New Payload Initiatives for Shipments to WIPP Will Expand DOE's Ability to Dispose of Transuranic Waste - 9063

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ABSTRACT

The Waste Isolation Pilot Plant (WIPP) shipping and disposal operations currently employ two different disposal methods: one for Contact Handled (CH) waste and another for Remote Handled (RH) waste. CH waste is emplaced in a variety of payload container configurations on the floor of each disposal room. In contrast, RH waste is packaged into a single type of canister and emplaced in pre-drilled holes in the walls of disposal rooms. CH waste containers are shipped to WIPP in unshielded Type B packages licensed by the Nuclear Regulatory Commission (NRC), whereas RH waste is shipped in similarly licensed shielded packages that also include lead to attenuate higher energy gamma photons to meet transportation dose limits. Because the lead employed in the existing shipping packages (called the RH-72B) does not attenuate neutrons, this transportation and disposal system is not able to accommodate neutron emitting waste streams.

Recently, DOE proposed the use of gamma-shielded containers that would allow packaging of gamma-emitting RH waste in a configuration that could be shipped in a CH shipping package and emplaced on the floor of WIPP disposal rooms, while still being counted against repository capacity limits as RH waste. The gamma-shielded containers can be handled by contact. The NRC reviewed the license application for these gamma-shielded containers and the approval is pending, but expected at the end of 2008. Concurrent with the submission to NRC, DOE submitted a planned change request to the U.S. Environmental Protection Agency to allow the placement of the gamma shielded containers in the repository with other CH waste. This paper presents an update of the status of DOE's gamma-shielded container initiative.

In addition to the gamma-shielded container, to increase the versatility of the RH shipping process, the Department of Energy (DOE) is considering the development of a new method to shield neutron-emitting waste, which would be shipped and emplaced using the same RH-72B canister-based system currently employed at WIPP. DOE is evaluating the possible packaging of neutron-emitting RH waste streams in either 57 liter (15 gallon) or 114 liter (30 gallon) drums and shipping them inside a nominal RH canister configured with a high density polyethylene (HDPE) "sleeve" inside. Commercially available thick-walled HDPE tubing could be used to manufacture the sleeves. End-cap inserts (also made of HDPE) would provide neutron shielding for pathways out the axial ends of the canister.

This paper describes the neutron-shielded canister design and possible testing, as well as the regulatory approach that would be used to meet the requirements that apply to WIPP and its associated transportation system. This paper also describes the candidate neutron-emitting RH transuranic waste inventory that could be packaged and disposed in neutron-shielded canisters.

Finally, the status of another packaging initiative, called the TRUPACT-III, which has been in development for several years, is reported in this paper. The TRUPACT-III, a rectangular shipping container also currently under review by the NRC, is a Type B package that will be used to ship boxes too

large to fit in the TRUPACT-II. DOE proposes to over-pack existing fiberglass, plastic, and even wooden boxes into large over-pack containers, referred to as Standard Large Boxes (SLB-2). The SLB-2 over-pack containers will be shipped to WIPP in the TRUPACT-III, unloaded just like other payload containers, and emplaced in the WIPP underground as contact handled TRU waste.

INTRODUCTION

The Waste Isolation Pilot Plant has safely operated as America's first deep geologic repository licensed to dispose of long-lived radioactive waste for almost ten years. Both legislation (Public Law 102-579, WIPP Land Withdrawal Act) [1] and legally binding agreements between the DOE and the State of New Mexico (Stipulated Amendment to the Agreement for Cooperation and Consultation) limit the waste that may be emplaced in WIPP to defense-related transuranic materials.

The vast majority of the waste emplaced in WIPP since opening has been "Contact Handled" (CH) transuranic waste, which is defined as waste exhibiting an external dose rate at the surface of the disposal package less than 2 milli-sieverts per hour (2 mSv/h). In 2007 WIPP received regulatory authorization from the EPA and the State of New Mexico to begin emplacing Remote Handled (RH) waste. RH waste is defined as waste that exhibits a dose rate at the surface of the packaged material in excess of 2 mSv/h. The WIPP Land Withdrawal Act [1] legislated these definitions and numerical criterion.

