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NOV 1 5 2007

Mr. Juan Reyes
Ariel Rios Building, Mail Code: 6608J
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Washington, DC 20460

Subject: Transmittal of Planned Change Request for Shielded Containers

Dear Mr. Reyes:

This letter and its attachments provide the U.S. Department of Energy (DOE) request for U.S. Environmental Protection Agency (EPA) approval to emplace a portion of the Remote-Handled (RH) Transuranic (TRU) Waste in shielded containers in the Waste Isolation Pilot Plant (WIPP). RH TRU waste can be emplaced in a shielded container if the dose at the surface of the container is less than 200 mrem/hour. The containers will be transported to WIPP in the Nuclear Regulatory Commission-certified HalfPACT transportation containers. The shielded containers will be managed and emplaced on the floor of the repository in a fashion similar to what is used for CH TRU waste, although these containers will still be recorded as RH TRU waste in the WIPP Waste Information System, and the volume of the waste will be counted against the limit of 250,000 cubic feet (7,079 cubic meters) of RH TRU waste, as set by the Consultation and Cooperation Agreement between the DOE and the state of New Mexico. The proposed approach differs from the present practice of emplacing all RH TRU waste in canisters in the walls of the WIPP repository. This request is being submitted to increase the efficiency of utilization of the WIPP facility by easing the restrictions on waste handling needed during emplacement of RH waste canisters in the walls of the rooms.

The robustness of the shielded container design has been demonstrated by its passing the Department of Transportation (DOT) and the Nuclear Regulatory Commission (NRC) drop tests. A Performance Assessment (PA) was conducted to evaluate the effect of shielded containers on long-term repository performance. The PA showed that the emplacement of RH TRU waste in shielded containers has no discernable impact on the current WIPP baseline or on postulated releases. The attached documentation provides additional information and justification for this Planned Change Request (PCR), along with a Fact Sheet on the subject that can be used to inform the public of DOE's PCR submittal.

This change request was prepared in accordance with Title 40 CFR 194.4 and DOE believes that this is a non-significant change that does not require a rulemaking. If you have any questions regarding this request, please contact Russell Patterson at (505) 234-7457.

Sincerely,

David C. Moody

David C. Moody
Manager

Enclosure

CBFO:AMO:RP:KJB:07-2218:UFC5486

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cc: w/enclosures

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Planned Change Request for Shielded Containers

Summary

The U.S. Department of Energy (DOE) is proposing to package and emplace a portion of the Remote Handled (RH) Transuranic (TRU) Waste inventory in shielded containers at the Waste Isolation Pilot Plant. The use of the shielded containers will enable DOE to expedite the cleanup of various TRU waste sites by significantly increasing the rate at which portions of the RH TRU waste can be received and emplaced at the WIPP. The shielded containers will be transported to WIPP in the HalfPACT transportation container. The shielded containers will be managed and emplaced in the rooms of the repository in a fashion similar to what is currently used for Contact Handled (CH) TRU waste. The robustness of the containers has been demonstrated by passing the Department of Transportation (DOT) 7A Type A and the Nuclear Regulatory Commission (NRC) Type B drop tests and are awaiting regulatory approval.

The RH waste that will be emplaced in shielded containers is included in the current inventory for the WIPP. Candidate RH waste streams for shipment and disposal in shielded containers have been selected based on the requirement to keep the radiation surface dose rate below 200 millirems per hour (mrem/h). These waste streams and containers will remain designated as RH waste in the WIPP Waste Information System (WWIS).

A performance assessment (PA) was conducted to evaluate the effect of emplacing shielded containers in the disposal rooms on long-term repository performance. Bounding assumptions were used to evaluate the effects of emplacing shielded containers in the repository. Results show that the WIPP will continue to comply with the containment requirements.

This document and its attachments demonstrate that emplacing RH waste in the WIPP using shielded containers will not have a significant impact upon repository performance.

1.0 Current Practice for RH TRU Waste

Currently RH TRU waste is loaded into a single type of container, the RH TRU waste canister. This canister is cylindrical in shape with approximate dimensions of 120 inches in length and 26-inches in diameter. The canister walls have a nominal thickness of 0.25-inches and are constructed entirely of steel. The canister is either directly loaded or loaded with waste that that has been pre-packaged in 55 gallon drums, 30 gallon drums or metal cans. Shipment of the canisters is in the RH-TRU 72-B Cask, an NRC Type B certified transportation container. Another Type B container that will be used to ship RH TRU waste is the CNS-10-160B. In this cask the waste is shipped in 55-gallon drums. The 55-gallon drums are then loaded into canisters at the WIPP facility. For disposal the canisters are placed in holes that are drilled in the walls of the disposal rooms.

2.0 Proposed Change

2.1 Description of Shielded Container

The shielded container has approximately the same exterior dimensions as a 55-gallon drum and is designed to hold a 30-gallon drum. The cylindrical sidewall of the shielded container has 1-inch thick lead shielding sandwiched between a double-walled steel shell as shown in Figure 1. The external wall is 1/8 inch thick, and the internal wall has a thickness of 3/16 inch. The lid and the bottom of the container are made of carbon steel and are 3-in thick. The empty weight of the containers is approximately 1,800 pounds. The shielded container and the inner 30-gallon drum will be vented. The container has been tested to DOT Type 7A and NRC Type B Hypothetical Accident Conditions (HAC) specifications. This will ensure the container is safe for transport and handling and will contain and shield the waste under the most severe accident conditions.

2.2 Performance Assessment

The DOE demonstrates compliance with the containment requirements according to the Certification Criteria in Title 40 CFR, Part 194 by means of PA calculations. WIPP PA calculations are used to estimate the probability and consequence of radionuclide releases from the repository to the accessible environment for a regulatory period of 10,000 years after facility closure, and compared to regulatory limits.

The baseline assumption in WIPP PA is that all RH TRU waste would be emplaced in canisters in the walls of the repository. An impact assessment, termed the Shielded Container Performance Assessment (SCPA) was conducted in the following five step process to quantify the affect of shielded containers use on long term repository performance:

1. Evaluate the WIPP PA baseline assumptions, models, and parameters to determine which are affected by the use of shielded containers;
2. Develop an analysis design to incorporate necessary modifications to the baseline approach;
3. Develop necessary parameters for the SCPA;
4. Execute WIPP PA codes; and
5. Conduct an analysis of results, including a comparison with baseline predictions of long term repository performance.

The review of WIPP PA determined that the primary modification to the baseline assumptions was the re-location of a portion of the RH TRU waste from boreholes in the walls of the waste rooms to the disposal rooms. This change requires the creation of new parameters in certain PA models. The new parameters represent the fraction of repository volume occupied by waste and the area for RH TRU waste disposal in the walls of the repository for scenarios that model the inclusion of shielded containers. It was determined that no other changes to the baseline were necessary to represent the presence of shielded containers.

The SCPA used a bounding approach to model the effects of waste in shielded containers. The baseline scenario (SCPA scenario 1) assumes that all of the RH TRU waste is emplaced in canisters in the walls of the repository. SCPA scenario 2 assumes that all of the RH TRU waste is emplaced in shielded containers, rooms of the repository. No other changes were made to the PA baseline for this scenario. SCPA scenario 3 assumes that half of the RH TRU waste is emplaced in shielded containers in the rooms of the repository and half of the RH TRU waste is emplaced in canisters in the walls of the repository. No other changes were made to the PA baseline for this scenario. A comparison of the results from SCPA scenario 2 and SCPA scenario 3 to the baseline estimates of releases in SCPA scenario 1 identified the effects of the emplacement of shielded containers on repository performance. As described below, the effect was not discernable.

A single, composite waste stream is used to represent all of the RH TRU waste in SCPA scenarios 1 through 3. SCPA scenario 4 is a repeat of SCPA scenario 2, with the exception that the 77 individual RH TRU waste streams are explicitly represented instead of using a single average waste stream to represent the RH TRU waste. A comparison of the results from SCPA scenarios 2 and 4 identified the effects of using an average RH TRU waste stream to represent all RH TRU waste.

The SCPA concludes that the WIPP continues to comply with the containment requirements specified in 40 CFR §191.13 if RH TRU waste is emplaced in shielded containers. The results with shielded containers in scenarios 2, 3 and 4 are not discernibly different than the results of the current compliance baseline with scenario 1. This statement applies to all release pathways: cuttings and cavings, spallings, direct brine releases, groundwater releases, and total releases. Furthermore, the explicit representation of individual RH TRU waste streams is not warranted since the representation of RH TRU waste with a single, composite RH TRU waste stream does not result in discernibly different results than when individual RH TRU waste streams are used.

- The radionuclides Cs-137, Co-60, and Sr-90 are much more prevalent in RH waste, but their impact on long-term performance is negligible because these radionuclide have relatively short half-lives of 30, 5, and 29 years, respectively (Leigh and Trone 2005). After roughly 100 years the total activity of RH waste is approximately 0.1% of that of CH waste.

- The remote-handled (RH) waste inventory is limited to a maximum volume of 7080 m^3 (250000 ft^3) which accounts for approximately 4% of the total waste volume (DOE 2004).

The summary report for the SCPA is provided in Attachment 1, Analysis Report for the Shielded Container Performance Assessment, Sandia National Laboratories, 2007.

2.3 Waste Inventory

An analysis of RH TRU waste streams was performed to determine which waste streams could be loaded in shielded containers and meet the 200 mrem/hour limit surface dose rate limit. This analysis started by calculating the number of 30-gallon drum equivalents expected to be generated using the WIPP capacity volume for RH TRU waste (7,080 m^3). Each 30-gallon drum will be inserted in a 55-gallon shielded container (see Figure 1 for a drawing of the shielded container). Once the number of shielded containers was determined, the inventories of cellulose, plastic, and rubber (CPR), steel, and lead used in packaging and emplacement were determined. Though DOE does not plan to put the entire inventory of RH waste into shielded containers, this assumption was made to identify an upper bound on the change to CPR, steel, and lead inventories. The emplacement scenarios for the shielded container, for purposes of this analysis, assume that 3-packs will be stacked 3 high in the WIPP repository. As part of this analysis, the RH TRU waste inventory was also screened using gamma factors and Microshield® evaluations to estimate the limiting gamma emitter activity per shielded container that would produce a contact dose of less than 200 mrem/h. Candidate waste streams were then selected from populations of drums that have a high probability to be adequately shielded (i.e. are less than 200 mrem/h) for handling based on these calculations. The details of his analysis are provided in Attachment 2 - Analysis of RH TRU Wastes for Containment in Lead Shielded Containers, INV-SAR-08, Rev. 0, Los Alamos National Laboratory-Carlsbad.

2.4 Operations

Upon arrival at the WIPP facility, the shielded containers will be processed in the same fashion as CH TRU waste. After receipt at the WIPP facility, the 3-pack assemblies will be removed from the HalfPACT transportation container using existing lifting fixtures and equipment in the CH Waste Handling Building. The 3-pack assemblies will remain intact and will enter the sequence of operations and will be processed, tracked and downloaded to the underground repository along with CH containers. The 3-pack assemblies of shielded containers will be emplaced randomly in the underground disposal rooms along with the CH waste. Figure 3 shows a typical anticipated emplacement configuration, with 3-pack assemblies of shielded containers interspersed with CH container types. Emplacement of the 3-pack assemblies of shielded containers is expected to utilize existing waste handling equipment and fixtures.

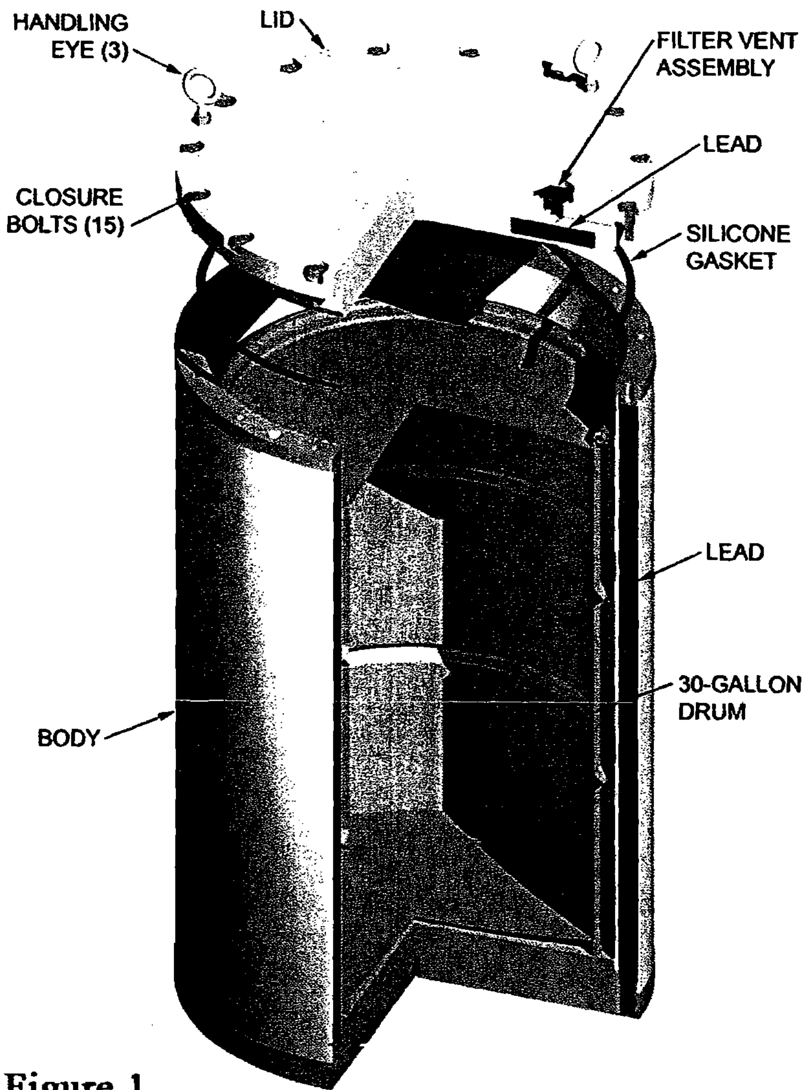
The handling and emplacement of shielded containers will have minimal impact on waste handling equipment and ventilation systems. For example the slip sheets will be modified to accommodate the 3-pack assemblies and a new triangular spaceframe pallet will be developed. The WWIS (WIPP Waste Information System) will be used to track the waste components, packaging, transportation and emplacement information in the same method as other waste that is transported and emplaced at the WIPP. The waste will be tracked as RH TRU waste. Certain data fields in the WWIS will be modified to accommodate the new payload container and associated waste component limits.

2.5 Transportation

The shielded containers will be assembled in a 3-pack configuration on a triangular pallet, be surrounded by radial and axial dunnage components, and be transported within the existing HalfPACT transportation container. The 3-pack configuration will remain intact throughout transportation and emplacement (Figure 2). The shielded container is designed to stay within the parameters of the HalfPACT design and licensing bases e.g., payload weight, decay heat and radiation dose rate limits. To ensure the robustness of the container, it was subjected to DOT 7A Type A testing that included 4 foot drops of the bare container onto an unyielding surface using four potentially worse-case orientations. As part of the safety analysis, a 3-pack of containers was drop tested 30-feet inside a HalfPACT ICV (Inner Containment Vessel) as part of the Hypothetical Accident Condition (HAC) evaluation required by Title 10 CFR Part 71. The HAC tests evaluate and ensure the containers will adequately shield the RH TRU waste contained within under the most severe accident conditions. The thermal, shielding and criticality evaluations were performed by analysis using similar methodology as presented in the HalfPACT Safety Analysis Report (SAR), RH-TRU 72-B SAR and the TRUPACT II SAR. The tests were successful and the results will be used to demonstrate compliance with all applicable DOT and NRC standards, ultimately leading to certification of the payload container as a DOT 7A, Type A container and as an authorized payload container for shipment within the NRC certified HalfPACT Type B Packaging. DOE is awaiting regulatory approval. The success of this testing proved the container is safe even after being subjected to worst case severe handling or accident condition impacts as specified within the DOT and NRC regulations.

