Contract No:

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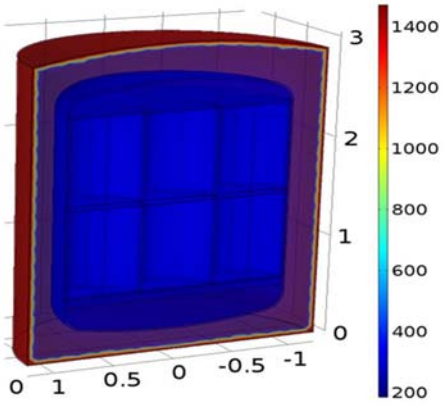
Disclaimer:

Innovative Plutonium Waste Forms: Acceptability to Ship to WIPP

The mission of the Waste Isolation Pilot Plant in New Mexico is the safe and permanent disposition of transuranic radioactive waste from atomic energy defense activities of the United States. The plant consists of an underground repository in a salt formation that is free of flowing water, easily mined, impermeable, and geologically stable. The salt rock naturally seals fractures and closes openings over time. The repository is now anticipated to receive a greater amount of plutonium materials than originally envisioned. An engineered waste form for safe and efficient transport and long-term disposal of plutonium materials is an urgent need. An optimal waste form could also reduce the disposition life cycle and its associated costs to the taxpayer.



(Surface temperature profile, in °F, of a TRUPACT-II with 14 55-gallon drums, each with 19 watts, fully engulfed in a pool fire.)

In the current work, the feasibility of an innovative disposition method of a stainless steel – plutonium waste form, transported in a TRUPACT-II shipping canister and designated as contact handled waste (i.e., dose rate $\leq$ 200 mrem per hour), is investigated. Through criticality assessment and thermal modeling, the stainless steel – plutonium waste form is shown to be a viable option worthy of further investigation.

Awards and Recognition

None.

Intellectual Property Review

This report has been reviewed by SRNL Legal Counsel for intellectual property considerations and is approved to be publically published in its current form.

SRNL Legal Signature

Signature **Date**

Innovative Plutonium Waste Forms: Acceptability to Ship to WIPP

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Subcontractor: None

Thrust Area: NMM

Project Start Date: October 1, 2017
Project End Date: September 30, 2018

Plutonium disposition is a high-profile issue gathering state and national attention. The State of South Carolina is in litigation against DOE due to a lack of plutonium disposition on the legislatively-agreed schedule. Disposal options are needed that can minimize the length and cost of the life cycle for disposition of plutonium materials. Regardless of the waste form utilized, it must be acceptable for disposition at WIPP.

The project objective is to perform advanced modeling studies involving heat loading of waste forms with higher levels of plutonium loading, and studies to optimize plutonium levels and shipping packages that would be acceptable for shipment to WIPP. This project is integral to the overall evaluation of the technical and programmatic issues involved with the acceptability of shipping innovative plutonium waste forms for shipment to WIPP. This is a key objective for the Nuclear Material Management Focus Area to accelerate EM plutonium disposition.

FY 2018 Objectives

- Model criticality with respect to waste form and packaging assembly geometry
- Model waste form heat generation and dose rate
- Examine gas generation characteristics
- Evaluate possibility of Attractiveness Level E designation for waste form
- Evaluate suitability with respect to WIPP acceptance criteria and other regulatory standards

Introduction

WIPP is a deep geologic repository located 26 miles east of Carlsbad, New Mexico. Its mission is the safe and permanent disposition of transuranic radioactive waste from atomic energy defense activities of the United States. The WIPP repository is located approximately 2150 feet underground in a salt formation that is part of the Delaware Basin. This salt formation is free of flowing water, easily mined, impermeable and geologically stable. The salt rock naturally seals fractures and closes openings over time. Disposal of TRU waste began in 1999 and continues today with waste acceptance assisting in the cleanup of 22 generator sites nationwide.

The repository is now anticipated to receive a greater amount of plutonium materials than originally envisioned. An engineered waste form for safe and efficient transport and long-term disposal of plutonium materials is an urgent need. An optimal waste form could also reduce the disposition life cycle and its associated costs to the taxpayer. In particular, if an engineered waste form could qualify as Attractiveness Level E under DOE-STD-1194-2011, significant cost savings

could be realized. Such a waste form could also be used for plutonium disposition at non-DOE facilities outside the U.S.