CH waste is emplaced at WIPP in a number of different container configurations. Examples of the different waste container configurations include 7-packs of 208-liter drums, 3-packs of 380-liter drums, 10-drum overpacks (TDOPs), and standard waste boxes (SWBs). The CH waste container configurations are generally placed in stacks of three on the disposal room floors, with TDOPs being the exception. TDOPs are approximately the height of two stacks of drums, and they are always placed directly on the room floor with a single additional waste container configuration on top. The CH waste is emplaced in the rooms as it arrives. Figure 1 shows an example of CH waste emplaced in WIPP with various container configurations.

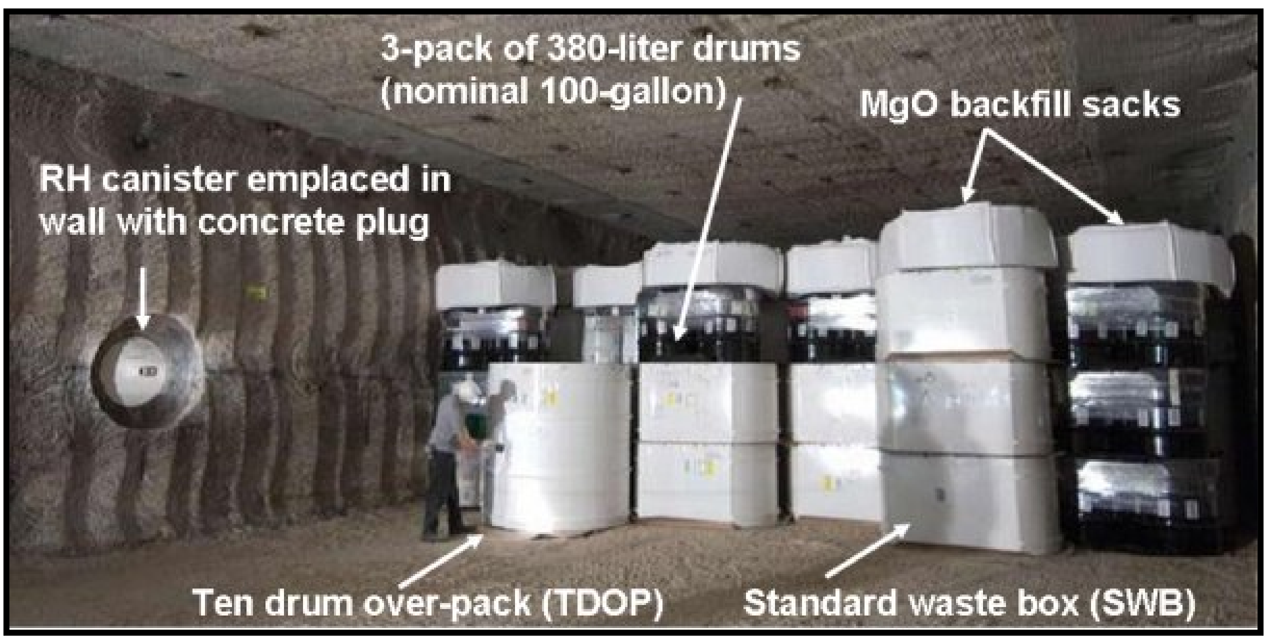

Fig. 1. A previously emplaced RH waste canister has been inserted in the borehole in the wall at left, with a concrete plug in front to shield personnel working in the CH disposal room.

Currently, RH waste is disposed in RH-TRU waste canisters, which are 306 cm long and 66 cm diameter cylinders. The canister walls are 0.64 cm thick and are made entirely of steel. The canister is either directly loaded with RH waste, or it over-packs other RH waste containers (e.g., 208-liter drums or 113-liter drums). The canisters are placed in horizontal holes that are drilled perpendicular to the faces of the walls of the repository rooms, with a concrete plug emplaced in front of the canister to provide shielding for personnel working in the open disposal room. Once the walls of a disposal room have been filled with RH canisters, CH waste is placed on the floor in front of the walls, completely filling the available volume.