3.0 Conclusion

The results of the Shielded Containers PA indicate that the shielded containers will have a minimal impact on long-term repository performance and therefore on compliance with the 40 CFR Part 194 requirements. With regard to the Waste Inventory, the DOE will not be adding or removing RH TRU waste streams and will be selecting those that will not exceed the surface dose rate limit of 200 mrem/hr when emplaced in shielded containers. The impact on the WIPP facility and operations will be limited to revision of certain aspects of the WWIS and to procedural changes to the process of transporting, handling and emplacement of the shielded containers. The addition of this payload container will allow DOE to realize greater efficiencies in transporting and emplacing RH TRU waste in a safe and compliant manner.



HANDLING EYE (3)
LID
FILTER VENT ASSEMBLY
LEAD
CLOSURE BOLTS (15)
SILICONE GASKET
LEAD
30-GALLON DRUM
BODY

Figure 1

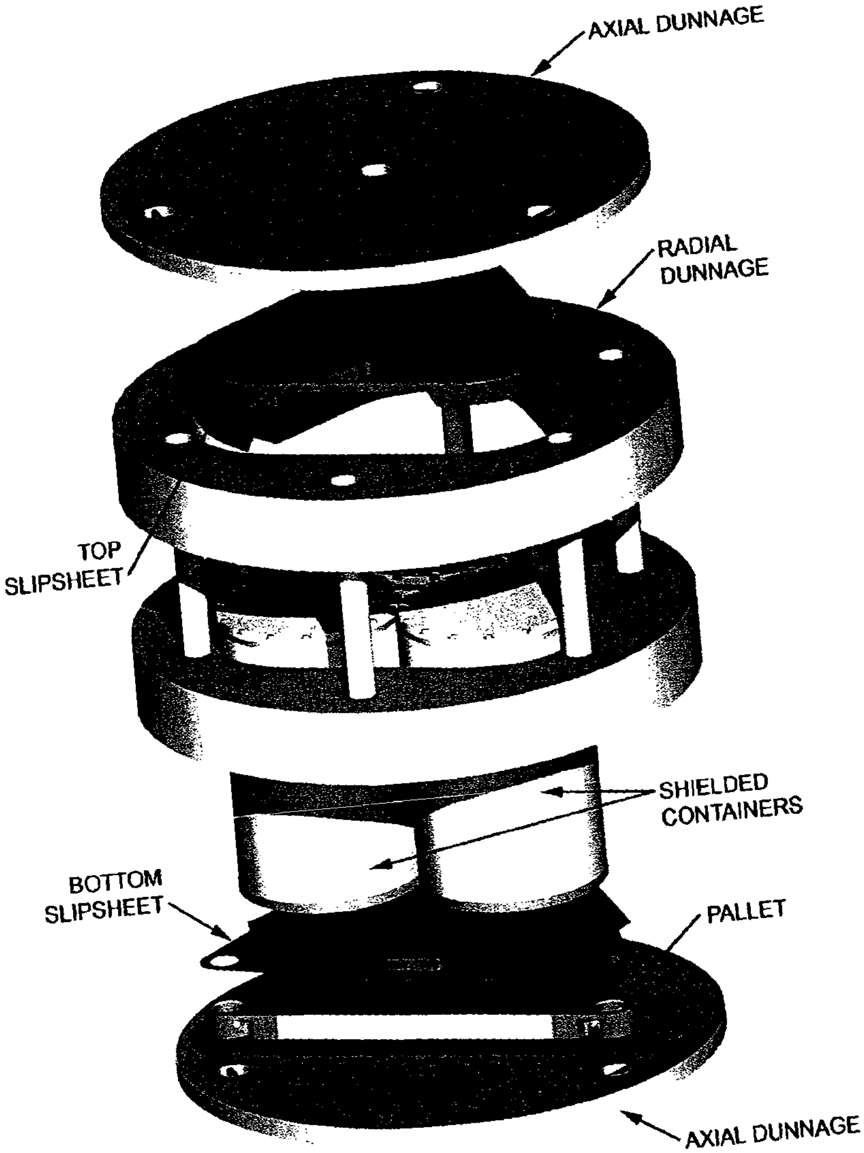

AXIAL DUNNAGE
RADIAL DUNNAGE
TOP SLIPSHEET
SHIELDED CONTAINERS
BOTTOM SLIPSHEET
PALLET
AXIAL DUNNAGE

Figure 2

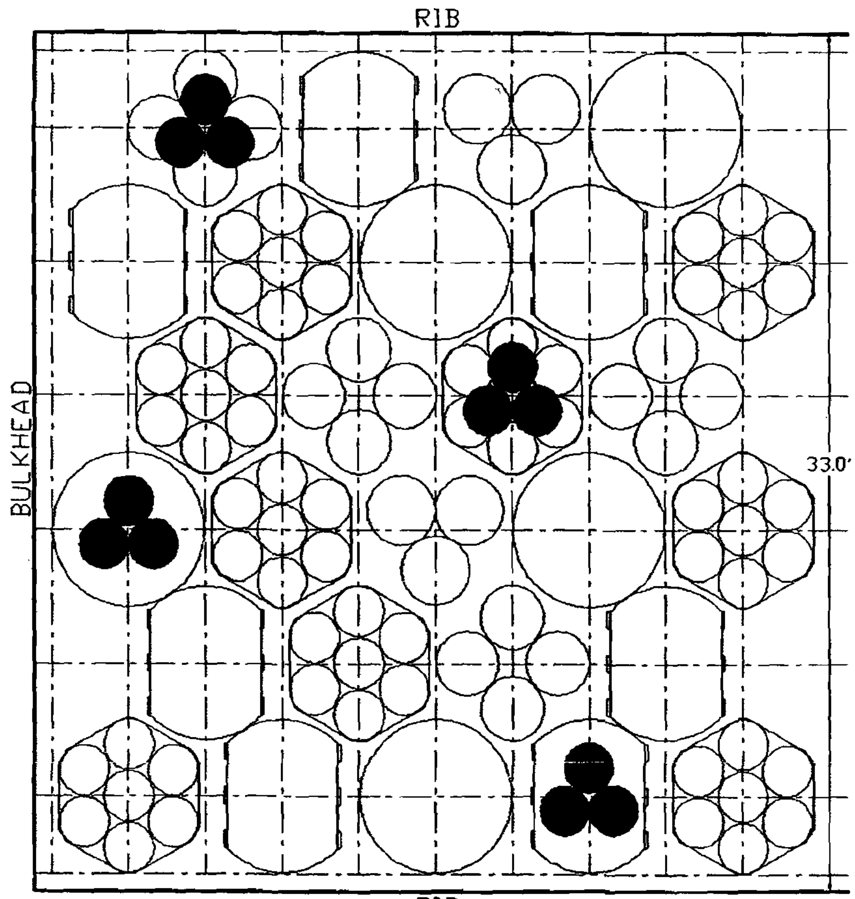


Figure 3

Shielded Containers - Randomly Emplaced

References

DOE. 2004. Title 40 CFR Part 191 Compliance Recertification Application for the Waste Isolation Pilot Plant, DOE/WIPP 2004-3231, 10 vols., US Department of Energy, Carlsbad Field Office, Carlsbad, NM.

Leigh, C. D. and Trone, J.R. 2005. Calculation of the Waste Unit Factor For the Performance Assessment Baseline Calculation, Rev. 0. Sandia National Laboratories. Carlsbad, NM. ERMS 539613.

Sandia National Laboratories
Waste Isolation Pilot Plant

Analysis Report for the Shielded Container Performance Assessment, Revision 1.0

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WIPP:1.4.1.2:PA:QA-L:546255

walls of the repository, emplaced in canisters. SCPA scenario 2 assumed that all of the RH waste would be emplaced in shielded containers, located on the floor of the repository. No other changes were made to the baseline approach for this scenario. SCPA scenario 3 assumed that half of the RH waste would be emplaced in shielded containers located on the floor of the repository and half of the RH waste would be emplaced in canisters located in the walls of the repository. No other changes were made to the baseline approach for this scenario. A comparison of the results from SCPA scenario 2 and SCPA scenario 3 to the baseline estimates of releases identified the effects the emplacement of shielded containers on repository performance.

In the baseline scenario (and SCPA scenarios 2 and 3), a single, composite waste stream was used to represent all of the RH waste. SCPA scenario 4 is a repeat of SCPA scenario 2, with the exception that the 77 individual RH waste streams are explicitly represented instead of using a single average waste stream to represent the RH waste. A comparison of the results from SCPA scenarios 2 and 4 identified the effects of using an average RH waste stream to represent all RH waste.

This analysis concludes that the WIPP continues to comply with the containment requirements specified in 40 CFR 191.13 when representing the disposal of RH waste in shielded containers. Analysis results with shielded containers are not discernibly different than the results of the current compliance baseline. Moreover, this analysis concludes that the packaging and emplacement of RH waste in shielded containers has no discernable impact on releases. This statement applies to all release pathways: cuttings and cavings, spallings, direct brine releases, groundwater releases, and total releases. Furthermore, the explicit representation of individual RH waste streams is not warranted since the representation of RH waste with a single, composite RH waste stream does not result in discernibly different results than when individual RH waste streams are used.

List of Figures

1 INTRODUCTION

The Waste Isolation Pilot Plant (WIPP) is a deep geologic repository developed by the U.S. Department of Energy (DOE) for the disposal of transuranic (TRU) radioactive waste. Containment of TRU waste at the WIPP is regulated by the U.S. Environmental Protection Agency (EPA) according to the requirements set forth in Title 40 of the Code of Federal Regulations (CFR), Part 191. The DOE demonstrates compliance with the containment requirements according to the Certification Criteria in Title 40 CFR, Part 194 by means of performance assessment (PA) calculations that are conducted by Sandia National Laboratories (SNL). WIPP PA calculations are used to estimate the probability and consequence of radionuclide releases from the repository to the accessible environment for a regulatory period of 10,000 years after facility closure.

PA calculations were included in DOE's 1996 WIPP Compliance Certification Application (CCA, DOE 1996), and in a subsequent Performance Assessment Verification Test (PAVT, MacKinnon and Freeze 1997a, 1997b, 1997c). Based in part on the CCA and PAVT PA calculations, the EPA certified that the WIPP met the containment criteria, and the WIPP was approved for disposal of transuranic waste in May 1998 (EPA 1998). PA calculations were also an integral part of DOE's 2004 WIPP Compliance Recertification Application (CRA-2004, DOE 2004). During their review of the CRA-2004, the EPA requested an additional performance assessment calculation be conducted with modified assumptions and parameter values (Cotsworth 2005). This PA is referred to as the WIPP 2004 Compliance Recertification Application Performance Assessment Baseline Calculation (CRA-2004 PABC, Leigh et al. 2005a), and when the EPA recertified the WIPP in March 2006 (EPA 2006), the CRA-2004 PABC was established as the WIPP PA technical baseline.

On January 24, 2007, the WIPP received the first shipment of remote-handled (RH) TRU waste (DOE 2007). RH waste is currently packaged for disposal in RH-TRU waste canisters. These canisters are loaded into boreholes that are drilled in the walls of the WIPP waste disposal rooms. To improve operational efficiency, DOE is now proposing a change to the emplacement of RH waste. DOE proposes to package a subset of RH waste streams in containers with lead-shielding, and these shielded containers would be placed on the floor of the disposal rooms, similar to the emplacement of contact-handled (CH) waste containers.

DOE has tasked SNL to assess the impact of emplacing RH waste in shielded containers on the long term performance of the repository by conducting a performance analysis. SNL conducted an impact assessment, termed the Shielded Container Performance Assessment (SCPA), and analyzed the results. The PA was conducted in accordance with "Analysis Plan to Assess the Impact of Shielded Container Emplacement in the Waste Isolation Pilot Plant" (AP-135), which was written specifically to guide the execution of this PA. This document details how SNL conducted the SCPA and analyzed its results.

Following this introduction (Section 1), Section 2 provides background details on current waste emplacement methods, the characteristics of RH waste, and the impact of RH waste on WIPP PA releases. Section 3 details the methodology and approach used for designing and conducting the

Figure 1. CH Waste Packaging Configurations in the WIPP. The black drums in the picture are 55-gallon drums shrink wrapped together into a 7-pack, and the containers on the floor are TDOPs. A SWB is placed on top of a TDOP on the right side of the picture. At the top of each stack is a supersack of MgO.

Currently, RH waste is disposed in the RH-TRU waste canister (Figure 2). This canister is cylindrical in shape; its length is 120.5 in, and it has a diameter of 26 in. The canisters have a nominal wall thickness of 0.25 in, and they are made entirely of steel. The canister is either directly loaded with RH waste, or it is packaged with RH waste containers (e.g., 55-gallon drums or metal cans) (DOE 2006a). The canisters are placed in horizontal holes that are drilled perpendicular to the faces of the walls of the repository rooms.

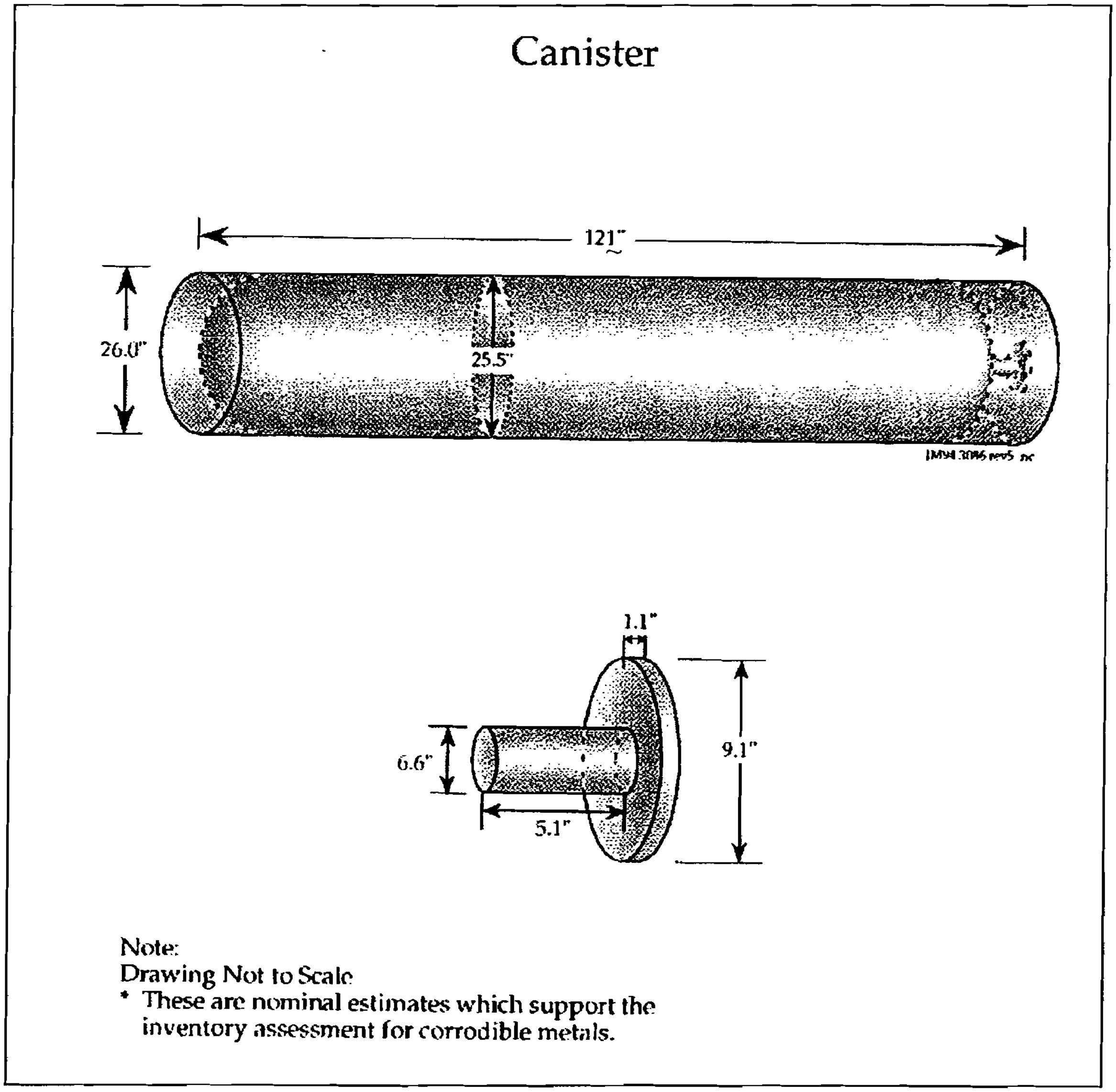

Figure 2. RH-TRU Waste Canister (from page A-3 of DOE 1995). The pintle component of the canister is shown in the lower portion of the figure and is used during the loading of canisters.

