaults cannot be transported in their current configuration to another facility. Technical barriers that must be overcome include characterization approaches to meet transportation and disposal facility requirements; remote repackaging alternatives, potentially including ones that could facilitate repackaging at the storage site; and transportation alternatives, including shipment of the vaults without repackaging.

Shielded Transfer Tanks (STTs)
Five lead-shielded cylinders (Fig. 5) were used during the 1960s to transport fission products from Hanford's high level waste tanks and mixed actinides and fission product materials from Savannah River Site to ORNL. The tanks have been in storage for over 35 years and contain residual amounts of materials. The issue of potential hydrogen and oxygen buildup from radiolytic hydrolysis must be addressed. Safety issues have been identified with venting the STTs at their present location and with moving them prior to venting. After this technical barrier has been addressed, the STTs must be vented, characterized, repackaged, and transported to a disposal site. Other technical barriers include characterization approaches to meet transportation and disposal facility requirements; remote repackaging alternatives, potentially including ones that could facilitate repackaging at the storage site; and transportation alternatives, including shipment without repackaging.

Fig. 4. Casks of legacy materials.

Fig 5. Shielded transfer tank.

SUMMARY

Capabilities do not exist at ORNL in a single facility or combination of existing facilities to process all remote-handled solid waste streams that will be addressed by EM cleanup activities. If these waste streams are not processed in a timely manner, new storage facilities and multiple handlings of materials will be required and the site's D&D and remediation schedules could be adversely impacted. Evaluations are under way to identify cost-effective and timely options for disposition of ORNL's challenging materials.

Alternatives to be evaluated include packaging and direct shipment of waste from the D&D site, off-site treatment options, and use of a combination of new and existing on-site facilities for waste treatment and packaging. The evaluations will consider the limitations and risks associated with each option, along with cost and schedule, for processing a given waste stream. The evaluation will determine if a combination of treatment options can reduce the costs and schedule for disposition of EM cleanup waste streams from the baseline case of a single facility with multiple technologies to address all waste streams. The potential advantages that could result from this evaluation include accelerating disposition of a large volume of remote-handled waste; a cost reduction for characterization, repackaging, and disposal of waste streams; accelerated closure of waste storage areas at ORNL; and the associated environmental risk reductions.

REFERENCE

1. B. D. PATTON, R. T. JUBIN, S. M. ROBINSON, and S. D. VAN HOESEN, "Unique Remote Handled Waste Management Issues at Oak Ridge National Laboratory," Proc. Waste Management 2009 (March 2009).