As is evident from Figure 1, emplacement of RH waste must occur well before the advancing stack of CH waste reaches individual RH boreholes. In addition, the current RH disposal process requires the use of specialized equipment to drill holes perpendicular to the faces of the repository walls. Only activities solely dedicated to RH borehole drilling may be conducted while emplacing RH canisters.

STATUS UPDATE OF GAMMA-SHIELDED CONTAINER INITIATIVE

In 2007 a gamma-shielded container was designed and tested by the DOE [2]. Figure 2 shows the basic design of the gamma-shielded container. The initial design of the gamma shielded container resulted in very robust performance during testing. Ironically, this was due to the softness of the lead used as the primary shielding material. The 2.54 cm thick lead "sandwich" was chosen somewhat arbitrarily. However, once the lead thickness was chosen, the remaining design parameters derived from that thickness. To simplify construction, it was decide to not make the end pieces with "sandwiched lead", but rather, employ solid thick steel plate that provided an equivalent gamma-shielding capability. This resulted in almost 9 cm thick end caps of solid stainless steel (a filter vent assembly is integrated into the top cap). With a bolted arrangement to affix the top to the lead sides, and with the bottom end welded into the primary cylinder, the overall construction is extremely robust. Drop tests, both outside the HalfPACT shipping container and inside the inner containment vessel of the HalfPACT, with shock absorbing dunnage to protect the integrity of lead shielding in an hypothetical accident condition, showed that the gamma shielded container met all shipping and handling requirements with many times more safety factor than necessary.

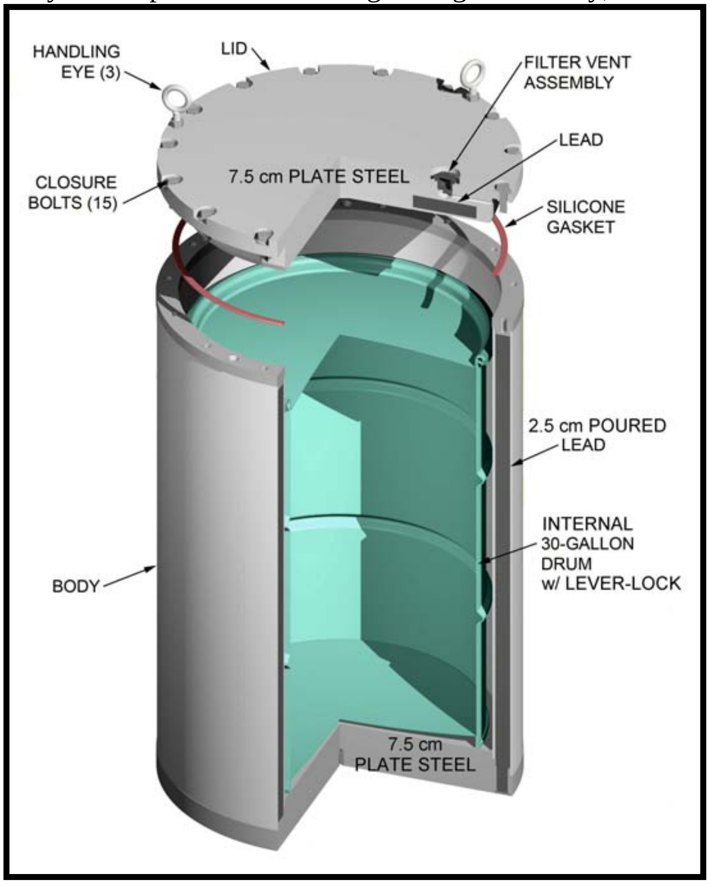

Fig. 2. The Shielded Container design is optimized to accommodate a significant fraction of the RH TRU waste inventory.