2.2.1 Waste Streams Eligible for Emplacement in Shielded Containers

In the current WIPP PA baseline inventory there are 690 CH waste streams and 77 RH waste streams (Leigh et al. 2005b). WIPP PA represents the RH inventory as one composite RH waste stream, and the activity of this composite waste stream is determined by taking a volume-weighted average of all 77 RH waste streams.

The shielded containers will be used for the emplacement of RH waste when the shielding in the containers is sufficient to lower the surface dose of the RH waste contents to within the prescribed limits for CH waste. Crawford and Taggert (2007) indicate that waste containing less than 2 curies of Cs-137 or 0.12 curies of Co-60 per 30 gallon drum would be eligible for packaging in shielded containers. Using this criteria, Crawford and Taggert (2007) estimated that 1,922 m^3, or approximately 27%, of the total RH waste inventory in the current baseline would be eligible for emplacement in shielded containers.

Crawford and Taggert (2007) note that there is some uncertainty in the amount of RH waste that could be placed in the shielded containers. Crawford and Taggert (2007) determined the volume of RH waste that would be packaged in shielded containers by determining which waste streams, on average, contained less than 2 curies of Cs-137 or 0.12 curies of Co-60 per 30 gallon drum. However, when the actual waste is packaged, the screening process will actually be performed on a container-by-container basis, not a waste stream basis. To handle this uncertainty, the SCPA has taken a bounding approach to modeling the quantity of waste packaged in shielded containers. (Note: This uncertainty applies to this assessment only, and not to waste characterization and acceptance processes.)

2.2.2 Emplacement of Shielded Containers

The shielded containers will be bundled in groups of 3 (3-packs) and emplaced on the floors of the waste rooms as it arrives. RH waste that is not packaged in shielded containers will be emplaced in the boreholes as previously described in Section 2.1.

2.3 RH Waste Characteristics and Impact on Releases

TRU waste is classified as either contact-handled (CH) or remote-handled (RH) based on the contact dose rate at the surface of the waste container. If the contact dose rate is less than 200 millirem per hour (2 milliSievert per hour), the waste is defined as CH-TRU (DOE 1988). If, on the other hand, the contact dose rate is greater than or equal to 200 millirem per hour, the waste and its container are defined as RH-TRU (DOE 1988). Consistent with the Land Withdrawal Act (US Congress 1992), only RH-TRU waste with a surface dose less than or equal to 1000 rem per hour (10 Sievert per hour) is eligible for disposal at the WIPP.

The remote-handled (RH) waste inventory is limited to a maximum volume of 7080 m^3 (250000 ft^3) which accounts for approximately 4% of the total waste volume (DOE 2004). Moreover, the emplaced RH-TRU waste is not to exceed a total activity of 5.1 million Ci (~ 18.9 x 10^{16} Becquerel) and a total activity concentration of 23 Ci per liter maximum activity level (averaged found in RH and CH waste for the radionuclides with the highest concentrations. As seen in this table, such radionuclides as Cs-137, Co-60, Sr-90 and Y-90 are much more prevalent in RH waste, but their impact on long-term performance is negligible because these radionuclide have relatively short half-lives of 30, 5, and 29 years and 2.67 days, respectively (Leigh and Trone 2005).

Table 4. CH and RH Waste Radionuclide Inventories (Table ES-5 from DOE 2006b) [1,2]

Nuclide	CH Waste (Ci/m3)	RH Waste (Ci/m3)
Am-241	2.8E+00	2.0E+00
Ba-137m	4.1E-02	5.6E+01
Cm-244	3.7E-02	1.5E-01
Co-60	5.8E-06	2.6E-01
Cs-137	4.4E-02	6.0E+01
Eu-152	1.1E-05	3.3E-01
Pu-238	8.6E+00	5.4E-01
Pu-239	3.4E+00	7.4E-01
Pu-240	5.6E-01	2.2E-01
Pu-241	1.2E+01	1.8E+01
Sr-90	3.3E-01	4.6E+01
Y-90	3.3E-01	4.5E+01

1-Summary shows the ten radionuclides with the highest concentration in curies per cubic meter for both CH-TRU and RH-TRU waste. The list includes twelve radionuclides because the ten radionuclides with the highest concentration are different for CH-TRU and RH-TRU waste.
2-Decayed through December 31, 2001.

The surface dose rate is determined by several factors, including container type and shielding, radiation type, and curie content. It should further be noted that an elevated surface dose rate, relative to that from CH waste, does not necessarily imply that RH waste has a higher total curie content or density. This note is important from a repository performance standpoint because curie content is a factor in determining releases, not surface dose.

The activity associated with RH waste is compared to that of CH waste in Figure 4 and Figure 5. As shown in these figures, RH waste activity is relatively small in total curies to CH waste, and RH has a lower density of EPA Units than CH waste has. The short half-lives of Cs-137, Co-60, and Sr-90 in RH waste result in a short interval over which RH waste has substantial activity. RH waste is expected to have little impact on long-term performance because the total RH waste activity is approximately 2 orders of magnitude of the total activity of CH waste (see Figure 4). This expectation is confirmed by the results with full PA methodology, as discussed next.

conclude that releases of RH waste are not a significant contributor to total releases at any probability level.

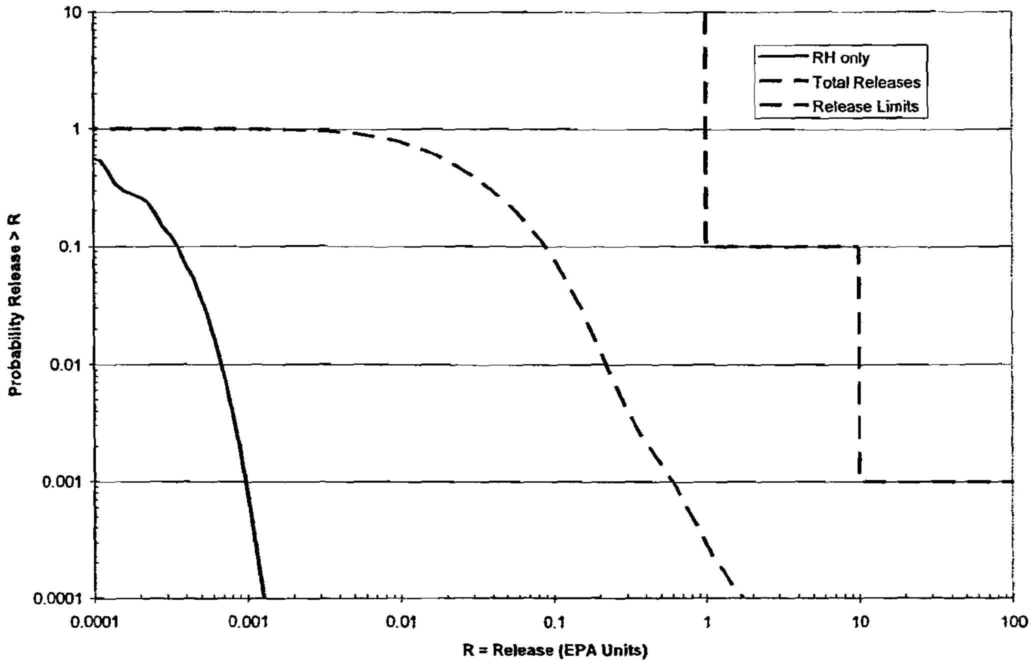

Figure 6. Mean Normalized Total Releases and RH Releases from CRA-2004 PABC Replicate 1.

Table 5. CRA-2004 PABC Replicate 1 Releases at Probabilities of 0.1 and 0.001.

	Probability = 0.1	Probability = 0.001
Total Releases (EPA units)	8.86E-02	5.98E-01
RH Releases (EPA units)	3.55E-04	9.82E-04

3 SCPA METHODOLOGY

The "Analysis Plan to Assess the Impact of Shielded Container Emplacement in the Waste Isolation Pilot Plant" (AP-135, Dunagan and Vugrin 2007) was developed specifically to guide the execution of the SCPA. The SCPA was conducted in a five step process:

1. Evaluate WIPP PA baseline assumptions, models, and parameters to determine which are affected by the use of shielded containers;
2. Develop an analysis design to incorporate necessary modifications to the baseline approach;
3. Develop necessary parameters for SCPA;
4. Execute WIPP PA codes; and
5. Conduct an analysis of results, including a comparison with baseline predictions of long term repository performance.

The introduction of the shielded containers does not affect projected inventories for waste materials. Thus, parameters related to the waste inventory and mechanical properties of the waste are unaffected by the use of shielded containers. Consequently, the SCPA used the CRA-2004 PABC values for waste inventory parameters and the mechanical properties of the waste.

3.1.2 Emplacement and Container Materials

The impact of using shielded containers on emplacement and container materials has been evaluated by Crawford and Taggert (2007). At the time that SNL started to develop an analysis plan for the SCPA, there was some uncertainty as to what quantity of RH waste would be packaged in shielded containers, so SNL requested that Crawford and Taggert conduct their calculations under the assumption that all of the RH waste would be packaged in the shielded containers (Dunagan 2007a). This approach allowed Crawford and Taggert to identify an upper bound on the change in emplacement and container materials.

The baseline inventory contains 1.2E+09 moles of organic carbon from CPR materials (Nemer 2007). The RH waste contains 7.8E+06 moles of organic carbon, and the RH packaging materials contribute 1.4E+06 additional moles of organic carbon to the total inventory. There are no CPR emplacement materials associated with the current RH emplacement methodology.

When shielded containers are used to emplace RH waste, additional CPR emplacement materials will be needed since there will be more waste stacks on the floor of the repository. These emplacement materials include additional slip sheets, shrink wrap, and the supersacks that contain magnesium oxide (MgO). Table 7 contains Crawford's and Taggert's (2007) estimates for CPR materials. Crawford and Taggart (2007) found that no rubber will be used for packaging or emplacement of shielded containers.

Table 7. Cellulose, Plastic, and Rubber (CPR) RH Packaging and Emplacement Materials When All RH Waste is Packaged in Shielded Containers.

CPR Component	Mass from Packaging Materials (kg) [1]	Moles of Organic Carbon from Packaging Materials [2,3]	Mass from Emplacement Materials (kg) [1]	Moles of Organic Carbon from Emplacement Materials [2,3]
Cellulose	0.0E+00	0.0E+00	2.4E+04	8.9E+05
Plastic	1.1E+05	6.9E+06	4.3E+05	2.7E+07
Rubber	0.0E+00	0.0E+00	0.0E+00	0.0E+00

[1] Crawford and Taggert (2007)
[2] Moles of organic carbon in cellulose = mass in kg x (6000 moles/162 kg)
[3] Moles of organic carbon in plastic = mass in kg x (6000 moles/162 kg) x 1.7

As discussed previously in Section 3.1.1, the CPR contents of the waste materials will not change with the use of shielded containers, so the use of shielded containers only affects the CPR materials related to emplacement and packaging materials. Packaging all RH waste in shielded containers would increase the organic carbon quantity in the inventory by 3.3E+07 moles. This quantity is calculated by summing the organic carbon from the packaging and emplacement materials for RH waste when shielded containers are used and subtracting the organic carbon for those materials from the baseline inventory (6.9E+06 + 8.9E+05 + 2.7E+07 -

with a homogeneous mix of waste (referred to as the Standard Waste Model that was used in the CCA and PAVT) and another in which a panel contains only the stiff waste packages containing supercompacted waste. In the latter cases, the waste packages were assumed to be incompressible. Additional intermediate cases were considered as well. Based on that performance assessment, DOE concluded that:

- Explicit representation of the specific features of the waste and its associated packaging, such as structural rigidity, is not warranted in modeling since performance assessment results are relatively insensitive to the effects of such features.
- Total releases are essentially unchanged by the use of different porosity surfaces because when gas generation is present uncertainty in the constitutive model of the waste is overshadowed by the support provided by the generated gas pressure.

Furthermore, Hansen et al. (2004) showed that the Standard Waste Model used for the CCA resulted in the greatest variability in porosity and leads to the highest values for pressure in the repository. Thus, Hansen et al. (2004) concluded that performance assessment should use the Standard Waste Model for waste porosity. This model was used for waste porosity in the CRA-2004 PABC. EPA agreed with this conclusion, that stiff waste is beneficial (Marcinowski 2004).

Even though the shielded containers are more structurally rigid than the 55-gallon drums, the SCPA used the CRA-2004 PABC porosity surfaces that were calculated with the Standard Waste Model since repository performance is relatively insensitive to the structural rigidity of waste and waste containers as shown in Hansen et al. (2004).

3.1.4 Chemical Conditions

The emplacement of shielded containers in the WIPP has the potential to dramatically increase the amount of lead in the repository. The amount of iron present in the repository will also increase, although not as significantly as lead. The additional lead and iron have the potential to impact several aspects of the repository chemical environment such as: the redox conditions after repository closure, microbial gas generation due to consumption of CPR materials, consumption of microbially produced carbon dioxide (CO_2) and the formation of actinide/organic ligand complexes. The impact of the additional lead and iron on each of these aspects has been reviewed and is discussed below. This review has determined that there is no significant impact on the chemical environment in the WIPP. As a result, the baseline approach used in the CRA-2004 PABC for modeling actinide solubility and other chemical environment parameters is appropriate to use in the SCPA.

3.1.4.1 Changes in Fe and Pb Densities due to Shielded Containers

The baseline estimates of iron densities at the repository closure are 110 and 59 kg/m^3, in the CH and RH waste, and 170 and 540 kg/m^3, in the CH and RH waste containers, respectively (Crawford 2005a). Given the total CH volume of 1.69E+05 m^3 and an RH volume of 7080 m^3 (U.S. Congress 1992), the estimated total mass of iron in the CH and RH wastes, including reducing conditions in the repository, and these conditions are favorable with respect to the speciation of actinides (Appendix SOTERM, DOE 2004). After the available O_2 is consumed in the closed repository, the steels will undergo anoxic corrosion by the following reaction:

$$Fe + (x+2)H_2O \Leftrightarrow Fe(OH)_2 \cdot xH_2O + H_2 \quad (1)$$

This reaction will consume water and lower brine saturation levels in the repository as well, which further benefits repository performance. Although it is known that the corrosion of iron in the repository will lead to anoxic conditions, no quantitative predictions of redox conditions (i.e. Eh) were made for the CRA-2004 PABC. Quantification of the redox state is difficult in low temperature geochemical systems because equilibrium among the many redox couples is generally not obtained. The effects of lead on the repository redox state were also not explicitly considered in the CRA-2004 PABC because of the relatively small amount of lead as compared to iron in the repository.

The possible effects of lead on the redox conditions of the repository were investigated by Wall and Enos (2006). Their initial set of thermodynamic calculations indicates that lead will oxidize in water at 25 °C and 1 atm. This oxidation process results in the formation of a number of lead species, with $PbO(s)$ and $Pb_3O_4(s)$ being the most likely to form in an anoxic environment like the WIPP. Wall and Enos (2006) also show that in the presence of CO_2 and H_2S lead will form additional solid species such as $PbCO_3$ and PbS. Because lead corrodes in processes very similar to iron, the presence of lead provides additional evidence for the maintenance of redox conditions in the repository. In addition, the corrosion of lead also consumes water and will lower brine saturation levels in the repository.

Thus, the addition of lead into the repository due to shielded container emplacement is not expected to have a significant impact upon the redox conditions in the repository. No laboratory experiments have been conducted yet to study the lead corrosion process under WIPP conditions, and the rates of corrosion are not known. Due to the uncertainties relating to the corrosion of lead, the SCPA will not model lead corrosion. For the aforementioned reasons, this approach is conservative. A test plan (Wall and Enos 2006) has been written to conduct iron and lead corrosion studies under WIPP-like conditions, and Sandia is in the process of conducting these experiments.

