Summary of a Revised Safety Impact Analysis for the Lead Shielded Container Assembly

Scope

This white paper summarizes the results of a revised safety impact analysis conducted on the lead shielded container assembly (SCA). The purpose of the revised impact analysis is to identify any potential changes to the total effective (radiation) dose to on-site workers and the maximally exposed offsite-individual from previous analyses performed to support the WIPP Documented Safety Analysis (DSA). The revised analysis considers the potential for the lead in a SCA to melt during a fire/accident event and the resulting impacts on total effective radiation dose. The analysis provides the bounding fire scenarios that are required for development of the WIPP DSA. In that these scenarios are conservative, more realistic scenarios are also provided to explain what is more likely to occur. The WIPP DSA currently considers a variety of waste containers for contact-handled transuranic (CH TRU) waste, including 55-gallon drums, 85-gallon drums, 100-gallon drums; standard waste boxes (SWB); ten drum overpacks; and pipe configurations overpacked in 55-gallon drums. The 85-gallon drum, 100-gallon drum, SWB and ten drum overpacks may also be used to overpack smaller waste containers, e.g., a 55-gallon drum may be overpacked in an 85-gallon drum.

The analysis presented in this white paper is conservatively based on the previous accident analysis and hazard controls that were selected for the SCA based on DOE-STD-5506. The process described in this white paper evaluates the potential impacts from the lead in SCAs melting during a fire/accident on total effective dose to on-site workers and to members of the public. This impact analysis has been performed as a step in the process of seeking EPA approval for the use of SCAs at WIPP.

Description

The SCA is proposed as an alternative to disposal of remote-handled (RH) transuranic (TRU) waste in canisters in the ribs (walls) of the disposal rooms. The SCA will be used to emplace selected RH TRU waste streams in the WIPP repository. RH TRU waste that emits significant gamma radiation can be packaged within the SCAs if the lead shielding reduces the surface dose rate to less than 200 mRem/hour, which is the level that is safe for handling as a contact-handled container. The SCA can then be managed as a CH TRU waste container and emplaced on the floor, rather than in the walls of disposal rooms.

The SCA has approximately the same exterior dimensions as a 55-gallon drum and holds a single 30-gallon drum that will contain the RH TRU waste (See Figure 1). The cylindrical sidewall of the SCA has nominal 1-inch-thick lead shielding sandwiched within a double-walled steel shell. The external wall is 11 gauge (0.091 inch) steel and the internal wall is 7 gauge (0.144 inch) steel. The lid and the bottom of the container are made of carbon steel and are approximately 3 inches thick. The 30-gallon inner container has a gross internal volume of 4.0 ft^3 (0.11 m^3) and a maximum loaded weight of 2,260 pounds. The empty weight of the SCA is 1,726 pounds.

The SCA has been tested to Department of Transportation (DOT) Type 7A specifications and is approved by the U.S. Nuclear Regulatory Commission as an authorized packaging configuration for use with the HalfPACT package. This testing and certification ensure that the container will contain the waste under the most severe transportation accident conditions. The SCAs will be configured as an assembly of three containers, i.e., a three-pack, for transport in the HalfPACT and for emplacement at WIPP.

Upon arrival at the WIPP facility, the SCA will be processed with a method similar to that for CH TRU waste. After receipt, the 3-pack assembly will be removed from the HalfPACT using existing lifting fixtures and equipment in the CH Bay portion of the Waste Handling Building. The 3-packs will be placed on a facility pallet (two 3-packs in a single layer) and downloaded to the underground repository along with other CH TRU waste containers. The 3-pack assembly of SCAs will be emplaced randomly on the floor of the underground disposal rooms along with other CH TRU waste containers.