Application was made in 2008 to the U.S. Nuclear Regulatory Commission (NRC) for amendment of the certificate of compliance for the HalfPACT shipping package that would allow the gamma-shielded container to be transported to the WIPP [3]. NRC's review of the application is ongoing. However, NRC did issue a request for additional information in November 2008. Nothing in the request would indicate that NRC will suggest any changes to the extremely robust design as submitted. DOE anticipates final NRC approval of the gamma-shielded container as an approved payload configuration in the HalfPACT in early 2009.

In conjunction with the NRC application, DOE also submitted a planned change request (PCR) to the U.S. Environmental Protection Agency (EPA) in December 2007, seeking approval for use of the gamma-shielded container for emplacement of waste at WIPP [4]. EPA's review of the DOE's PCR is ongoing, although DOE anticipates ultimate approval to be granted by EPA also in early 2009, right on the heels of NRC's approval of the amendments to the HalfPACT Certificate of Compliance.

After receiving NRC and EPA approvals for the gamma-shielded container, DOE anticipates submitting a Resource Conservation Recovery Act (RCRA) permit modification request to the New Mexico Environment Department (NMED), seeking to add the gamma-shielded container to the suite of containers authorized for disposal at WIPP. DOE anticipates NMED approval of the addition of the gamma-shielded container in mid-2009.

POTENTIAL NEED FOR NEUTRON-SHIELDED CANISTERS

To increase the versatility of the RH shipping process, DOE is considering the development of a new method to shield neutron-emitting RH waste, which would be shipped and emplaced using the same RH-72B canister-based system currently employed at WIPP. DOE is evaluating the possible packaging of neutron-emitting RH waste streams in either 57 liter (15 gallon) or 114 liter (30 gallon) drums and shipping them inside a nominal RH canister configured with a high density polyethylene (HDPE) "sleeve" inside – see Figure 3. Commercially available thick-walled HDPE tubing could be used to manufacture the sleeves. End-cap inserts (also made of HDPE) would provide neutron shielding for pathways out the axial ends of the canister.

Because surface neutron dose rates measured outside the neutron-shielded canister containing neutron-emitting waste would typically be less than 2 mSv/hr, the neutron-shielded canister would otherwise qualify as CH waste. However, DOE proposes to categorize it as RH waste and dispose of it in pre-drilled holes in the walls of disposal rooms, just like gamma-emitting RH waste.

At this time, the only TRU waste inventory that may require such neutron shielding to meet transportation dose rate limits is managed at the Oak Ridge National Laboratory (ORNL). At ORNL, the Radiochemical Engineering Development Center (REDC) is the production, storage, and distribution center for the heavy-element research program of the U.S. Department of Energy.

The REDC and the neighboring High Flux Isotope Reactor (HFIR) produce quantities of transuranium elements for use in research and nuclear defense applications. Operations for both facilities were begun in 1966. Since then, the REDC has been the main center of production for transcurium elements in the United States, including transuranic isotopes that exhibit high spontaneous fission rates, such as Curium-244 and Californium-252.

Californium-252 (^{252}Cf) is an intense neutron emitter that is readily encapsulated in compact neutron sources. Californium-252 is used in a variety of industrial and research applications, both defense related and commercial. It has a half-life of only 2.6 years and decays by alpha emission (96.9%) and spontaneous fission (3.1%). One microgram of ^{252}Cf emits 2.3 million neutrons/s, each with an average energy of 2.1 MeV.