3.1.4.3 Microbial Gas Generation

The waste disposed within the WIPP contains significant quantities of CPR materials. In the CRA-2004 PABC microbial activity is assumed to consume some portion of the CPR materials over time resulting in the generation of significant quantities of CO_2, H_2S, hydrogen (H_2), and nitrogen (N_2). This microbial activity has the potential to significantly affect the mobility of actinides in several ways. The production of significant amounts of CO_2 due to microbial consumption of CPR materials is likely to have the greatest impact on the chemical environment in the WIPP. The presence of CO_2 will acidify any brine present in the repository and increase the solubilities of the actinides (Appendix SOTERM, DOE 2004). For this reason the DOE emplaces MgO into the repository to buffer the f_{CO2} and pH within ranges that favor for lower actinide solubilities (Appendix BARRIERS, Section BARRIERS-2.0, DOE 2004). There are

$$PbCO_3(s) + H_2S(g) \Leftrightarrow PbS(s) + H_2O(l) + CO_2(g) \quad (5)$$

A result of these reactions is that some of the CO_2 consumed via reactions (2) and (3) will be released back into the repository chemical environment. Although the mass balance calculations of Wall and Enos (2006) show that iron and lead have the potential for significant CO_2 sequestration, Brush and Roselle (2006) state that determining how much carbon dioxide would actually be consumed is difficult because of the uncertainties associated with that process (such as kinetic effects). In addition, WIPP PA models do not consider consumption of carbon dioxide by any material other than MgO. Thus, the SCPA will use the baseline approach for modeling carbon dioxide consumption and not model iron and lead carbonation.

3.1.4.5 Organic Ligand Complexation

Organic ligands are a likely component of the waste materials to be emplaced in the WIPP. Organic ligands have been shown to complex with actinides, which would increase the dissolved actinide concentrations in brine within the repository. However, organic ligands also complex strongly with multivalent metal cations. The result being that the multivalent metal cations will compete with actinides for complexation with the organic ligands. For the CRA-2004 PABC four organic ligands were included in the actinide solubility calculations: acetate, citrate, ethylenediaminetetraacetate (EDTA), and oxalate. These four ligands were chosen because they were the only water soluble organic ligands present in significant quantities in the waste (DOE 2004, Appendix SOTERM).

In the CRA-2004 PABC, solubility calculations were conducted to investigate the importance of organic ligand / actinide complex formation relative to Mg^{2+}/Ca^{2+}/organic ligand complexes. However, these calculations did not include the effects of other multivalent metal cations (such as Fe^{2+} and Pb^{2+}). These calculations showed that the organic ligands will not form complexes with the +III and +IV actinides to a significant extent under expected WIPP conditions due to their strong affinity for complexing with Mg^{2+} and Ca^{2+}.

Because the stability constant of the other metal cation species are similar to those of Ca^{2+} and Mg^{2+} (Martell et al. 1998), the presence of dissolved Fe^{2+} and Pb^{2+} in any available brine will further reduce the availability of binding sites for actinides on the organic ligands. Thus the increased amount of lead and iron placed in the repository due to shielded containers will further decrease the quantity of organic ligands available to form complexes with the actinides, which in turn should slightly reduce the solubilities of the actinides. The SCPA will use the baseline approach for modeling the impacts of organic ligands on actinide solubilities, since the solubilities would be reduced if this effect was included.

3.1.5 Heterogeneity of Waste Placement

A possible issue identified with the use of shielded containers is whether or not loading schemes and disposal schedules associated with the shielded containers could present inconsistencies with the baseline assumption of random waste emplacement. SNL staff have evaluated this concern and determined that the assumption of random waste emplacement is still valid for the SCPA.

Djordevic (2003) repeated the analysis of Sanchez and Trellue (1996) with the CRA-2004 inventory and determined that maximum temperature increase at the surface of an RH-TRU canister would be approximately 2° C, and the average temperature increase at the surface of an RH-TRU container would still be less than 1° C. The decrease in temperature increases is due to the fact that total heat load to total curie load ratio for the CRA-2004 decreased from the CCA values.

3.1.6.2 Temperature Increases for Shielded Containers

The SCPA will use the same waste inventory that was used in the CRA-2004 PABC, and since the total heat load to total curie load ratio has decreased from the CCA, use of the CCA ratio in the following discussion is conservative.

A shielded container has an internal volume (30 gallons) that is less than one-seventh of the internal volume of the RH-TRU container (approximately 235 gallons). The SCPA is using the same RH TRU waste inventory from the CRA-2004 PABC, so the radionuclide content of the waste is the same as the CRA-2004 PABC inventory. Thus, the maximum thermal load for a shielded container with RH waste would be less than 8.5 W (60 ÷ 7).

Furthermore, the walls of the shielded containers are much thicker than the walls of the RH-TRU container. The waste in RH-TRU containers is closer to the exterior surface of the container, and the heat must be conducted only through 0.25 in of steel (Figure 7). For the shielded containers, the heat must be conducted through a layer of 1 inch lead shielding and two steel layers that have a combined width of 0.3125 inch (Figure 7). Conservatively assuming that the waste in the shielded containers has the same thermal load to the curie load ratio (0.0037 W/Ci) as the value that Sanchez and Trellue (1996) used in their analysis, the significantly thicker walls of the shielded containers cause a smaller temperature increase at the surface of a shielded container than would be expected for a RH-TRU container. Consequently, the maximum temperature increase at the surface of a shielded container would still be less than 3° C. Furthermore, two objects in contact will reach a thermal equilibrium. That is, if two objects have different temperatures, they will reach a steady state equilibrium temperature that is less than the maximum temperature of the two objects and greater than the minimum temperature of the two objects. Thus, even if multiple shielded containers are placed in contact with one another, the maximum temperature increase will still be less than 3° C. This temperature increase is considered insignificant in the current PA technical baseline. Therefore, the SCPA followed the baseline approach to modeling heat from radioactive decay. Specifically, the effects of temperature increases as a result of radioactive decay were eliminated from PA calculations on the basis of low consequence to the performance of the disposal system.

TRU waste are assumed to not produce spallings releases" (Section 9.3 of Helton et al. (1998)). The same rationale is used to preclude the occurrence of DBRs for intrusions into RH waste. All of these assumptions are contingent upon the RH waste being placed in the RH-TRU canisters in the walls of the waste rooms. It should be noted that while DBRs and releases from groundwater transport do not occur for intrusions into RH waste areas, these releases are calculated using WIPP-scale data assuming homogeneous accessibility of RH- and CH-TRU waste activities by liquid in the repository.

Since shielded containers will be emplaced in areas containing CH waste, this waste could possibly be accessible to cavings and spallings (in addition to cuttings, DBRs, and long term releases) since the permeability in the CH waste areas is expected to be substantially higher than permeability of the salt in the walls. Thus, the SCPA included the possibility that cavings, spallings, and direct brine releases (in addition to cuttings releases) could occur if a borehole intruded an area with shielded containers.

3.1.8 Impact of Shielded Containers on Release Mechanisms

During the review of the CRA-2004, the EPA asked the DOE to assess the impact of container variability on releases, specifically spallings releases (Vugrin 2004). The DOE responded that

> "*the addition of new container types do not impact calculated spall releases (or cuttings and cavings) because PA conservatively assumes that the containers are not present. In Appendix PA, Attachment SCR, both features, events, and processes (FEPs) associated with container type (W4 Container Form and W34 Container Integrity) are screened out due to beneficial consequences. That is, the containers are assumed to instantaneously fail, making the waste material immediately available to cuttings, cavings, spallings, or other transport and release mechanism. The emplacement of additional container types in the repository can only impact the performance of the WIPP if it is assumed that they maintain some of their structural integrity. In the case of spallings, a robust container that would persist over time would at least delay or decrease the movement of radionuclides towards the intrusion borehole, and may, in an extreme case, isolate the waste material from spalling altogether. In either case, the releases would decrease if the physical properties of waste containers were included in performance assessment calculations. Because PA takes no credit due to the physical aspects of the container, container variability does not impact calculated spall releases*" (Vugrin 2004).

Consistent with the FEPs basis, while the shielded containers are expected to be more durable than the standard 55-gallon drums, the SCPA followed the baseline FEPs screening decisions and did not take credit for the physical aspects of the shielded containers. Thus, the mechanical properties of the containers will not affect PA predictions. This is considered to be a conservative assumption.

Issue	Section	SCPA
Contents of waste materials	3.1.1	DOE does not propose to modify the waste materials that will be emplaced in the WIPP, so the SCPA will use the waste inventory and mechanical parameters from the CRA-2004 PABC since they will not be affected by the use of shielded containers.
Emplacement and container materials	3.1.2	The SCPA will use the CRA-2004 PABC emplacement parameters for steel and CPR materials since the small change to these quantities caused by the use of shielded containers will not significantly affect repository performance.
Room closure	3.1.3	The SCPA will use the CRA-2004 PABC porosity surfaces that were calculated with the Standard Waste Model since repository performance is relatively insensitive to the structural rigidity of waste and waste containers.
Chemical conditions	3.1.4	Because the presence of lead is expected to have a generally beneficial effect on chemical conditions and decrease actinide solubilities, the SCPA will conservatively use the CRA-2004 PABC actinide solubilities that were calculated without explicitly including the effects of lead.
Heterogeneity of waste placement	3.1.5	The SCPA will assume that the stacks of CH and shielded containers are randomly distributed since mean releases are insensitive to uncertainty in the spatial arrangement of the waste.
Repository Temperature	3.1.6	The use of shielded containers does not affect any baseline assumptions pertaining to repository temperatures, so the SCPA will not make any modifications to these baseline assumptions.
Impact of waste location on release mechanisms	3.1.7	The SCPA will assume that RH waste in shielded containers is accessible to all release mechanisms.
Impact of shielded containers on release mechanisms	3.1.8	The SCPA will follow the baseline approach of assuming that all waste containers instantly fail, so the SCPA will conservatively not take credit for the physical properties of the shielded containers.
Location of RH waste streams	3.1.9	The SCPA will model RH emplacement with three scenarios: 1. All RH waste in the walls; 2. All RH waste on the floor; and 3. Half of the RH waste in the wall and half of the RH waste on the floors;

MATERIAL	PROPERTY	VALUE (UNITS)	DESCRIPTION
REFCON	FVW_ALLRH	0.402 (none)	Fraction of repository volume occupied by CH and RH waste in CCDFGF model (Scenario 2).
REFCON	FVW_HALFRH	0.394 (none)	Fraction of repository volume occupied by CH waste and half of total RH waste in CCDFGF model (Scenario 3).
REFCON	AREA_NORH	0 (m^2)	Area for RH waste disposal in CCDFGF model when all RH waste is included with CH waste on repository floors (Scenario 2).
REFCON	AREA_HAFRH	7.880e3 (m^2)	Area for RH waste disposal in CCDFGF model when half of total RH waste is included with CH waste on repository floors (Scenario 3).

3.4 *Execution of WIPP PA Codes*

APPENDIX B: RUN CONTROL contains all of the code execution and run control information for the SCPA.

3.5 *Analysis of Results*

The CRA-2004 PABC results represent the repository performance using baseline assumptions and parameters (scenario 1). The results of SCPA scenarios 2 and 3 were compared with the CRA-2004 PABC results to assess the potential impacts of shielded containers on repository performance. The results from the SCPA scenarios 2 and 4 were compared to assess the sensitivity of the explicit representation of individual waste streams on releases. For each set of comparisons, complementary cumulative distribution functions (CCDFs) were evaluated.

3.6 *Deviations from AP-135*

There were four deviations from the analysis plan, AP-135. One deviation was the container design. Figure 3 in AP-135 showed a preliminary design of the shielded container. This final design increased the thickness of the steel lid and bottom from 2.75" to 3". This change was captured in the steel estimates (Crawford and Taggart 2007) and can be seen in Figure 3 of this document.

The second deviation from AP-135 was the addition of more calculations to assess the impact of RH waste on releases. CCDFGF was rerun using the CRA-2004 PABC files (Leigh et al. 2005a) with the fraction of repository volume occupied by waste (REFCON:FVW) set equal to zero. By setting this parameter equal to zero the contribution from cuttings, cavings, and spallings releases from CH waste were eliminated from the total release results. This permits the evaluation of RH waste's impacts on total releases because the current baseline only attributes RH cuttings releases to the total releases results (see Section 3.1.7). Therefore, the cuttings output of this set of calculations represent the total releases from RH waste. The results of this calculation are shown in Section 2.3.

The third deviation from AP-135 is that additional qualified codes that were not explicitly called out in AP-135 were used in the SCPA calculations (see Table B. 1). These additional codes were used to capture the parameter changes that were required for the analysis.

smallest, and the mean DBRs for the CRA-2004 PABC are consistently the largest. The frequency and magnitude of DBRs are typically highest when a brine pocket has previously been intruded since the additional brine that enters the repository in these scenarios generally result in high pressures and brine saturations, conditions leading to DBRs. Thus, the trend in DBRs can be explained by evaluating the probability of hitting a brine pocket. Given that an intrusion intersects the berm area, the conditional probability that a borehole penetrates a Castile brine pocket is the product of two factors: P(E|B), the conditional probability that excavated area is intruded given that the berm area is intersected, and the sampled GLOBAL:PBRINE value. The CRA-2004 PABC and SCPA scenarios used identical sampled GLOBAL:PBRINE values, so the trend in mean DBRs is caused by the differences in P(E|B). P(E|B) is defined to be the sum of the RH and CH excavated areas, divided by the berm area.

$$P(E \mid B) = \frac{\text{CH Area} + \text{RH Area}}{\text{Berm Area}} \qquad (6)$$

The CH excavated area is defined to be 1.12e5 m^2 (REFCON:AREA_CH), and the berm area (repository footprint) is 6.29e5 m^2 (REFCON:ABERM). The RH area is the only term that varies, and Table 10 lists the RH areas for the three calculations. Since the CRA-2004 PABC has the largest RH area, the probability of intersecting a brine pocket (when the berm area is intersected) is highest for the CRA-2004 PABC, and, consequently, the CRA-2004 PABC resulted in the largest mean DBRs. Similarly, SCPA scenario 2 had the lowest DBRs since that calculation used the smallest RH area.

It should be restated that even though the CRA-2004 PABC had the largest mean DBRs at all probabilities, the difference between the DBRs for the CRA-2004 PABC and the SCPA scenarios were still extremely small and not large enough to discernibly impact mean total releases.

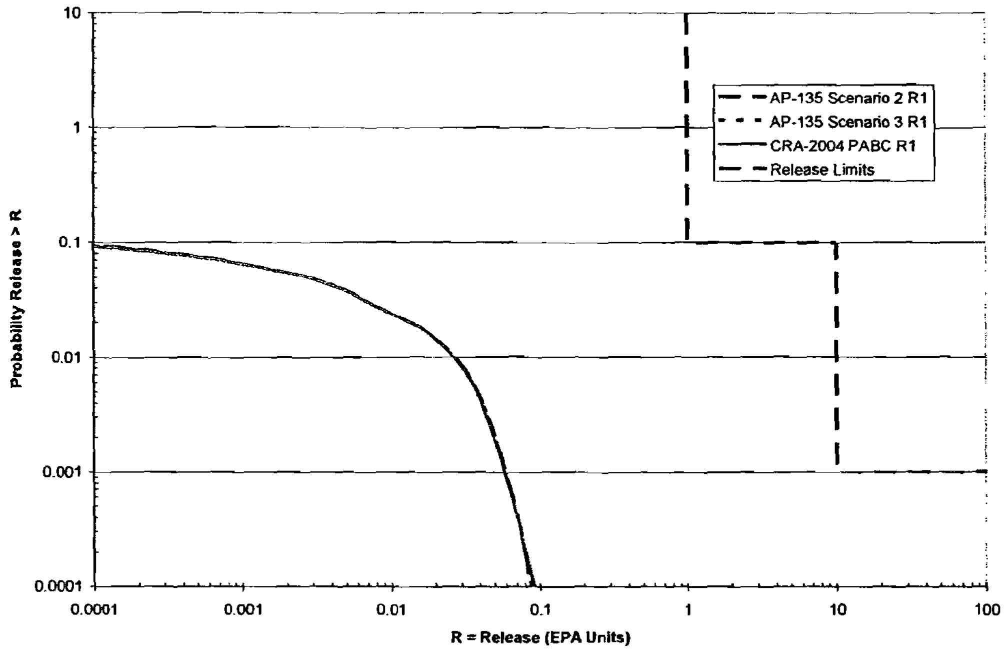

Figure 10. Mean Spallings Releases from SCPA Scenarios 2 and 3 and CRA-2004 PABC, Replicate 1.

