

TECHNOLOGICAL ENHANCEMENTS FOR OPTIMIZING THE TRU WASTE MANAGEMENT SYSTEM

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ABSTRACT

On March 26, 1999, the Waste Isolation Pilot Plant (WIPP) received its first shipment of transuranic (TRU) waste. On November 26, 1999, the Hazardous Waste Facility Permit (HWFP) to receive mixed TRU waste at WIPP became effective. Having achieved these two milestones, facilitating and supporting the characterization, transportation, and disposal of TRU waste became the major challenges for the National TRU Waste Program.

After the WIPP began receiving waste, it was evident that, at the rate at which TRU waste was being shipped to and received at WIPP, the facility was not being used to its full potential, nor would it be unless improvements to the TRU waste management system were made. This paper describes some of the efforts to optimize (to make as functional as possible) characterization, transportation, and disposal of TRU waste; some of the technological enhancements necessary to achieve an optimized national transuranic waste system (1); and the interplay between regulatory change and technology development

INTRODUCTION

As a first step toward maximizing TRU waste shipments to the WIPP while ensuring that waste generator and storage sites could comply with the WIPP Hazardous Waste Facility Permit and all other applicable regulations, the Department of Energy (DOE) initiated two studies to identify major issues impacting the National TRU Waste Program. The first study was a detailed evaluation of waste characterization requirements, costs and problems (2). The second study was a complex-wide re-engineering study (3). These two studies identified a number of initiatives to optimize characterization, transportation, and disposal activities.

Even after implementation of the majority of these initiatives, it became apparent that a longer term, more comprehensive look at all activities related to the national TRU waste management system was necessary. WIPP has been operational for nearly three years with an exceptional safety record. Significant challenges still remain in the scientific, engineering, regulatory, and political areas that need to be addressed. The National TRU Waste System Optimization Project has been established to identify, develop, and implement cost-effective system optimization strategies that address those significant challenges. Fundamental to these challenges is the balancing and prioritization of potential regulatory changes with potential technological solutions. In many cases, science and technology will be strong drivers in the need and justification for regulatory change. In other cases, technology will drive increased efficiency. This paper focuses on efforts to optimize characterization, transportation, and disposal operations by planning and implementing technological enhancements.

VISION FOR AN INTEGRATED, OPTIMIZED TRU WASTE SYSTEM

The TRU waste characterization, transportation, and disposal process is a quality assurance and compliance-based process designed to ensure that the WIPP Waste Analysis Plan (WAP) and other regulations are implemented at each generator/storage site. The goal of optimization is to increase the operational efficiencies of the national TRU waste system to allow faster, less-expensive disposal of TRU waste at the WIPP while maintaining safety and regulatory compliance. The vision is to move the process towards a performance-driven characterization approach.

In the context of the national TRU waste system, the desired performance-driven system will be based on operator accountability and the identification and tracking of performance metrics to measure progress toward milestones and provide feedback for additional system improvements. It will focus on identifying and acquiring the waste characterization information necessary to safely manage and dispose of TRU waste at the WIPP. Finally, it will focus on the quality of the data gathered rather than on how the information is acquired and documented, as is the case in the present characterization/certification system.

The features of a performance-driven TRU waste system, shown in Table I, include a performance-driven determination of required TRU waste properties, analytical requirements determined by repository performance, automated data management, and science- and technology-based optimization. Achieving this end state would result in obtaining waste characterization data with the required levels of confidence, reducing occupational worker radiation exposure to levels that are as low as reasonably achievable (ALARA), maintaining minimal risk to the public and environment, shortening the waste disposal schedule, and minimizing life-cycle operating costs.

Table I. Proposed End State for the Optimized National TRU Waste System.