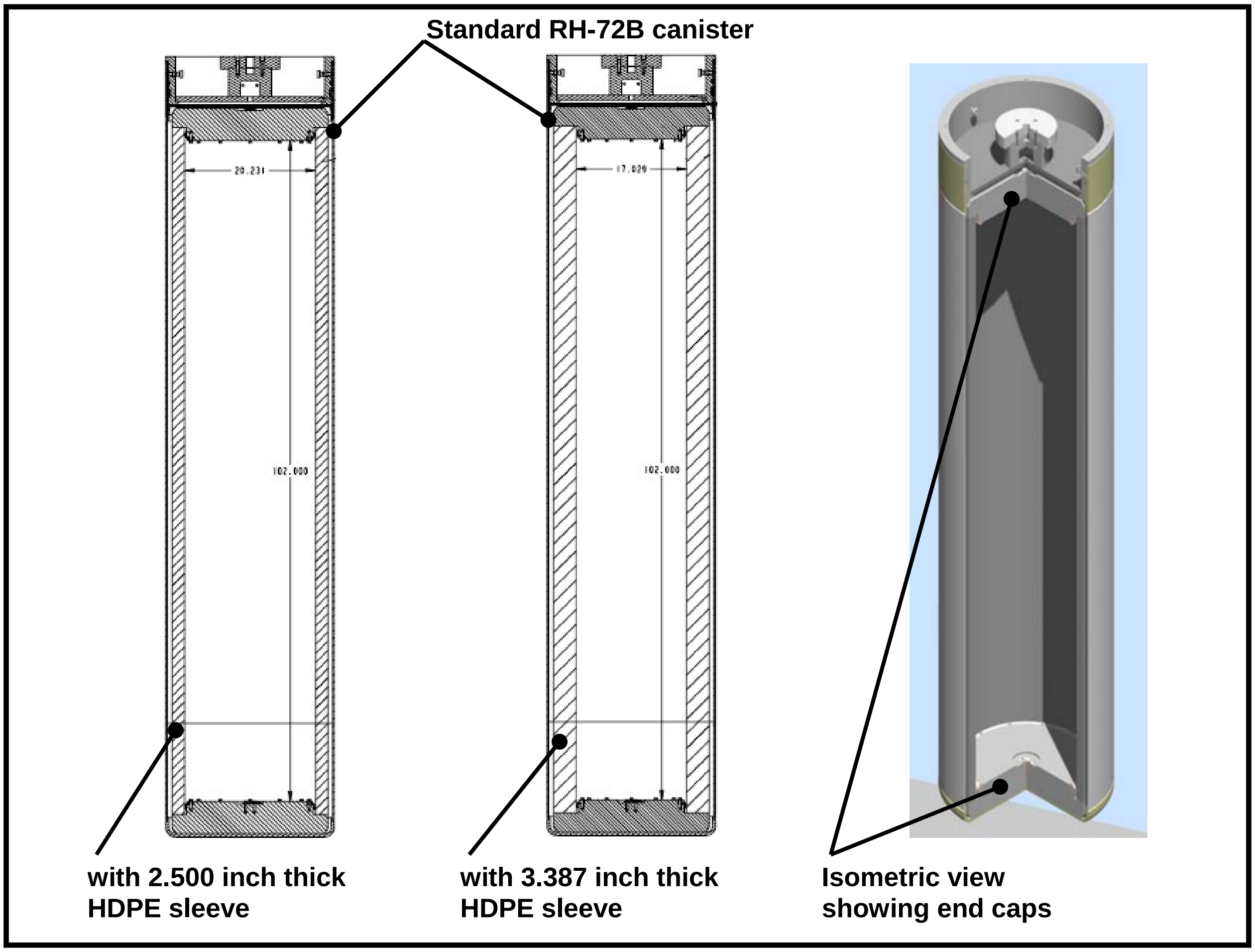

Fig. 3. General arrangement of neutron-shielded canister; note the HDPE sleeve and end caps.

TRU waste at REDC has been managed since the early 1970's for eventual disposal at WIPP, with most in the form of small individual packages placed in a large number of concrete casks (for both gamma and neutron shielding. The neutron and gamma dose rates of many of the small packages were measured when they were placed in the casks.

In 2008, CH waste packaging operations began at Oak Ridge for characterization and WIPP certification. As small packages were retrieved from the casks, screening for prohibited items and dose rate measurements were made. Packaging into 208 liter drums resulted in both contact handled and remote handled waste streams. Some packaging resulted in neutron dose rates that would not be able to be shipped in the RH-72B, and a more detailed analysis of the neutron-emitting waste forms was undertaken to evaluate whether neutron shielding would be necessary for shipping to WIPP. Note this constraint is limited to the Department of Transportation (DOT) dose rate limits during transportation, and not related to dose rate limits for disposal at WIPP.