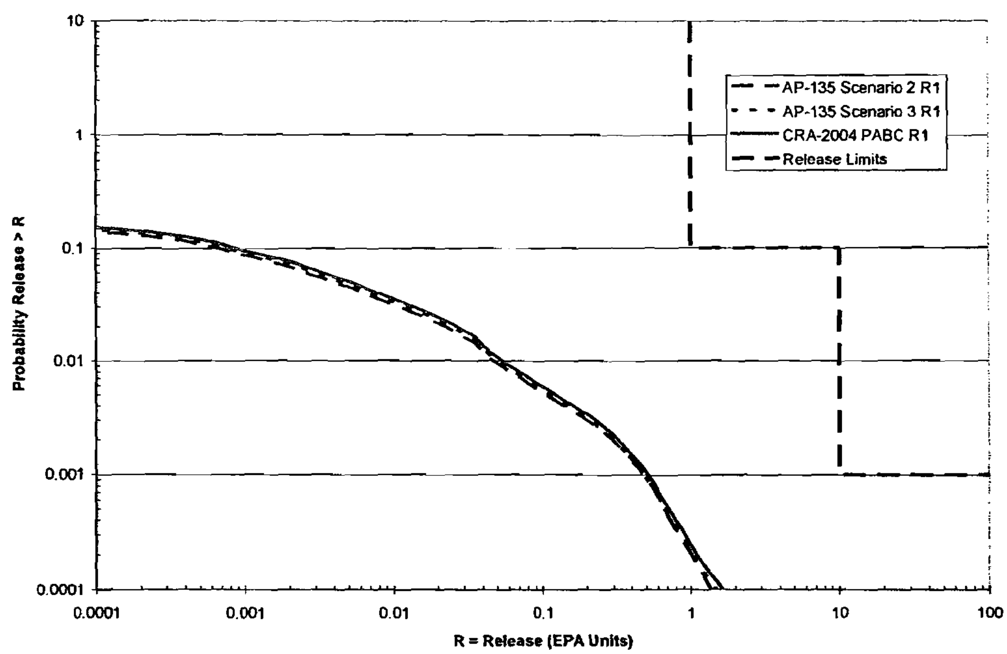

Figure 11. Mean DBRs from SCPA Scenarios 2 and 3 and CRA-2004 PABC, Replicate 1.

5 SUMMARY AND CONCLUSIONS

PA is the primary tool used by DOE to demonstrate compliance with the long-term disposal regulations in 40 CFR 191 (Subparts B and C) and the compliance criteria in 40 CFR 194. Previous PAs have used the assumption that all RH waste would be emplaced in canisters in the walls of the repository. DOE is proposing the use of a shielded container for the emplacement of RH waste. This shielded container would be placed on the floor of the repository in a manner similar to that used for CH waste disposal. DOE tasked SNL to assess the impact of emplacing RH waste in shielded containers on the long term performance of the repository by conducting a performance analysis using the current baseline PA system, making only those changes necessary to represent shielded containers in the WIPP.

The specific approach used in this analysis involved five steps:

1. Evaluate WIPP PA baseline assumptions, models, and parameters to determine which are affected by the use of shielded containers;
2. Develop an analysis design to incorporate necessary modifications to the baseline approach;
3. Develop necessary parameters for the SCPA;
4. Execute WIPP PA codes; and
5. Conduct an analysis of results, including a comparison with baseline predictions of long term repository performance.

The review of baseline assumptions determined that the primary modification that needed to be made to the WIPP PA baseline assumptions was the re-location of the RH waste from the boreholes in the walls of the repository to the floor of the repository. This would also require the creation of new parameters to represent this change in certain PA models. The new parameters would represent the fraction of repository volume occupied by waste and the area for RH waste disposal in the walls of the repository for scenarios that model the inclusion of shielded containers. It was determined that no other changes to the baseline were necessary to represent the presence of shielded containers.

Due to uncertainty pertaining to the quantity of RH waste that could be emplaced in shielded containers, the SCPA used a bounding approach to model what waste would be packaged in shielded containers. The baseline scenario was the CRA-2004 PABC where the RH waste is all located in the walls of the repository, emplaced in canisters. SCPA scenario 2 assumed that all of the RH waste would be emplaced in shielded containers, located on the floor of the repository. No other changes were made to the baseline approach for this scenario. SCPA scenario 3 assumed that half of the RH waste would be emplaced in shielded containers located on the floor of the repository and half of the RH waste would be emplaced in canisters located in the walls of the repository. No other changes were made to the baseline approach for this scenario. A comparison of the results from SCPA scenario 2 and SCPA scenario 3 to the CRA-2004 PABC results identified the effects on releases of the emplacement of shielded containers in the repository on the current baseline.

6 REFERENCES

Barnhart, C.L., and Vestal, R. 1983. "Effect of Environmental Toxicant on Metabolic Activity of Natural Microbial Communities", *Applied and Environmental Microbiology*. Vol. 46, 970-977.

Brush, L. H., and G. T. Roselle. 2006. Geochemical Information for Calculation of the MgO Excess Factor. Memo to Eric D. Vugrin, November 17, 2006. Sandia National Laboratories. Carlsbad, NM. ERMS 544840.

Capone, D.G., Reese, D.D., and Kiene, R.P. 1983. "Effects of Metals on Methanogenesis, Sulfate Reduction, Carbon Dioxide Evolution, and Microbial Biomass in Anoxic Salt Marsh Sediments", *Applied and Environmental Microbiology*. Vol. 45, 1586-1591.

Cotsworth, E. 2005. EPA Letter on Conducting the Performance Assessment Baseline Change (PABC) Verification Test. U.S. EPA, Office of Radiation and Indoor Air, Washington, D.C. ERMS 538858.

Crawford, B.A. 2005a. "Waste Material Densities in TRU Waste Streams from TWBID Revision 2.1 Version 3.13, Data Version D.4.15". Analysis Report, April 13, 2005. Carlsbad, NM: Los Alamos National Laboratory. ERMS 539323.

Crawford, B.A. 2005b. "Tables Containing Lead Data from TWBID Rev. 2-1 D.4.15". Memorandum to J. Trone, October 20, 2005. Carlsbad, NM: Los Alamos National Laboratory. ERMS 541735.

Crawford, B, and Taggart, D. 2007. Analysis of RH TRU wastes for Containment in Lead Shielded Containers. Los Alamos National Laboratory Carlsbad Operations, Simple Analysis Report INV-SAR-08, Rev 0.

Djordjevic, S. 2003. Estimation of Maximum RH-TRU Thermal Heat Load for WIPP for Compliance Recertification Application, Rev. 1. Sandia National Laboratories, Carlsbad, NM. ERMS 531593.

DOE (U.S. Department of Energy). 1988. Radioactive Waste Management, Order 5820.2A. Washington, D.C.

DOE. 1995. Remote-Handled Transuranic Waste Study; DOE/CAO-1095, DOE Carlsbad Field Office. Carlsbad, NM.

DOE. 1996. Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot. DOE/CAO-1996-2184, U.S. Department of Energy Waste Isolation Pilot Plant, Carlsbad Area Office, Carlsbad, NM.

DOE. 2004. Title 40 CFR Part 191 Compliance Recertification Application for the Waste Isolation Pilot Plant, DOE/WIPP 2004-3231, 10 vols., US Department of Energy, Carlsbad Field Office, Carlsbad, NM.

Konopka, A., Zakharova, T., Bischoff, M., Oliver, L., Nakatsu, C., and Turco, R.F. 1999. "Microbial Biomass and Activity in Lead-Contaminated Soil", *Applied and Environmental Microbiology*. Vol. 65, 2256-2259.

Leigh, C. D. and Trone, J.R. 2005. Calculation of the Waste Unit Factor For the Performance Assessment Baseline Calculation, Rev. 0. Sandia National Laboratories. Carlsbad, NM. ERMS 539613.

Leigh, C. D., J. F. Kanney, L. H. Brush, J. W. Garner, G. R. Kirkes, T. Lowry, M. B. Nemer, J. S. Stein, E. D. Vugrin, S. Wagner, and T. B. Kirchner. 2005a. 2004 Compliance Recertification Application Performance Assessment Baseline Calculation, Revision 0. Sandia National Laboratories, Carlsbad, NM. ERMS 541521.

Leigh, C. D., J. R. Trone and B. Fox 2005b. TRU Waste Inventory for the 2004 Compliance Recertification Application Performance Assessment Baseline Calculation. Sandia National Laboratories, Carlsbad, NM. ERMS 541118.

MacKinnon, R. J., and G. Freeze. 1997a. Summary of EPA-Mandated Performance Assessment Verification Test (Replicate 1) and Comparison With the Compliance Certification Application Calculations, Revision 1. Sandia National Laboratories, Carlsbad, NM. ERMS 422595.

MacKinnon, R. J., and G. Freeze. 1997b. Summary of Uncertainty and Sensitivity Analysis Results for the EPA-Mandated Performance Assessment Verification Test, Rev. 1. Sandia National Laboratories, Carlsbad, NM. ERMS 420669.

MacKinnon, R. J., and G. Freeze. 1997c. Supplemental Summary of EPA-Mandated Performance Assessment Verification Test (All Replicates) and Comparison With the Compliance Certification Application Calculations, Revision 1. Sandia National Laboratories, Carlsbad, NM. ERMS 414880.

Marcinowski, F. 2003. Environmental Protection Agency (EPA) Preliminary Review of Information for the Advanced Mixed Waste Treatment Project (AMWTP). U.S. Environmental Protection Agency, Washington, D.C. ERMS 532413.

Marcinowski, F. 2004. Environmental Protection Agency: Letter to R. Paul Detwiler on March 26, 2004 from Frank Marcinowski Approving the Disposal of Compressed Transuranci Waste From the AMWTF at the WIPP. U.S. environmental Protection agency, Washington, D.C. ERMS 534327.

Martell, A.E., Smith, R.M., and Motekaitis, R.J. 1998. *NIST Critically Selected Stability Constants of Metal Complexes Database, Version 5.0.* NIST Standard Reference Database 46. ERMS 506474.

Nemer, M.B. 2007. Effects of Not Including Emplacement Materials in CPR Inventory on Recent PA Results. Sandia National Laboratories. Carlsbad, NM. ERMS 545689.

Wilson, C., D. Porter, J. Gibbons, E. Oswald, G. Sjoblom, and F. Caporuscio. 1997b. Conceptual Models Third Supplementary Peer Review Report, U.S. Department of Energy, Carlsbad Area Office, Office of Regulatory Compliance, April 1997. ERMS 510790.

Zucconi, L., Ripa, C., Alianiello, F., Benedetti, A., and Onofri, S. 2003. "Lead Resistance, sorption and accumulation in a *Paecilomyces lilacinus* strain", *Biology and Fertility of Soils.* Vol. 37, 17-22.

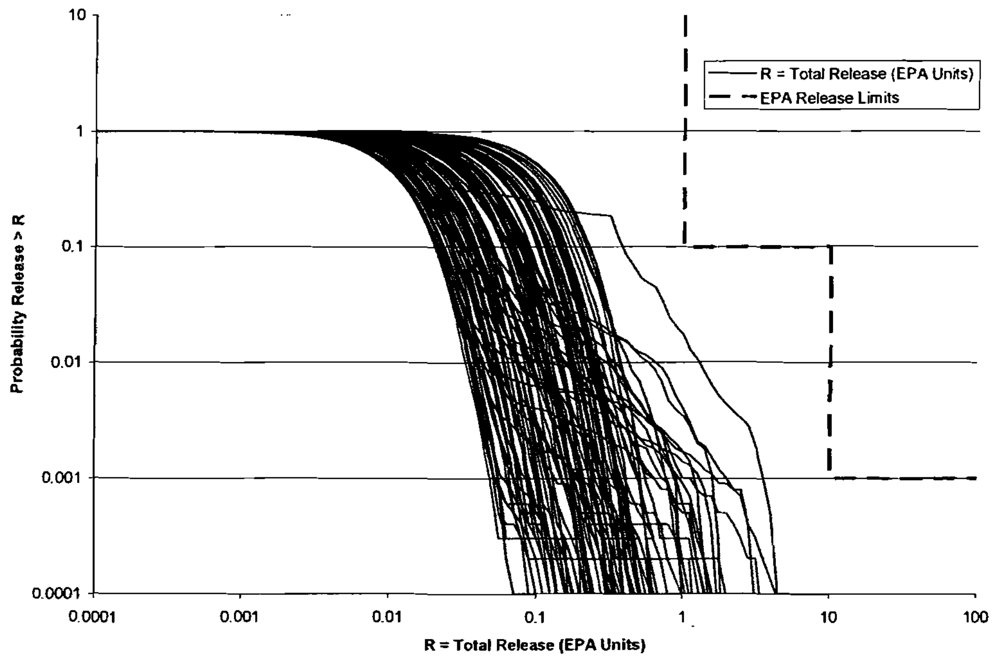

Figure A. 2. Total Releases for SCPA Scenario 2, Replicate 2.

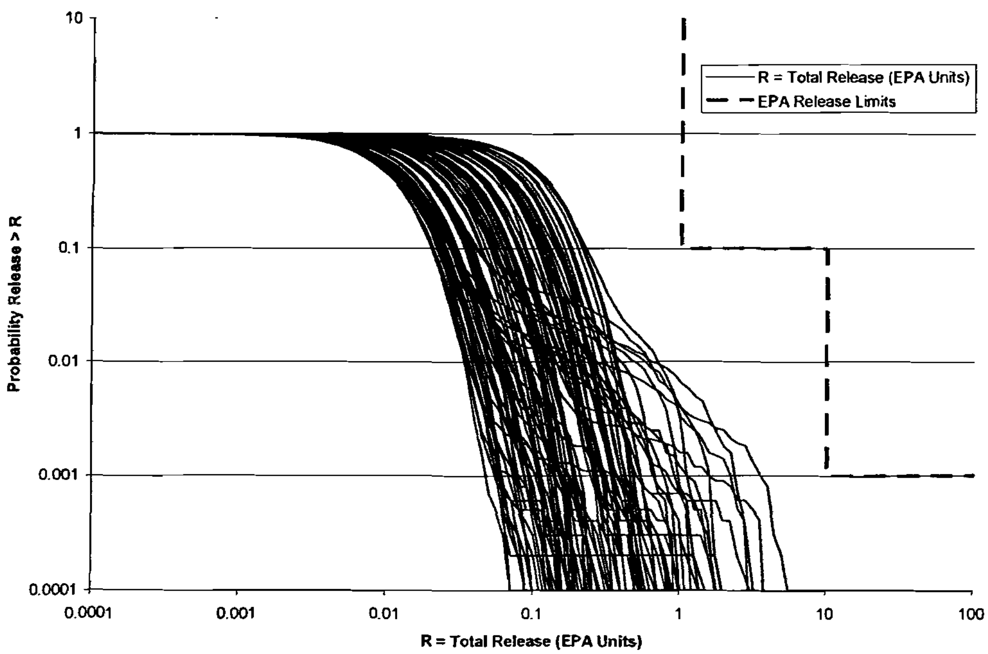

Figure A. 3. Total Releases for SCPA Scenario 2, Replicate 3.