In the current work, the feasibility of an innovative disposition method of a stainless steel – plutonium waste form, transported in a TRUPACT-II shipping canister and designated as contact handled waste (i.e., dose rate $\leq$ 200 mrem per hour), is investigated. Through criticality assessment and thermal modeling, the stainless steel – plutonium waste form is shown to be a viable option worthy of further investigation.

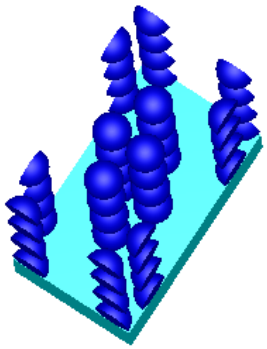
Approach

Potential alternative waste forms were examined based on past and current studies at SRNL. For the selected form(s), advanced studies concerning heat loading and packaging optimization were conducted.

Radioactive material package design involves many aspects for which SRNL has expertise. The project utilized the advanced modeling expertise at SRNL to potentially eliminate the need to perform physical testing. Since new materials are available and can be accurately modeled, the selected waste disposition method can be incorporated into the computer models and a series of parametric studies can determine if a packaging is capable of providing the necessary level of containment to allow the package to be approved for storage at WIPP and transportation within commerce. Factors that must be considered in a new, innovative design include, but are not limited to, weight of the contents and packaging, thermal load within the contents, distribution of the contents within the waste form, total mass of the nuclear material within the waste form, and the dispersal of the contents when impacted in accident scenarios.

Results/Discussion

A waste form consisting of stainless steel alloyed with plutonium was selected for detailed study. This waste form is engineered to be stable, uniform, and self-shielding. The proposed packaging assembly consists of placing stainless steel ingots, or pucks, in 55-gallon drums inside a TRUPACT-II canister to be managed as contact handled waste. The TRUPACT-II canister is well insulated so that heat does not readily reach the surface from the inside, or reach the contents from the outside.

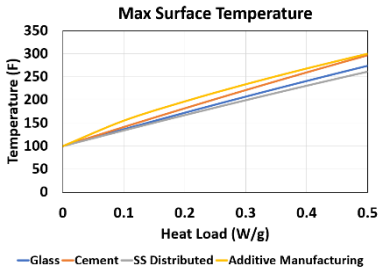


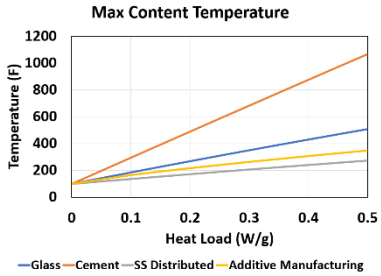
Example of criticality modeling using an infinite array of spheres.

COMSOL Multiphysics® was used to model the thermal properties of the proposed waste forms to be sent to WIPP. An initial scoping study was performed to compare different materials within a single 55-gallon drum. The wattage was varied so that the maximum surface temperature of the drum, and the maximum temperature of the contents of the drum could be calculated. Of the forms examined, stainless steel was shown to have the most favorable thermal characteristics with the lowest temperature of the drum surface and contents.

FY 2018 Accomplishments

- Thermal modeling of the packaging assembly of stainless steel – plutonium alloy-filled 55-gallon drums, in a 7x2 array, was performed for two scenarios to calculate surface temperature profile based on a 19-watt heat source per drum, and to calculate the drum temperature profile in an accident scenario involving a fully engulfing pool fire at 1475° F for 30 minutes.
- Criticality assessments were performed on four ingot geometries. Dry cases resulted in a k_{eff} of less than 0.6. Including water increased k_{eff} , but subcriticality for the analyzed configurations was maintained.





Future Directions

The modeling studies indicate that the proposed disposition method is a viable option and should be investigated further. Future work would include the following:

- Optimization of waste form composition
- Modeling of gas generation, dose rate, and additional criticality studies
- Evaluation of feasibility of designation of the waste form as Attractiveness Level E per DOE-STD-1194-2011
- Obtaining approvals for shipping to WIPP.

FY 2018 Publications/Presentations

There were no reports or presentations from this work during FY 2018. At this time, no presentations are anticipated within the next six months.

References

DOE-STD-1194-2011, DOE Standard: Nuclear Materials Control and Accountability, June 2011

Acronyms

TRU Transuranic
WIPP Waste Isolation Pilot Plant

Intellectual Property

No invention disclosures, copyright disclosures, patent applications, or patents granted.

Total Number of Post-Doctoral Researchers

No post-doctoral researchers involved.