The emplacement configuration of the SCA 3-pack is constrained by its weight and by its footprint. The 3-packs will not be emplaced more than two levels high. In addition, the 3-pack assembly will not be placed at the bottom of a stack with other CH TRU waste assemblies on top due to the smaller footprint of the 3-pack assembly relative to a 7-pack of 55-gallon drums or other waste containers. No sacks containing Magnesium Oxide (MgO) will be placed on top of the SCA 3-pack due to the smaller footprint of the 3-packs relative to the size of the MgO sacks. However, each disposal room will continue to be monitored to ensure the MgO excess factor remains at 1.2 or greater prior to room closure. Existing waste handling equipment and fixtures will be used for the emplacement of the SCA 3-pack. There are no plans to introduce new waste handling equipment and fixtures for the unloading, transporting and emplacement process.

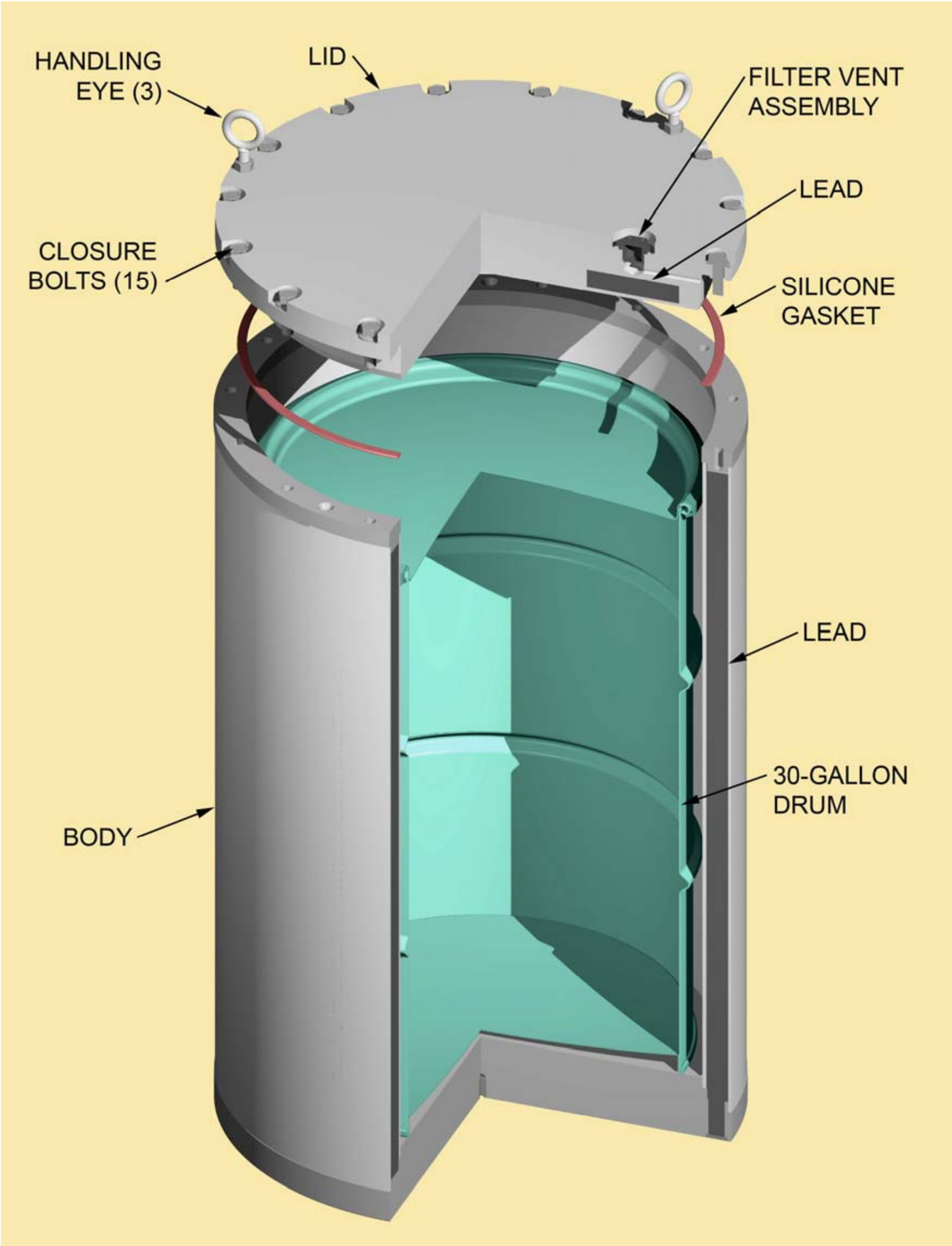

Figure 1. Isometric View of the Lead Shielded Container Assembly

Shielded Container's Impact on the Probability of Occurrence of an Accident

The use of SCAs for emplacement of RH TRU waste at WIPP will not increase the probability of occurrence of an accident previously considered because they will be handled and emplaced in the disposal rooms in the same manner as what is currently used for CH waste. No new equipment will be required because the existing waste handling equipment can be used within the applicable design capacities. Minimal changes will be necessary to the waste handling procedures, except for those related to emplacement configuration.

The WIPP DSA is required to consider a minimum set of hazard event scenarios which includes fires, explosions, loss of confinement, direct radiation exposure, criticality, and externally initiated and natural phenomena. Site specific scenarios are developed for each of these categories. Each scenario evaluates a consequence for each authorized waste container configuration. Not all waste containers are damaged in every scenario. For example a 55-gallon drum is assumed to be damaged for all drops above four feet; however, it is anticipated that the SCA will not be damaged from the same drop scenario because of its more robust design. Therefore, the four foot drop scenario would not be applicable for the SCA.

Table 1 summarizes all the fire scenarios that are applicable to the SCA and that were considered in this safety impact analysis. The scenarios in Table 1 have been analyzed with a two-pronged approach: (1) worst case analyses for specific fire scenarios, and (2) a bounding approach for the remaining fire scenarios. A separate report, *Fire Analysis of the Shielded Container for the Waste Isolation Pilot Plant Carlsbad, New Mexico* **(**WTS2010b), evaluates the worst case fire scenarios which are applicable to a SCA, and concludes that the worst case fire has no