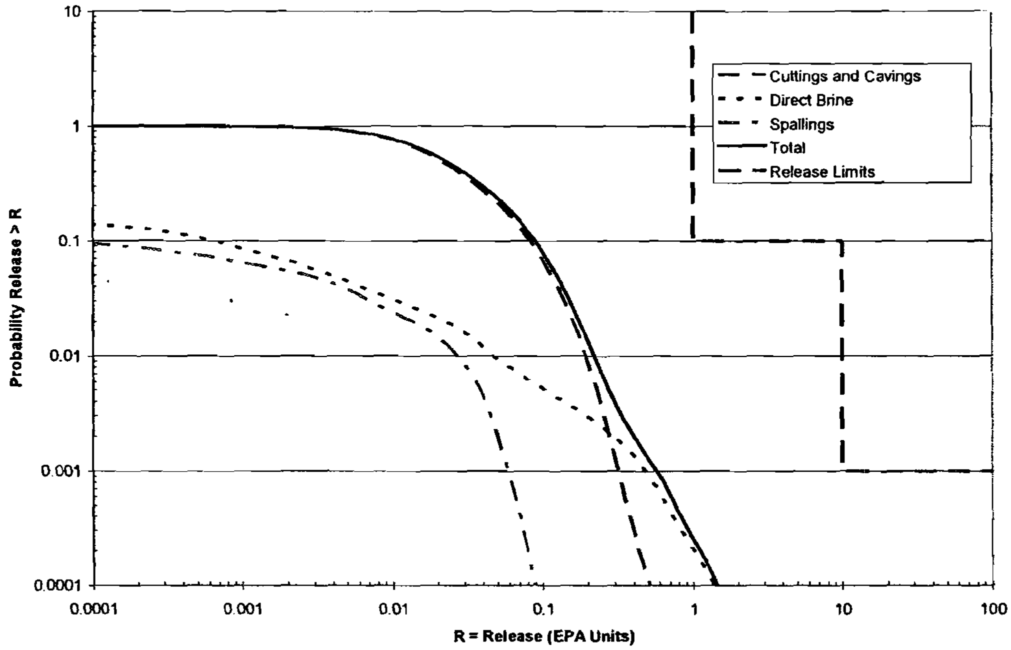

Figure A. 6. Mean Releases Mechanisms for SCPA Scenario 2, Replicate 1.

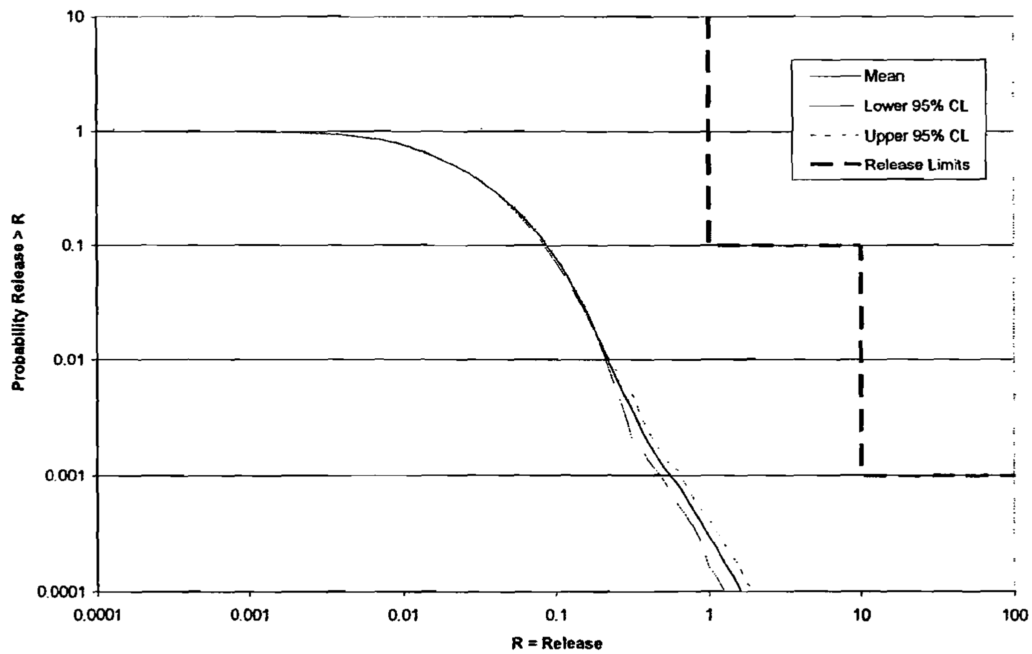

Figure A. 7. Total Release Confidence Intervals for SCPA Scenario 2.

Output	EPU_AP135_RH_*x*.DIA	LIBAP135_EPU	AP135-0
Output	EPU_AP135_RH_*x*_ACTIVITY.DIA	LIBAP135_EPU	AP135-0

1. $x \in \{\text{HALF, INDIVIDUAL, TOTAL}\}$

Table B. 5. CCDF Construction Run Control Scripts

Step	Codes in Step	Scripts	CMS Library	CMS Class
1	GENMESH MATSET	EVAL_GENERIC_STEP1.COM	LIBAP135_EVAL	AP135-0
2	POSTLHS	EVAL_CCGF_STEP2.COM	LIBAP135_EVAL	AP135-0
3	PRECCDFGF	EVAL_CCGF_STEP3.COM SUB_CCGF_STEP3.COM	LIBAP135_EVAL	AP135-0
4	CCDFGF	EVAL_CCGF_STEP4.COM SUB_CCGF_STEP4.COM	LIBAP135_EVAL	AP135-0

Table B. 6. CCDF Construction Step 1 Input and Output Files

	File Names[1,2]	CMS Library	CMS Class
SCRIPT			
Script Input	EVAL_CCGF_AP135_*a*_STEP1.INP	LIBAP135_EVAL	AP135-0
Script Log	EVAL_CCGF_AP135_*a*_STEP1.LOG	LIBAP135_CCGF	AP135-0
GENMESH			
Input	GM_CCGF_CRA1BC.INP	LIBCRA1BC_CCGF	AP135-0
Output	GM_CCGF_AP135_*b*.CDB	LIBAP135_CCGF	AP135-0
Output	GM_CCGF_AP135_*b*.DBG	NOT KEPT	NOT KEPT
MATSET			
Input	MS_CCGF_AP135_*b*.INP	LIBAP135_CCGF	AP135-0
Input	GM_CCGF_AP135_*b*.CDB	LIBAP135_CCGF	AP135-0
Output	MS_CCGF_AP135_*b*.CDB	LIBAP135_CCGF	AP135-0
Output	MS_CCGF_AP135_*b*.DBG	NOT KEPT	NOT KEPT

1. $a \in \{\text{IMPACT, S2, S3, S4}\}$
2. $b \in \{\text{RH\_IMP, S2, S3, S4}\}$

Table B. 7. CCDF Construction Step 2 Input and Output Files

	File Names[1,2,3]	CMS Library	CMS Class
STEP 2			
Script Input	EVAL_CCGF_AP135_STEP2_R*r*_*b*.INP	LIBAP135_EVAL	AP135-0
Script Log	EVAL_CCGF_AP135_STEP2_R*r*_*b*.LOG	LIBAP135_CCGF	AP135-0
POSTLHS			
Input	LHS3_DUMMY.INP	LIBCRA1BC_LHS	AP135-0
Input	LHS2_CRA1BC_R*r*.TRN	LIBCRA1BC_LHS	AP135-0
Input	MS_CCGF_AP135_*b*.CDB	LIBAP135_CCGF	AP135-0
Output	LHS3_CCGF_AP135_R*r*_*b*_V*vvv*.CDB	LIBAP135_CCGF	AP135-0
Output	LHS3_CCGF_AP135_R*r*_*b*.DBG	LIBAP135_CCGF	AP135-0

1. $r \in \begin{cases} \{1,2,3\} & \text{for each S2 or no S} \\ \{1\} & \text{for each S3, S4, RH\_IMP} \end{cases}$

SCRIPT			
Script Input	EVAL_CCGF_STEP4_AP135_R*r*_*b*.INP	LIBAP135_EVAL	AP135-0
Script Log	EVAL_CCGF_STEP4_AP135_R*r*_*b*.LOG	LIBAP135_CCGF	AP135-0
CCDFGF			
Input	CCGF_CRA1BC_CONTROL_R*r*.INP	LIBCRA1BC_CCGF	AP135-0
Input	CCGF_AP135_RELTAB_R*r*_*b*_MOD.DAT*	LIBAP135_CCGF	AP135-0
Input	CCGF_AP135_RELTAB_R*r*_*b*.DAT**	LIBAP135_CCGF	AP135-0
Output	CCGF_AP135_R*r*_*b*.OUT	LIBAP135_CCGF	AP135-0
Output	CCGF_AP135_R*r*_*b*.DBG	NOT KEPT	NOT KEPT

1. $r \in \begin{cases} \{1,2,3\} & \text{for each S2} \\ \{1\} & \text{for each S3, S4, RH\_IMP} \end{cases}$

2. $b \in \{\text{RH\_IMP, S2, S3, S4}\}$

*File used for S2 and S4

**File used for S3 and RH IMP

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LOS ALAMOS NATIONAL LABORATORY
CARLSBAD OPERATIONS

Simple Analysis Report
INV-SAR-08
Revision 0

Analysis of RH TRU Wastes for Containment in Lead Shielded Containers

Effective Date: 8/30/07

Originators:

Bev Crawford, LANL-CO Inventory Team Leader — Date 8/30/07

Dan Taggart, LANL-CO Difficult Waste Team — Date 8/30/07

Technical Review:

Bill McInroy, LANL-CO Inventory Team Member — Date 8/30/07

Approved by:

Bev Crawford, LANL-CO Inventory Team Leader — Date 8/30/07

Tim Burns, LANL-CO Deputy Group Leader — Date 8/30/07

INV-07-08-25-01-01

TABLE OF CONTENTS

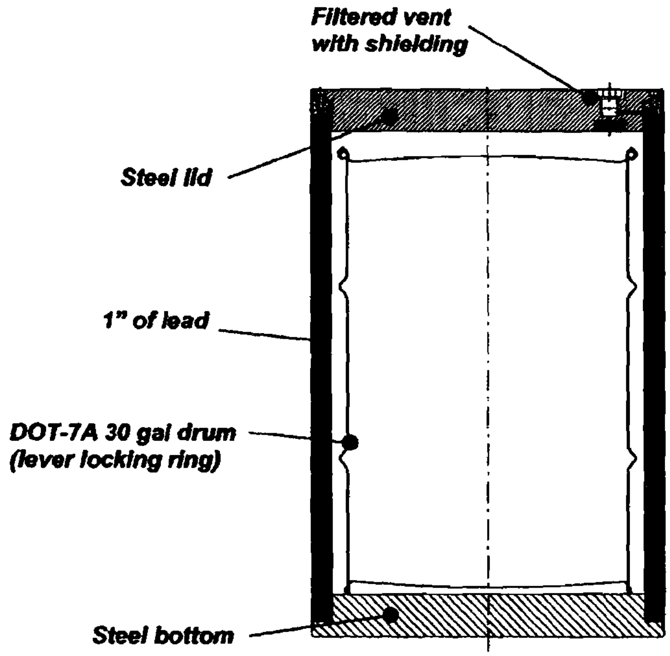


Figure 1

2.0 SCOPE AND LIMITATIONS

This simple analysis was performed as delineated in INV-AP-01, Revision 2, *Analysis Plan for Transuranic Inventory* and INV-SP-03, Revision 3, *Responding to Request for Quality Level 1 Inventory Information* under the LANL-CO Quality Assurance Program defined in LCO-QPD-01, *LANL-CO WIPP Quality Assurance Plan.* This simple analysis was documented in accordance with LCO-QP9-1, Revision 2, *Analyses*. Microshield software is qualified in accordance with LCO-QP19-1, *Software Quality Assurance* (LANL 2005).

The limits for this analysis include the WIPP RH capacity volume of 7080 m^3 and the interior volume of a 30-gallon drum of 0.113 m^3. The limiting activity for a shielded container, not taking credit for the waste's radiation absorption and assuming uniform radioactivity, is 2 Ci Cs-137 or 0.12 Ci Co-60 per 30-gallon waste drum[1]. A sum of fractions rule is used when more than one of the limiting radionuclides is present in a waste stream.

3.0 DEFINITIONS AND ACRONYMS

Acronyms and definitions for terms used in this procedure are located in *LANL-CO Acronyms and Definitions* in the LANL-CO Document Center (http://lcodocs.lanl.gov/) and are available as a stand alone document upon request.

[1] These two isotopes dominate the external radiation of 67 of the 87 RH waste streams.

Constituent	Assumption
CPR	**Packaging Material - CPR:** 1) There is no cellulose in packaging materials for shielded containers. 2) The plastic drum handling bag mass in the shielded container is 4 lbs or 1.81 kg (Donner 2007). 3) There is no rubber in packaging material for the shielded container. **Emplacement Material - Plastic in a 3-pack:** 4) A top reinforcement plate and a bottom slip-sheet of polyethylene are used for each 3-pack of shielded containers. 5) The mass of the reinforcing plate and bottom slip-sheet are 15.785 kg for each 3-pack of shielded containers (Burns 2005). 6) Plastic stretch wrap is used for each 3-pack in the same mass as that used for seven-packs of 55-gallon drums. 7) The mass of the plastic wrap is assumed to be 0.998 kg per 3-pack (Burns 2005). **Emplacement Material - Plastic in a 3 high stack of 3-packs:** 8) The supersacks containing MgO are composed of woven polypropylene. 9) The mass of the polypropylene in the supersack is 3.447 kg per sack. 10) Each supersack has a polyethylene slip-sheet on the bottom of the sack. 11) The mass of the supersack plastic slip-sheet is 7.892 kg per supersack. **Emplacement Material - Cellulose in a 3 high stack of 3-packs:** 12) Cardboard stabilizers (composed of cellulosic material) are used for the supersacks. 13) The cellulosic material in the stabilizer is assumed to be 3.447 kg (Burns 2005)
Steel	1) The total steel per shielded container including 30-gallon drum is 901 lb or 409 kg (assuming 3.00 inch thickness in base and lid). 2) There is no steel used in the repository for emplacement of shielded containers.
Lead	1) The total lead per shielded container is 950 lbs or 431 kg. 2) There is no lead used in the repository for emplacement of shielded containers.

4.4 Mass of Plastic, Steel, and Lead Packaging Materials

The masses of lead, steel and plastic ($M_{Pb/steel/plastic}$) packaging material provided in Table 1 were used to determine the total mass of each packaging material constituent as shown in equation 4.

Eqn. 4. $N_{30} \times M_{Pb/steel/plastic} = PTPb_{/steel/plastic}$

Where:
N_{30} is the number of shielded containers based on the capacity volume of 7080 m^3 (eqn. 1),
$M_{Pb/steel/plastic}$ is the mass of lead, steel or plastic packaging material (see Table 1), and.
$PT_{Pb/steel/plastic}$ is the total mass of lead, steel or plastic packaging material in WIPP from shielded containers.

The mass of each of these packaging materials and the total mass of each constituent expected to be present in the capacity volume of RH-TRU waste in the repository is presented in Table 6 of section 6.2 *Packaging and Emplacement Material Densities for RH-TRU Waste in Shielded Containers.*

4.5 Mass of Emplacement Materials (CPR)

The total mass of plastic emplacement material in the repository that is contributed by the shielded containers and the stacks described above, is the sum of the plastic associated with the 3-packs and the plastic associated with the stacks. The total mass of plastic emplacement material is calculated using equation 5, below.

Eqn. 5. $(N_{3pk} \times PM_{3pk}) + (N_{stack} \times PM_{ss}) = ETplastic$

Where:
N_{3pk} is the number of 3-packs generated from the 30-gallon drums in the repository,
PM_{3pk} is the mass of the plastic slip-sheet, reinforcement plate and stretch wrap for each 3-pack of shielded containers,
N_{stack} is the number of stacks that will be generated from shielded containers stacked 3 high,
PM_{ss} is the mass of the plastic in the supersack and slip-sheet in a stack, and
$ET_{plastic}$ is the total mass of plastic emplacement material associated with the shielded containers in the repository.

The total mass of emplaced plastic material in the repository is presented in Table 7 of section 6.2 *Packaging and Emplacement Material Densities for RH-TRU Waste in Shielded Containers.*

The total mass of cellulose emplacement material in the repository is contributed solely by the cardboard stabilizer in the supersacks. There is no rubber used for emplacement of

5.1 Determination of Dominant Gamma Emitters in the PABC RH Inventory

The activity concentration for each radionuclide in each RH waste stream was multiplied by a gamma factor (Shleien, 1992) specific to that radionuclide to identify the dominant gamma emitters (contributing to at least 95% of the external radiation dose). The gamma factors of the dominant gamma emitting radionuclides were adjusted using Microshield (in some cases using user defined sources) to reflect gamma absorption in the 30-gallon drum's steel wall (waste absorption was not considered). These results are presented in Table 9 section 6.4. *Candidate Waste Streams* (see Table 2 for absorption assumptions used in screening).