Performance-driven TRU Waste Program
<ul style="list-style-type: none">• Performance-driven determination of waste properties• Analytical requirements determined by repository performance• Verification at centralized characterization facility• Automated data management (transparent)• Science-and technology based optimization

In order to achieve an optimized system, a process for integrating technological enhancements has been established. It is iterative and involves the following steps:

- Identify issues and barriers impeding the flow of TRU waste to WIPP for disposal. This identification can occur from any source within the national TRU waste system.
- Identify and evaluate options for overcoming barriers to the flow of TRU waste from generator/storage sites to the WIPP. Evaluation criteria include: effectiveness and efficiency of process, cost, timeliness, feasibility of implementation, and expert opinion.
- Develop plans to implement those options that will achieve operational economies, compliance, and efficiencies for treatment, characterization, transportation, and disposal of TRU waste at the WIPP.
- Develop and deploy technologies that will have significant, positive impact on the ability of the DOE Complex to characterize, ship, and dispose of TRU waste.
- Review and prioritize the needs of the national TRU waste management system to ensure that all goals of system optimization are being met.

APPROACH

Technology deployments and research development and deployment (RD&D) activities will be used to support breakthrough improvements in the areas of administrative/operational efficiency, regulatory change, and enhancement of the overall efficiency of the TRU waste system. Initial evaluation of the optimization initiatives identified a number of technology deployments and RD&D activities that could increase the efficiency of TRU waste characterization, transportation, and disposal. These activities are coordinated with the TRU and Mixed Waste Focus Area (TMFA) and include:

- Characterization
 - Non-destructive Examination (NDE)
 - Non-destructive Assay (NDA)

- Transportation
 - Payload enhancement initiatives
 - RH TRU waste handling
 - Improved payload containers
- Data Automation
- Corrosion Abatement
- Treatment

Characterization

All TRU waste to be shipped to the WIPP must be characterized (determine the chemical, radiological, and physical attributes of the TRU waste) in accordance with strict criteria. Characterization activities include non-destructive examination (NDE) and non-destructive assay (NDA) on the containers. Currently, there are no proven capabilities for NDE or NDA for remote handled (RH) TRU waste. Visual examination and repackaging of wastes with high radiation fields are extremely labor intensive with associated increases in worker radiation exposure.

Non-destructive Examination Need for Remote-Handled (RH) TRU waste: There is a need to develop an NDE system which can provide the high penetrating power required to interrogate both CH and RH shielded packages. For example, CH waste drums containing large amounts of americium are lead-lined in order to reduce exposure. Current real-time-radiography (RTR) techniques cannot analyze the content of the lead-lined drums. Similarly, RH waste inserts and casks are too thick for conventional RTR analysis. Interrogation may be further complicated by high radiation levels and contributed “white noise” from inside the drum. Ideally, this NDE would be deployed inside a hot cell for RH TRU waste.

While performing NDE outside of a hot cell is advantageous because it requires minimal changes to current technology, observation of prohibited items would then require that the waste container be introduced into a hot cell to remove the items. Therefore, one technology deployment involves configuring a radiography system for hot cell operations. Radiography equipment configured for hot cell operations is expected to be demonstrated in FY03 or FY04.

The TMFA has identified funds in FY03 to address the NDE for RH TRU waste. Emerging improvements in software and hardware should allow commercially available state-of-the-art equipment to perform NDE of shielded and RH TRU waste drums. The detectors would be inside the hot cell and the digital recording equipment outside the cell. Commercially available equipment to examine lead-lined drums and digital technologies that can subtract “white noise” from the background in high radiation fields found in RH TRU waste drums could be deployed through the Accelerated Site Technology Deployment Program.

Non-destructive Assay Need for RH TRU Waste: Two difficult science problems associated with RH TRU waste containers are (1) determining the plutonium-239 fissile gram equivalent content to assure that it is less than the 325 gram-limit, and (2) determining that the thermal power is less than 50 watts for combustible waste containers, and less than 300 watts for noncombustible waste containers. In RH TRU waste, the plutonium radiation signal is small

compared to the very large background of radiation from fission products. New radioassay techniques need to be developed that can determine a small fission neutron or gamma ray signal in the presence of a high gamma-ray background.