increase in consequence beyond the existing worst case scenario E-01G-CH/RH-UG. Based on this result, a judgment is made that there will be no increase in the consequence of the remaining applicable fire scenarios. This is an acceptable approach for DSA dose consequence calculation, where qualitative judgment is encouraged based on bounding analysis by DOE-Standard-3009-94, *Preparation Guide for U. S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analysis* and DOE-STD-5506, *Preparation of Safety Basis Documents for Transuranic Waste Facilities*. To summarize, Table 1 is a comprehensive list of all applicable fire scenarios and WIP-032 provides the detailed analysis of selected worst case fire scenarios that bound the scenarios in Table 1.

Table 1 also lists all the criticality scenarios that are applicable to the SCA and that were considered in this safety impact analysis. Criticality consequences are not approached in the same manner as other scenarios. If a criticality event were to occur, the consequence to facility workers would be fatal. For this reason all possible scenarios involving criticality must be analyzed to ensure the events will not occur with any of the authorized waste container types. The criticality analyses were therefore updated to include the use of the SCA. The reports *Summary of Nuclear Criticality Safety Evaluation for Shielded Containers at the Waste Isolation Pilot* (WTS 2009) and *WIPP Safety Analysis Calculation* (WTS 2010a) evaluate the credibility of criticality scenarios which are applicable to a SCA and concludes that the possibility of a criticality event is incredible (i.e., less than 10^{-6} per year) (see 14A and14B events in Table 1).

The SCA has a similar configuration to a 55-gallon Type A drum that is overpacked in a SWB. In other words, the 30-gallon drum inside a SCA is similar to a 55-gallon drum overpacked in a SWB although the SCA is more structurally robust than the SWB. Because of the similarity in physical configuration and because the SCA is more robust structurally than a SWB, the damage ratios provided for overpacked containers in DOE-STD-5506 are considered bounding for the SCA for events involving mechanical insults.

Fire events that directly involve CH waste containers were evaluated in (WTS 2010b) and are referenced in Table 1 of this white paper. The analysis of fire events concludes that the design and construction of the SCA is similar to certain physical attributes of other TRU waste containers that have been exposed to fire testing (WTS 2010b, Section 5.0 and Table 5-1). For fires, the SCA was compared to the direct loaded 55-gallon drum. Consistent with DOE-STD-5506 Appendix C, a damage ratio (DR) of 0.5 applies to arrays of 10 or more drums involved in an exposure or fully engulfing pool fire. A DR of 1.0 applies to arrays of less than 10 drums, and to drums which experience impact followed by fire.