Table 2 – Assumptions and Knowns Used for Determination of Dominant Gamma Emitter and Maximum Activity for Shielded Containers

Considerations	Assumptions
Important Drum Characteristics	The drum is composed of 18 gauge (0.047 inch) iron wall.
Absorption	1) The gamma emitted is not absorbed by the waste. 2) The gamma emitted is not absorbed by the container wall for determination of the shielded container curie limits but is absorbed for the dominant gamma emitting radionuclide determination..

Microshield 6.02 was used subsequent to the gamma factor screening to determine the maximum activity of the dominant gamma emitters that would result in a contact dose rate less than 200 mrem/h when overpacked in a shielded container. Microshield calculations were performed on a Dell 3.2 GHz platform equiped with 2.0 Gb RAM and 233 Gb Hard Drive using a Windows XP Professional Service Pack 2 operating system. The maximum activity loadings are presented in section 5.2 *Determination of the Maximum Activity Concentration Loading for the Shielded Containers.*

The shielded container was modeled as having a 3" thick iron top and bottom, with radial walls consisting of a 0.188" thick iron inner liner, 1" thick lead and 0.125" thick Fe outer liner. A cylindrical volume representing a 30 gallon drum was uniformly filled with 1 curie of each dominant radionuclide. The exposure rate at the very top of the shielded container and at the radial wall surface at the shielded container half-height was calculated. The largest of these values was used to set the activity limit per shielded container. The energies and intensities of the gamma radiations modeled are printed with the results in attachment 2

The final results of gamma factor screening using radionuclides from waste streams decay corrected to 2002 are presented in Table 10 section 6.4 *Candidate Waste Streams*. The candidate waste streams are also presented in this table.

Table 4 – CH-TRU Cellulose, Plastic, Steel and Lead Inventory Data Reproduced from TWBIR-2004

	Packaging Density[1] (kg/m^3)	Emplacement Mass[2] (kg)	Emplacement Density (kg/m^3)
Cellulose	0	2.07×10^5	1.22×10^0
Plastic	1.7×10^1	1.48×10^6	8.78×10^0
Steel	1.7×10^2	0	0
Lead	0[3]	0	0

[1]Taken from Table 25 (DOE 2006).
[2]Taken from Table 34 (DOE 2006).
[3]A small amount of lead (1.3×10^{-2}) has been reported in repository waste material parameter roll ups. This quantity is essentially zero.

6.2 Packaging and Emplacement Material Densities for RH-TRU Waste in Shielded Containers

The total number of shielded containers based on the RH capacity volume of 7080 m^3 is presented in Table 5. In addition to the number of shielded containers, the number of 3-packs of shielded containers and the number of stacks is reported in Table 5.

Table 5- Number of Containers in Capacity Volume

Capacity Volume (m^3)	Volume of 30-gallon container (m^3)	Container Count	No. 3-packs	No. Stack
7080	0.113	62,655	20,885	6,962

The packaging material for a shielded container includes plastic, steel and lead. The masses for plastic in a shielded container were obtained from (Donner 2007). The masses of steel and lead in the shielded containers were obtained from the assumptions provided in Table 1 of this report and arose from the Shielded Container Project guidance. The total

	Mass from Packaging[1] (kg)	Packaging Density (kg/m^3)	Mass from Emplacement[2] (kg)	Emplacement Material Density (kg/m^3)
Steel	2.56×10^7	3.62×10^3	0	0
Lead	2.70×10^7	3.81×10^3	0	0

[1]Mass of packaging materials taken from Table 6.
[2]Mass of emplacement materials taken from Table 7.

6.3 Dominant Gamma Emitters

The ranking of the dominant external dose contributors in the PABC RH-TRU waste inventory is shown in Table 9. The results clearly indicate that the contribution of Cs-137 is highest for most of the RH-TRU waste streams. The second highest gamma contribution comes from Am-241 and the third is Co-60.

Table 9– Radionuclides Contributing to Highest Dose in PABC RH-TRU Waste Streams

Radionuclide	Rank					
	1st	2nd	3rd	4th	5th	Total Times in Top 5
Am-241	10	14	3	0	0	27
Cs-137	56	6	0	0	0	62
Cm-243	0	0	1	1	0	2
Cm-244	2	1	0	0	0	3
Cm-247	0	1	0	0	0	1
Co-60	11	6	0	0	0	17
Cs-134	0	3	4	0	0	7
Eu-152	1	2	0	1	0	4
Eu-154	0	2	3	2	0	7
Pu-238	3	4	1	0	0	8
Pu-239	4	3	1	0	0	8
Pu-240	0	0	5	1	0	6
Pu-243	0	0	1	0	0	1
Th-229	0	0	0	0	1	1

[1]Ranking is equivalent to the number of waste streams where the radionuclide was identified as contributing to >95% of the gamma dose accounting for absorption due to the container wall.

RL-W420	26.70	237
RL-W421	315.59	2793
RL-W428	21.36	190
RL-W433	43.61	386
RL-W436	488.61	4324
RL-W445	130.83	1158
RL-W446	22.25	197
RL-W621	12.46	111
RL-W658	43.61	386
RL-W663	16.02	142
RL-W664	2.67	24
RL-W686	0.89	8
RL-W687	0.89	8
RL-W701	0.89	8
T003-773A-HET	17.04	151
Totals	1,921.64	17,023

7.0 SUMMARY

The CPR, steel and lead have been reported for CH-TRU waste using the PABC TRU waste inventory and have been calculated for new packaging and emplacement materials assuming 7080 m^3 of waste will be emplaced in the WIPP repository using lead shielded containers. The PABC TRU waste inventory has also been evaluated for candidate waste streams. The candidate waste streams that are expected to contain less than 2.0 Ci Cs-137 or 0.12 Ci Co-60 per 30-gallon drum constitute 1,922 m^3 of the total PABC RH-TRU waste inventory. Some waste streams that exceed the limiting activity for 30-gallons of waste may also be considered for shipment to WIPP in shielded containers based on assay results on a per container basis.

8.0 ATTACHMENTS

Attachment 1: Letter from Dunagan
Attachment 2: Example Microshield 6.02 Output

9.0 REFERENCES

Burns 2005. Estimation of Cellulose, Plastic and Rubber Based on TWBID, Revision 2.1, Data Version D.4.16, Los Alamos National Laboratory, Carlsbad NM. INV-0607-01-46-26.

Department of Energy (DOE) 2006, *Transuranic Waste Baseline Inventory Report – 2004*, DOE/TRU-2006-3344.

Attachment 1 - Dunagan Letter

To be consistent with PA calculations and models, a volume of 7,080 m^3 should be used when determining the density of RH emplacement materials. A volume of 169,000 m^3 should be used to calculate the density of CH emplacement materials.

The procedure used to determine these quantities should be consistent with the above assumptions, and the data must be collected and analyzed in accordance with a quality assurance program approved by the Carlsbad Field Office. In order to complete our analysis according to DOE's schedule, we will need this information on or before August 31, 2007. If you have any questions about the requested data, please contact me.

Sincerely,

Signature on file

Sean Dunagan

Cc:
Steve Kouba, WTS
Sean White, WTS
Beverly Crawford, LANL
Bill McInroy, LANL
Moo Lee, SNL
David Kessel, SNL
Eric Vugrin, SNL
Department 6711 Day File

X-Sieve: CMU Sieve 2.2
X-Server-Uuid: 6CEB1540-FE13-491B-9872-FD67060ED864
Subject: RE: Shielded Container Inventory Needs
Date: Wed, 8 Aug 2007 06:58:35 -0600
X-MS-Has-Attach:
X-MS-TNEF-Correlator:
Thread-Topic: Shielded Container Inventory Needs
Thread-Index: AcfZQToMdLUJFi2ITG+tOPvvMtl0gQAenYlQ
From: "Dunagan, Sean" <sdunaga@sandia.gov>
To: "Beverly Crawford" <crawford@lanl.gov>
X-OriginalArrivalTime: 08 Aug 2007 12:58:36.0142 (UTC)
FILETIME=[D524D0E0:01C7D9BB]
X-TMWD-Spam-Summary: TS=20070808125835; SEV=2.2.2; DFV=B2007080809;
IFV=2.0.4,4.0-9; AIF=B2007080809; RPD=5.02.0125; ENG=IBF;
RPDID=7374723D303030312E30413031303230362E34364239424446422E303042332C7373
3D312C6667733D30;
CAT=NONE; CON=NONE
X-MMS-Spam-Filter-ID: B2007080809_5.02.0125_4.0-9
X-WSS-ID: 6AA762761V83166346-01-01
X-Proofpoint-Virus-Version: vendor=fsecure engine=4.65.5502:2.3.11,1.2.37,4.0.164
definitions=2007-08-08_04:2007-08-07,2007-08-08,2007-08-08 signatures=0
X-Proofpoint-Spam: 0
X-PMX-Version: 4.7.1.128075

From what I understand the iron won't be changing but the steel from the
containers will cause a changes. So, yes we are interested in the
steel. Do you expect a change in iron from the containers as well?

Sean Dunagan

-----Original Message-----
From: Beverly Crawford [mailto:crawford@lanl.gov]
Sent: Tuesday, August 07, 2007 4:18 PM
To: Dunagan, Sean
Cc: Vugrin, Eric D; Lee, Moo; Bill McInroy
Subject: Re: Shielded Container Inventory Needs

Sean:
I think in item 2 of your request you are asking for the density of
steel (as per the original request) not iron. Please let me know.
Bev

At 02:42 PM 8/7/2007, Dunagan, Sean wrote:

>Beverly and Bill

Attachment 2: MicroShield 6.02 Outputs

10.0 Example 1 – Side shields with a 1 Ci Cs-137 source.

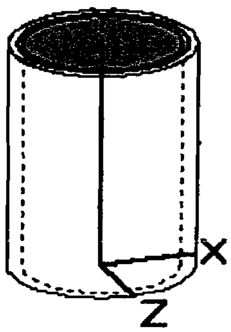
MicroShield v6.02 (6.02-00069)
Los_Alamos_National_Laboratories

Page	:1	**File Ref**	:
DOS File	:ModifiedShieldedDrumSideShield.ms6	**Date**	:
Run Date	: August 30, 2007	**By**	:
Run Time	: 10:43:19 AM	**Checked**	:
Duration	: 00:00:00		

Case Title:
Description:
Geometry: 7 - Cylinder Volume - Side Shields

Source Dimensions:

Height	70.333 cm	(2 ft 3.7 in)
Radius	24.498 cm	(9.6 in)



Dose Points

A	X	Y	Z
# 1	29.2354 cm	35.1663 cm	0 cm
	11.5 in	1 ft 1.8 in	0.0 in

Shields

Shield N	Dimension	Material	Density
Source	8092.399 in³	Air	0.00122
Shield 1	.542 in	Air	0.00122
Shield 2	.188 in	Iron	7.86
Shield 3	1.0 in	Lead	11.34
Shield 4	.125 in	Iron	7.86
Transition		Air	0.00122
Air Gap		Air	0.00122

Source Input : Grouping Method - Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm³	Bq/cm³
Ba-137m	9.4600e-001	3.5002e+010	7.1337e+000	2.6395e+005
Cs-137	1.0000e+000	3.7000e+010	7.5409e+000	2.7901e+005

Buildup : The material reference is - Shield 3
Integration Parameters

Radial	10
Circumferential	10
Y Direction (axial)	20

Results

Energy MeV	Activity Photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0045	3.634e+08	0.000e+00	1.205e-24	0.000e+00	8.259e-25
0.0318	7.246e+08	0.000e+00	1.768e-23	0.000e+00	1.473e-25
0.0322	1.337e+09	1.963e-318	3.304e-23	1.580e-320	2.659e-25
0.0364	4.865e+08	1.229e-229	1.375e-23	6.982e-232	7.815e-26
0.6616	3.149e+10	2.036e+04	3.759e+04	3.948e+01	7.288e+01
Totals	**3.441e+10**	**2.036e+04**	**3.759e+04**	**3.948e+01**	**7.288e+01**

12.0 Example 3 - Dose with 30 gallon drum wall.

MicroShield v6.02 (6.02-00069)
Los_Alamos_National_Laboratories

Page	:1	**File Ref**	:
DOS File	:18GaugeSteel.ms6	**Date**	:
Run Date	: August 30, 2007	**By**	:
Run Time	: 10:50:28 AM	**Checked**	:
Duration	: 00:00:00		

Case Title: Case 1
Description: Case 1
Geometry: 1 - Point

Dose Points

A	X	Y	Z
# 1	10 cm 3.9 in	0 cm 0.0 in	0 cm 0.0 in

Shields

Shield N	Dimension	Material	Density
Shield 1	.047 in	Iron	7.86
Air Gap		Air	0.00122

Source Input : Grouping Method - Actual Photon Energies

Nuclide	curies	becquerels
Ba-137m	9.4600e-001	3.5002e+010
Cs-137	1.0000e+000	3.7000e+010

Buildup : The material reference is - Shield 1
Integration Parameters

Results

Energy MeV	Activity Photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0318	7.246e+08	3.407e+01	3.646e+01	2.838e-01	3.037e-01
0.0322	1.337e+09	7.840e+01	8.396e+01	6.309e-01	6.757e-01
0.0364	4.865e+08	1.959e+02	2.117e+02	1.113e+00	1.203e+00
0.6616	3.149e+10	1.547e+07	1.629e+07	3.000e+04	3.158e+04
Totals	**3.404e+10**	**1.548e+07**	**1.629e+07**	**3.000e+04**	**3.158e+04**

14.0 Example 5 - User defined Am-241 source.

MicroShield v6.02 (6.02-00069)
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Page	:1		**File Ref**	:
DOS File	:18GaugeSteel.ms6		**Date**	:
Run Date	: August 30, 2007		**By**	:
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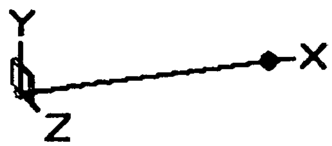
Duration	: 00:00:00			

Case Title: 1 Ci Am-241
Description: Case 1
Geometry: 1 - Point



Dose Points

A	X	Y	Z
# 1	10 cm	0 cm	0 cm
	3.9 in	0.0 in	0.0 in

Shields

Shield N	Dimension	Material	Density
Shield 1	.047 in	Iron	7.86
Air Gap		Air	0.00122

Source Input : Grouping Method - User Defined Energies

Group #	Energy (Mev)	Activity Photons/sec	Point Source Photons/sec	% Energy Activity
1	0.0263	8.8800e+008	8.8800e+008	2.853
2	0.0322	6.4380e+006	6.4380e+006	.025
3	0.0332	4.6620e+007	4.6620e+007	.189
4	0.0427	2.0350e+006	2.0350e+006	.011
5	0.0434	2.7010e+007	2.7010e+007	.143
6	0.0556	6.6970e+006	6.6970e+006	.045
7	0.0579	1.9240e+006	1.9240e+006	.014
8	0.0595	1.3283e+010	1.3283e+010	96.451
9	0.0698	1.0730e+006	1.0730e+006	.009
10	0.0758	2.2200e+005	2.2200e+005	.002
11	0.099	7.5110e+006	7.5110e+006	.091
12	0.103	7.2150e+006	7.2150e+006	.091
13	0.123	3.7000e+005	3.7000e+005	.006
14	0.1253	1.5096e+006	1.5096e+006	.023
15	0.1466	1.7057e+005	1.7057e+005	.003
16	0.1696	6.4010e+004	6.4010e+004	.001
17	0.208	2.9267e+005	2.9267e+005	.007
18	0.3225	5.6240e+004	5.6240e+004	.002
19	0.3324	5.5130e+004	5.5130e+004	.002
20	0.3354	1.8352e+005	1.8352e+005	.008
21	0.3686	8.0290e+004	8.0290e+004	.004
22	0.3767	5.1060e+004	5.1060e+004	.002
23	0.619	2.1978e+004	2.1978e+004	.002
24	0.6624	1.3468e+005	1.3468e+005	.011
25	0.722	7.2520e+004	7.2520e+004	.006