The dose rate criterion separating CH from RH waste is 2 mSv/h, which can be made up of any arithmetic combination of neutron and gamma dose rates. The DOT dose rate limit during transportation is 2 mSv/h at the surface of the shipping cask and 0.1 mSv/hr at 2 meters from the surface of the shipping cask. This latter dose rate limit, 2 meters away from the cask, is intended to limit the dose to occupants of other vehicles or bystanders during shipment. Because the RH-72B shipping cask was always intended to only provide shielding from gamma radiation, it does not significantly shield neutron-emitting materials. A neutron dose rate just larger than 2 mSv/h at the surface of individual 208 liter drums packaged in a remote handled canister within the RH-72B shipping cask results in a neutron dose rate that would exceed the DOT limit. Thus, the neutron dose rate of waste that can be shipped in the gamma-shielded R-72B cask is limited.

Note that the DOT dose rate limits apply to any shipment. Thus, contact handled waste containing minor amounts of gamma emitting radionuclides, but with neutron dose rates near the CH vs. RH criterion of 2 mSv/h, would not be able to be shipped as CH or RH waste without some form of supplemental neutron shielding. Note the CH shipping packages (TRUPACT-II) does contain almost 20 cm of thermal insulating foam between the inner contents and the outside contact surface, which does provide some neutron attenuation.

A subsequent review of the historical REDC data taken when the concrete casks were packaged over the years was conducted. All historical data and projections of neutron dose rates for this review assumed (anticipated) that the neutron radiation weighting factor would eventually increase to the internationally recognized value of 20. Data included:

- Contact neutron and gamma dose rate measurements of the filled casks
- A calibration relating the cask-contact neutron dose rate to a known mass of ^{252}Cf centered within it
- Neutron dose rate measurements at 1 meter from each of the internal items (typically 4 liter “paint” cans), and
- measurement dates.

This review resulted in only a handful of concrete casks that contained internal packages with sufficient ^{252}Cf that would require the use of a neutron shield within an RH-72B canister. Note that much of the waste when packaged would still require use of the RH-72B since it also contains sufficient gamma emitting material to qualify as remote handled. The handful of concrete casks with sufficient ^{252}Cf to warrant neutron shielding was found to be relatively young. No casks older than those loaded before 1999 exhibited high neutron dose rates.

DOE has determined that because of the relatively small amount of neutron-emitting materials at ORNL at this time, a shielded neutron canister may not be necessary to manage such wastes. Recall that DOE earlier developed a pipe over-pack component for packaging small quantities of neutron emitting material in a polyethylene-lined pipe component. This configuration, in either the S-100 or S-300 version, is licensed by NRC for shipment in the TRUPACT-II or HalfPACT, although the current authorization is only for sealed neutron-emitting sources. At this time, DOE believes that a combination of waste disposal delay/timing (^{252}Cf half life = 2.6 years) and use of the S-100 or S-300 pipe over-pack component can be used to manage the neutron emitting waste from REDC at ORNL. However, DOE is evaluating other neutron-emitting waste streams at other facilities within the defense complex for the need for neutron shielded shipments to WIPP (as either CH or RH).

STATUS OF TRUPACT-III INITIATIVE

A significant fraction of the retrievable TRU waste around the weapons complex is already packaged into large boxes [5]. The exposure hazard and cost of facilities to repackage these boxes into payload containers that could be shipped in the TRUPACT-II led DOE to propose a large box initiative in 2003 that would eventually result in a new shipping container, referred to as the TRUPACT-III. A design based on an Areva shipping container used in France for similar purposes (the Gemini cask), was adopted and a test unit was constructed in 2005. In 2006, DOE tested the TRUPACT-III at the Sandia National Laboratories Aerial Cable Test Facility [Figure 4]. These tests resulted in an initial license application to the NRC in 2007 for shipment of CH TRU waste in the new Type B package. Unfortunately, this TRUPACT-III license application window coincided with the NRC changing its regulations to allow more than $7.4x10^{11}$ Becquerel (20 Curies) of plutonium in a single shipping package. While unrelated, the NRC regulatory update resulted in significant WIPP stakeholder concern, which slowed the application process.