As the primary shielding component of the SCA, the behavior of lead during a fire is an important consideration and is investigated further. As a result, unmitigated bounding fire accident scenarios have been developed based on requirements delineated in DOE-STD-5506.

The conservative bounding fire accident scenarios for the DSA are based on:

- Small, medium, and large fires involving vehicle collisions in the Waste Handling Building (WHB) – This analysis involves the collision of a SCA with a liquid fueled vehicle, resulting in a puncture of the SCA outer container wall. The subsequent diesel fuel pool fire heats and melts the lead, causing it to exit through the punctured outer wall. Total loss of shielding is assumed.

- Fire in the waste shaft results in catastrophic failure of the waste hoist – This analysis assumes a liquid fueled vehicle is driven into the open waste shaft when a SCA is on the waste conveyance in transit to the underground. The fire is assumed to fail the waste hoist, causing the waste conveyance and SCA to fall down the waste shaft. This will result in a breach of the SCA and a follow-on fire in the sump of the waste shaft, causing the lead to melt and leak out of the SCA. Total loss of shielding from the SCA is assumed.

- Small, medium, and large fires involving vehicle collisions in the underground – This analysis involves the collision of an SCA with a liquid fueled vehicle, resulting in a puncture of the SCA outer container wall. The subsequent diesel fuel pool fire heats and melts the lead, causing it to exit through the punctured outer wall. Total loss of shielding is assumed. This is the bounding DSA event because it involves a greater number of waste containers than other events.

Table 7-2 in WTS2010b shows the expected SCA response to thermal insult for short and long duration engulfing pool fires as well as exposure fires (nearby pool fire or ordinary combustible fires). Although SCAs are susceptible to a release during severe exposure fires, the consequences for direct loaded 55-gallon TRU drums are greater than the consequences for SCAs. The configuration for the SCAs has smaller numbers (i.e., three SCAs/waste assembly compared to seven 55 gallon TRU drums/ waste assembly). Because the material at risk (MAR) within each SCA is identical to that of a 55 gallon TRU drum and because the SCA is structurally more robust than a 55-gallon drum, the consequences for 55 gallon TRU drums are greater than the consequences for SCAs for exposure fires. (WTS-2010a, Section 2.2) It follows that there is no increase in consequence beyond what is already analyzed in the WIPP DSA using bounding fire scenarios.

Although bounding scenarios were developed in accordance with DOE-STD-5506, the more realistic fire scenarios include:

- No loss of lead from the shielded container. SCAs exposed to short-duration and fully engulfing pool fires are expected to have no release because of the space available within the double-walled steel shells for thermal expansion of the lead lining and because an engulfing pool fire provides uniform heating that makes stress concentrations and the associated material/weld failure unlikely.

- Minimum damage to the SCA based on 5% thermal expansion of melting lead within the double-walled steel shells overcoming seam welds. In this scenario only 5% of the melted lead would flow from the SCA rather than all the lead in the bounding scenarios. After the fire, the lead cools and contracts, resulting in a small void in the shielding. This could possibly occur when SCA are exposed to a nearby pool fire or ordinary combustible fires, experience uneven heating of the lead lining along with weakening of the outer container shell resulting, ultimately, in breach of the container outer shell and loss of lead lining through flow of melted lead through the breach.

SCAs involved in a long-duration, fully engulfing pool fire could be breached in a similar manner. And, SCAs which experience impact followed by fire would be expected to yield the same result.

The analysis of more realistic fire scenarios leads to the conclusion that there will not be a significant loss of lead from the SCA during a fire/ accident event.

For direct radiation exposure events (see E-13A events in Table 1) there is no change in frequency from those previously evaluated in Chapter 3 of the existing WIPP DSA. For criticality events, no credible criticality accident scenarios exist for the SCA during storage, handling, and disposal processes at the WIPP (WTS 2009, Executive Summary). Therefore, the handling and emplacement of SCA does not increase the probability of any of the initiating hazardous events for any of the accident scenarios considered by the WIPP DSA.