16.0 Example 7 - User defined Pu-238 source.

MicroShield v6.02 (6.02-00069)
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Page	:1	**File Ref**	:
DOS File	:18GaugeSteel.ms6	**Date**	:
Run Date	: August 30, 2007	**By**	:
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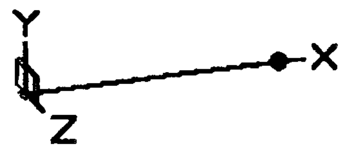
Case Title: 1 Ci Pu-238
Description: Case 1
Geometry: 1 - Point



Dose Points

A	X	Y	Z
# 1	10 cm	0 cm	0 cm
	3.9 in	0.0 in	0.0 in

Shields

Shield N	Dimension	Material	Density
Shield 1	.047 in	Iron	7.86
Air Gap		Air	0.00122

Source Input : Grouping Method - User Defined Energies

Group #	Energy (Mev)	Activity Photons/sec	Point Source Photons/sec	% Energy Activity
1	0.0435	1.5000e+007	1.5000e+007	66.149
2	0.0999	2.7000e+006	2.7000e+006	27.331
3	0.1527	3.5000e+005	3.5000e+005	5.418
4	0.201	1.4000e+003	1.4000e+003	.029
5	0.2582	3.1000e+001	3.1000e+001	.001
6	0.2991	1.8000e+001	1.8000e+001	.001
7	0.7059	2.0000e+001	2.0000e+001	.001
8	0.7083	1.5000e+002	1.5000e+002	.011
9	0.7428	1.9000e+003	1.9000e+003	.143
10	0.7664	8.1000e+003	8.1000e+003	.629
11	0.7834	8.9000e+000	8.9000e+000	.001
12	0.7863	1.2000e+003	1.2000e+003	.096
13	0.8044	4.4000e+001	4.4000e+001	.004
14	0.8058	2.2000e+001	2.2000e+001	.002
15	0.8082	3.0000e+002	3.0000e+002	.025
16	0.8517	4.6000e+002	4.6000e+002	.040
17	0.8805	5.9000e+001	5.9000e+001	.005
18	0.8832	2.8000e+002	2.8000e+002	.025
19	0.9044	2.4000e+001	2.4000e+001	.002
20	0.9267	2.1000e+002	2.1000e+002	.020
21	0.9419	1.7000e+002	1.7000e+002	.016
22	0.946	3.2000e+001	3.2000e+001	.003
23	1.001	3.7000e+002	3.7000e+002	.038
24	1.042	8.1000e+001	8.1000e+001	.009
25	1.085	3.4000e+001	3.4000e+001	.004

18.0 Example 9 - User defined Pu-240 source.

MicroShield v6.02 (6.02-00069)
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Page	:1	**File Ref**	:
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Run Date	: August 30, 2007	**By**	:
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Duration	: 00:00:00		

Case Title: 1 Ci Pu-240
Description: Case 1
Geometry: 1 - Point

Dose Points

A	X	Y	Z
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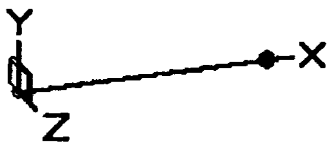
	3.9 in	0.0 in	0.0 in



Shields

Shield N	Dimension	Material	Density
Shield 1	.047 in	Iron	7.86
Air Gap		Air	0.00122

Source Input : Grouping Method - User Defined Energies

Group #	Energy (Mev)	Activity Photons/sec	Point Source Photons/sec	% Energy Activity
1	0.045	1.6650e+007	1.6650e+007	71.219
2	0.104	2.6196e+006	2.6196e+006	25.896
3	0.16	1.4874e+005	1.4874e+005	2.262
4	0.212	1.0730e+004	1.0730e+004	.216
5	0.538	5.4000e+001	5.4000e+001	.003
6	0.642	4.8100e+003	4.8100e+003	.294
7	0.688	1.2950e+003	1.2950e+003	.085
8	0.698	9.0000e+000	9.0000e+000	.001
9	0.874	2.1500e+002	2.1500e+002	.018
10	0.958	3.7000e+001	3.7000e+001	.003
11	0.96	1.9000e+001	1.9000e+001	.002
12	0.967	1.9000e+001	1.9000e+001	.002
Totals	**1.944e+07**	**2.390e+02 2.729e+02**	**4.734e-01**	**5.375e-01**

WIPP Technical Fact Sheet
Planned Change Request for Shielded Containers

Summary

The U. S. Department of Energy (DOE) has submitted a planned change request to use shielded containers for emplacement of selected remote-handled (RH) transuranic (TRU) waste streams on the floor of the repository. The use of the shielded containers will enable DOE to significantly increase the efficiency of transportation and disposal operations for RH TRU waste at the Waste Isolation Pilot Plant (WIPP).

The shielded container design has 1-inch thick lead shielding sandwiched between a double-walled steel shell with a 3-inch thick lid and base. The lead for the container may be recycled from excess DOE stock. This design has passed the drop testing for Department of Transportation (DOT) Type 7A specifications and the U.S. Nuclear Regulatory Commission (NRC) Type B specifications for shipping in the HalfPACT transportation container. The drop tests ensure there will be no loss of shielding. These results ensure that the shielded container is safe for transportation and handling and will prevent releases under the most severe accident conditions. The DOE is awaiting regulatory approval.

RH TRU waste whose activity is low enough to result in a dose rate of less than 200 millirem/hour on the outside surface of the shielded container is a candidate for emplacement in shielded containers. The shielded containers will be emplaced in the disposal rooms, along with CH TRU waste, but these waste streams will remain designated as RH TRU waste in the WIPP Waste Information System. A recent performance assessment has demonstrated that the use of shielded canisters for these waste streams has an insignificant impact on long-term performance of the repository.

Background/History

On January 24, 2007, WIPP received its first shipment of RH TRU waste (DOE 2007). RH TRU waste is currently packaged for disposal in RH canisters. The RH canisters are loaded into horizontal boreholes that are drilled perpendicular to the walls of the disposal rooms (DOE 2004, Section 3.2). The RH canister is cylindrical in shape with a length of about 120 inches and a diameter of 26 inches. The RH canister has a nominal wall thickness of 0.25 inches and is made entirely of steel.

The emplacement of RH TRU waste in the walls of the disposal rooms is appropriate and necessary for higher activity waste streams; however, there are several reasons why an alternative disposal method is advantageous for lower activity RH TRU waste steams. The drilling and emplacement operations for the RH canisters impede direct access to a room. This is the result of the large specialized equipment required to emplace the canisters into boreholes. Borehole drilling is limited to drilling 1 to 2 boreholes per shift. The borehole drilling equipment also restricts access to the room. The operations are time consuming; it requires one 8-hour shift to emplace a single RH TRU waste canister. A single RH waste canister evolution from receipt of the RH-TRU 72B until emplacement in the wall of the underground disposal room requires more than 10 hours. WIPP is limited to a maximum of 6 RH shipments per week just from the operational constraints. In contrast, the CH waste handling processes routinely allow 4-5 shipments (i.e., 3 HalfPACTs per shipment) per day to be received, unloaded and emplaced per day. Panels 1, 2 and 3 have been filled without emplacing any RH TRU waste canisters in the walls, limiting the available wall space for emplacement of RH TRU waste. Thus, the use of shielded containers can improve the efficiency of facility operations by minimizing the disruptions from in-the-wall emplacement of RH TRU waste canisters while providing additional storage locations for some of the RH TRU waste.

Proposed Change

DOE is therefore proposing a change to the emplacement scheme for a portion of the RH TRU waste. DOE proposes to package a subset of the RH TRU waste streams in lead-shielded containers. These containers would then be placed in the disposal rooms, in a similar manner to the emplacement scheme for CH TRU waste containers. Candidate RH TRU waste for disposal in shielded containers must result in a dose rate at the container surface of less than 200 millirem/hour. These waste streams and containers will remain designated as RH TRU waste in the WIPP Waste Information System (WWIS). They will count against the limit of 5,100,000 Curies for RH TRU waste defined by the WIPP Land Withdrawal Act and the limit of 250,000 cubic feet (7,080 cubic meters) for RH TRU waste defined by the Consultation and Cooperation Agreement between DOE and the state of New Mexico.

Shielded Container Design

The shielded container is designed to hold a 30-gallon drum, and has approximately the same exterior dimensions as a 55-gallon drum. The cylindrical sidewall of the shielded container has 1-inch-thick lead shielding sandwiched between a double-walled steel shell with an external wall thickness of 1/8 inch and an internal wall thickness of 3/16 inch. The lid and bottom of the container are made from 3.0 inch thick steel. (Figure 1) The empty weight of the container is approximately 1,800 pounds. The shielded container and any inner 30-gallon drums will be vented. Additional technical drawings of this design are in Sellmer (2007).

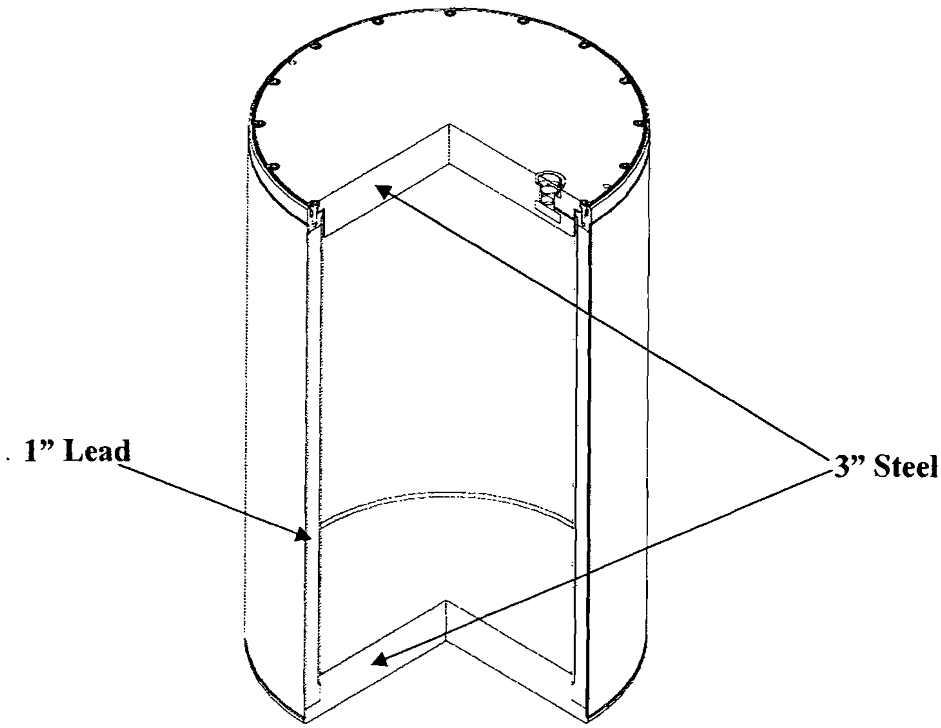


Figure 1. Isometric Exposed View of the Shielded Container

It has been estimated that RH TRU waste containing less than 2 curies of Cs-137 or 0.12 curies of Co-60 per 30 gallon drum is a candidate for packaging in shielded containers because the 1-inch lead shielding is predicted to reduce the surface dose rate to less than 200 millirem/hour.

Shielded Container Testing

The container design has successfully completed drop testing to the DOT 7A Type A specifications and to the NRC Type B specifications, for shipping in the existing HalfPACT, with a shielded container and associated dunnage dropped in a HalfPACT inner containment vessel. These results ensure that the container is safe for transportation and handling and will prevent releases under the most severe accident conditions. The design for the shielded container has been submitted to the NRC for their review and approval as a shipping container for RH TRU waste.

Impact on WIPP Performance

The Shielded Container Performance Assessment (SCPA) (Dunagan et al. 2007) was conducted to evaluate the impact of emplacing RH TRU waste in shielded containers on the long-term performance of the repository. Given the uncertainty in the exact amount of RH TRU waste that can be emplaced in shielded containers, the SCPA used a bounding approach that considered several extreme cases, including a case with all the RH TRU waste in RH containers in the walls (the current baseline) and a case with all the RH TRU waste in shielded containers in the rooms. The results from the SCPA indicate insignificant differences in repository releases for these two cases relative to the compliance limits (Dunagan et al. 2007 Figure 8). (Figure 2) This result is expected because the volume and radioactivity of all RH TRU waste streams is only a few percent of the total volume and total radioactivity for the baseline inventory in the PABC. RH TRU waste has negligible effect on long-term performance in any emplacement configuration.

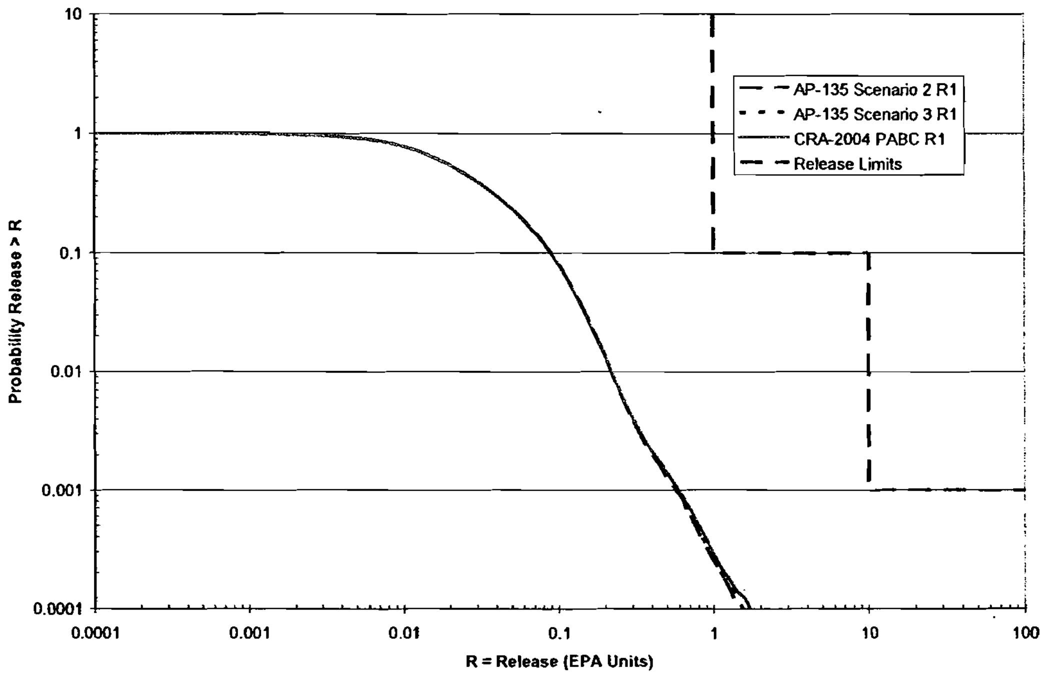


Figure 2. Mean Total Releases from SCPA Scenarios 2 and 3 and CRA-2004 PABC, Replicate 1

References

DOE. 2004. Title 40 CFR Part 191 Compliance Recertification Application for the Waste Isolation Pilot Plant, DOE/WIPP 2004-3231, 10 vols., US Department of Energy, Carlsbad Field Office, Carlsbad, NM.

DOE. 2007. First Remote-Handled Transuranic Waste Shipment arrives at WIPP. DOE News, January 24, 2007, 03DR0107. US Department of Energy, Carlsbad Field Office, Carlsbad, NM.

Crawford, Taggart, McInroy, Burns. 2007. Analysis of RH TRU Wastes for Containment in Lead Shielded Containers. Simple Analysis Report, INV-SAR-08, Revision 0. Los Alamos National Laboratory Carlsbad Operations, Carlsbad, NM.

Dunagan, S.C., Roselle, G.T., Vugrin, E.D., and J.J. Long. 2007. Analysis Report for the Shielded Container Performance Assessment. Revision 1. Sandia National Laboratories, Carlsbad, NM. ERMS 547358.

Leigh, C. D., J. F. Kanney, L. H. Brush, J. W. Garner, G. R. Kirkes, T. Lowry, M. B. Nemer, J. S. Stein, E. D. Vugrin, S. Wagner, and T. B. Kirchner. 2005. 2004 Compliance Recertification Application Performance Assessment Baseline Calculation, Revision 0. Sandia National Laboratories, Carlsbad, NM. ERMS 541521.

Sellmer, T. 2007. Final Container Design, Shielded Container. Washington TRU Solutions, Carlsbad, NM. ERMS 547052.