Fig. 4. The French Gemini prototype and full scale testing of the TRUPACT-III

The rigorous TRUPACT-III testing resulted in a design change that also made the license application more complex. The drop test regimen that DOE adopted included loading the test unit with more than the maximum payload requested in the form of loose metal bar stock. The logic behind this worst case payload configuration was that if the TRUPACT-III test design could pass the hypothetical accident condition (HAC) test criteria with loose unpackaged bar stock, then it might be possible to direct load TRUPACT-III containers in the future without requiring any pedigree on interior payload packages. This logic turned out to be unnecessarily onerous.

DOE drop tested the TRUPACT-III test unit (there was only one constructed) with loose metal bar stock multiple times. After multiple HAC impacts, the final leak rate testing indicated a primary seal failure. Subsequent examination showed that the multiple tests had resulted in the creation of significant metal shavings throughout the TRUPACT-III inner containment volume. Since all drop tests were performed in a pressurized condition (to simulate worst case conditions), the overpressure in the final set of drop tests (about 2 atmospheres) resulted in some of the metal shavings being forced into and trapped in the o-ring seals, which was the ultimate cause of the leak rate test failure.

In retrospect, DOE realizes it should have packaged the overweight payload materials into an inner payload container, such as the SLB-2 before testing. DOE believes that had the test payload been contained within an SLB-2 (which is DOT-7A certified), no metal shavings would have been present to compromise the leak rate criteria of the o-ring containment seals – even in the over-pressurized worst case condition of the HAC test. Regardless, DOE subsequently redesigned the o-ring seal area of the TRUPACT-III to include a robust “debris shield” that would keep any loose material within the containment volume from being able to get to the o-ring seals.

The NRC did not agree that the proposed debris shield would work as claimed. It issued a request for additional information in 2008, along with a condition that any subsequent license approval would be contingent on re-testing to demonstrate the debris shield would function as claimed. DOE plans to re-test a second test unit in spring 2009. This time, DOE intends to load the payload material into the SLB-2 before dropping, just like TRU waste would be in the real world application of the TRUPACT-III.

DOE is confident that this second test cycle will result in a successful re-application. If so, use of the TRUPACT-III shipping configuration could begin in late 2010. After NRC license approval, DOE must submit a planned change request to EPA for approval of the SLB-2 as a waste emplacement container. This planned change request will demonstrate that the new waste configuration will not compromise the long term performance of the repository (which should be obvious). Subsequently, a permit modification request to allow the use of the SLB-2 as an approved disposal container must be submitted to the New Mexico Environment Department to demonstrate that the new payload configuration will meet the requirements for protection of human health and the environment from the hazardous characteristics of the waste.

CONCLUSION

These concepts (like shipping what otherwise would be RH waste in shipping packages licensed for CH waste and disposal alongside CH drums; or shipping neutron-emitting waste in polyethylene-lined canisters with less then 2 mSv/hr contact dose rates in RH shipping packages) tend to blur the distinction between CH and RH waste types. DOE is sensitive to the perception by its critics that these shielding configuration proposals represent an attempt to circumvent the RH volume and radioactivity limits placed on WIPP operations. Every effort is being made to ensure that RH waste will conform to the limits set.

The container and shipping package concepts described in this paper will enhance the DOE's TRU waste shipping and disposal system. These enhanced capabilities will allow for potentially faster and more cost-effective cleanups by offering additional waste packaging and shipping alternatives to DOE generator sites. The TRUPACT-III will also provide a viable disposition pathway for large and bulky TRU waste items. These new container designs and shipping configurations are a continuation of the ground-breaking success that has been a hallmark of the WIPP project since its inception.

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