The TMFA has initiated development of a suite of technologies to address the characterization of RH TRU wastes: gamma spectrometry used with acceptable knowledge (GSAK) (Technology Management System Number (TMS #) 2053); a multi-detector analysis system (MDAS) TMS# 2042 is expected to be able to address the RH TRU waste with little or no acceptable knowledge. The MDAS is a complex array of detectors, both gamma and neutron. Similar to the proposed NDE equipment, the simplest NDA approach may be to use commercial, "off-the-shelf" equipment with detectors inside a hot cell and the digital recording equipment outside the cell. Modeling followed by experimental work may be needed to demonstrate this capability.

TRANSPORTATION

The objective of the CBFO Waste Transportation Program is to ensure shipment of all of the CH TRU and RH TRU waste inventories. Waste shipments must be performed in a safe, cost-effective manner, in compliance with all governing requirements, and fulfilling DOE site milestones, including closure schedules.

Payload Enhancement Initiatives

Typically, to control radionuclide contamination, TRU wastes are packaged within one or more closed polyethylene or polyvinyl chloride bags prior to being placed in a 55-gallon drum. Each bag provides an "inner layer of confinement." These layers of bags impede transport (diffusion) of radiolytically evolved hydrogen from the innermost bag to the container cavity (headspace), contributing to the presence of potentially flammable mixtures of hydrogen and air in the container. The use of a technology to breach inner layers of confinement inside of drums would provide significant savings to the clean-up and disposal process at many of the DOE TRU waste sites. Breaching of the bagged waste will allow many drums to be shipped, as it will eliminate the build-up of hydrogen gas within the inner bags and will allow shipment of drums that would have been over the wattage limit for the TRUPACT-II. It is anticipated that inner layer confinement reduction in conjunction with hydrogen gas getters would allow a large fraction of the over wattage wastes to meet wattage restrictions without undergoing thermal or alternative oxidation treatment.

There are two proposals for hydrogen gas getters (TMS #s 2021 and 2979). One is the evaluation of a Sol-Gel Metal Hydride at the Savannah River Site and Sandia National Laboratories and the second is the evaluation of a polymer encapsulated DEB at the Idaho National Engineering and Environmental Laboratory and the Los Alamos National Laboratory. Both technologies are in the applied research phase of development.

The TMFA is supporting an Inner Layer Confinement Reduction Program (TMS# 2999). There are two technologies being developed to breach the inner bags of 55-gallon drums. One technology is the Ultra-Bag Buster Technology, a cryogenic technology, and the other one is the NFT Breaching Technology, a mechanical technology. Once these technologies are demonstrated, they will be commercially available for deployment.

RH TRU Waste Handling

Many RH TRU waste sites need equipment capable of loading and characterizing RH TRU waste. The proposed technology development activity involves the development of a mobile system of specialized equipment to perform efficient and cost effective packaging of high activity wastes in approved RH TRU waste canisters. The resultant packaged canisters will then be further processed / characterized prior to shipment to the WIPP. This mobile system must be capable of performing all of the packaging and characterization operations with the canisters in either a horizontal or vertical position in existing hot cell facilities at various TRU waste sites.

The design for an RH TRU waste mobile loader (which can also be used to load CH TRU waste into the TRUPACT-II) has been completed. The mobile loader provides the mobile loading capability at the small quantity sites (SQSs). The design was funded by the CBFO, was completed in FY01, but it is not expected to be deployed until the FY03 timeframe.

Improved Payload Containers

Strict gas generation limits placed on TRU wastes to be shipped in the TRUPACT-II by the Nuclear Regulatory Commission may affect only a small fraction of the overall CH TRU waste inventory (about 1.8% after the approval of Revision 19 of the TRUPACT-II). But that small percentage could result in a significant drum-volume expansion (a factor of as much as 16 to 20 to one). In other words, one drum of the waste with the gas generation limit problem, when repackaged, could result in volume expansion to 20 drums to meet the regulatory requirement.

There are high costs associated with the repackaging of the high wattage waste. The CBFO is investigating alternative payload containers that could eliminate the need for repackaging. One payload container being evaluated for TRU mixed waste that is currently non-shippable to WIPP because of the gas generation limits is the ARROW-PAK™. This is a macroencapsulation treatment technology consisting of a high-density polyethylene (HDPE) sleeve with an HDPE fused end-cap that can be configured in a variety of lengths, diameters, and overall thicknesses.

Data Automation

Data management is a major cost element in the characterization and certification of TRU waste. Estimates for data management run as high as \$4,000 per drum. Under current requirements, as many as 15 separate individuals may have to review the paperwork on every TRU waste container that is certified, and as many as 60 individuals may review the paperwork on at least some of the containers.

An electronic data reporting system is needed to generate WIPP-compliant characterization data packages and to automatically review, verify, validate, and reconcile the data quality objectives, quality assurance objectives, quality control criteria, and calibration requirements. Such a system would significantly reduce the cost of generating these data.

At the October 2001 National TRU Waste Complex Corporate Board Meeting, four different data automation systems were demonstrated. The Corporate Board recommended that the "eQA" System, developed by Canberra, be adopted as the standardized automated data management approach for the Central Characterization Project, and that other sites consider adopting this system. The Board also recommended that work should continue on the NDA Expert Review System, developed by the INEEL with support from the TMFA and deployed at INEEL and LANL.

Corrosion Abatement

Wastes containing high concentrations of chlorinated volatile organic compounds (VOCs) may be subject to extensive corrosion from hydrochloric acid (HCl) generated by radiolysis and hydrolysis reactions occurring in the waste matrix. The acid corrosion can, over time, plug the vent filter or breach the metal waste container. Many of the DOE TRU waste sites list a significant quantity of their total TRU waste streams as probably containing chlorinated VOCs.

Research needs include: (1) understanding the underlying science associated with HCl formation by radiolysis or hydrolysis (2) understanding the solid-gas chemistry of corrosion in various parts of the waste drum, including the filter; (3) developing a non-invasive corrosion sensor that will allow simple and fast determination of the extent of corrosion of the interior surfaces of drums; and (4) developing non-corrosive drum vent filters or other mitigations in conjunction with filter improvements. This is estimated to be a three-year fundamental/applied research project.

Treatment

A number of mobile treatment units must be designed, developed, and deployed to treat a variety of wastes at the TRU waste sites. The highest priority development and deployment is for a thermal desorption unit for removing VOCs from TRU waste. Some work on development of thermal desorption treatment is being performed under the auspices of the TMFA, Alternatives to Incineration (ATI).

A current and projected inventory of mixed TRU waste that needs treatment is being conducted to define the target segment of the TRU waste inventory to be addressed. Then, the treatment options will be evaluated.

There is a need for a mobile treatment unit to treat free liquids in sludges, debris, and liquid TRU wastes. A significant portion of sludge wastes at sites cannot be transported or disposed of at the WIPP because they contain free liquids. TRU waste should contain as little residual liquid as reasonable but must not exceed 1% volume of the waste container. Because of various restrictions on the sites, as well as the cost and time to build a dedicated facility at each applicable site, most SQSs lack a method for removing waste sludges or debris from a drum in order to add absorbent to take up the free liquid. The TMFA is developing a technique to add absorbent at INEEL and this technique may be applicable at the SQSs.

CONCLUSIONS

The overarching goal of the Optimization Project is to increase National TRU Waste System efficiencies sufficiently to enable the NTP vision to be achieved 10 years early. It is essential that technology developments efficiently and cost effectively help the CBFO to achieve its vision of removing all TRU waste from DOE closure sites, to dispose all legacy TRU waste from DOE TRU waste sites with an ongoing nuclear mission, and to certify all newly generated TRU waste as it is generated. Several technology initiatives are in progress under the auspices of the TMFA to help achieve this vision.

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