Shielded Container's Impact on the Consequences of an Accident

The SCA will have the same limits on Plutonium-equivalent (PE) Curies and Fissile Gram Equivalent mass as a direct loaded CH TRU drum (WTS 2009, Section 2.1). More specifically, the fissile contents during transportation are limited by container and package limits defined in the *HalfPACT Safety Analysis Report* (DOE-CBFO 2009). With the same limits, there is no increase in the amount of TRU radionuclides available to be released by a given physical process. Stated differently, the total material-at-risk is unchanged for a CH TRU drum and a SCA.

The bolted lid design of the outer assembly of the SCA is qualitatively judged to be at least as structurally robust as an overpack container (WTS 2010a, Section 5.2) for all hazard event scenarios except fires. Therefore, the SCA is given the same damage ratio as overpacked containers for all hazard event scenarios except fires. For fires, the SCAs are damaged less than overpacked containers (WTS 2010b), and the total material released is less than that of TRU waste drums (previously identified) (WTS 2010a). For direct radiation exposure events (see E-13A events in Table 1) there is no change in the consequence to the on-site worker. The on-site worker consequences were qualitatively assessed to be low. These analyses assume the on-site worker has a reasonable opportunity to exit the scene of the event and take self-protective actions that will limit exposure. For criticality events, no credible criticality accident scenarios exist for the SCA (WIPP 2009, Executive Summary). In addition, engineering/administrative controls were developed that reduce the likelihood for a release of radioactive material to the off-site public and the co-located worker as required by DOE-STD-5006. As such, these controls are enforced by the DOE/WIPP-07-3373, Rev. 1, WIPP Technical Safety Requirements. Therefore, no new initiating events result from the handling and emplacement of SCAs. The selected engineering/administrative controls include:

- Only battery powered vehicles are allowed to handle waste containers in the WHB.
- The WHB is equipped with a fire suppression system.
- The WHB is equipped with a HEPA filtration system to minimized radiological releases.
- Access to the waste shaft entry room is controlled through doors and interlocks.
- The waste hoist has redundant supporting wire ropes and brakes.
- The underground waste handling vehicles are equipped with automatic/manual fire suppression systems.
- Only waste handling vehicles are authorized to approach the waste face in the underground.
- Waste handling equipment is subjected to pre-operational checks prior to use.

- Waste handling personnel must be trained and qualified on the use of associated equipment.
- Emergency response procedures require evaluation of the involved area and radiation surveys upon re-entry into the area.
- Air monitoring equipment that can detect air borne contamination and if detected the facility can initiate a series of actions including HEPA air filtration from the mine so that contamination does not escape the facility and evacuation of the potentially contaminated areas.

Therefore, there is no increase in the consequences for any of the accident scenarios considered by the WIPP DSA.

Table 1. Applicable Accident Scenarios for the Shielded Container Safety Impact Analysis

Event Number	Event Description	Reference Document
E-01A-CH/RH-UG	Single liquid-fueled vehicle fire impacting CH and RH waste (pool fire)	WTS 2010b
E-01A-CH/RH-WHB	Fuel pool fire at the roll-up door affecting CH and RH waste	WTS 2010b
E-01A-CH-UG	Single liquid-fueled vehicle fire in the underground during transport (pool fire)	WTS 2010b
E-01A-CH-WHB	Single liquid-fueled vehicle fire in CH Bay in close proximity to staged waste (pool fire).	WTS 2010b
E-01B-CH/RH-OA	Large fueled vehicle impacts waste staged on trailers or waste trailer impacts fuel tanker (pool fire)	WTS 2010b
E-01B-CH/RH-UG	Collision of two liquid-fueled vehicles during transport involving CH and RH waste (pool fire)	WTS 2010b
E-01B-CH-UG	Collision of two liquid-fueled vehicles in the underground during transport (pool fire)	WTS 2010b
E-01C-CH-UG	Single liquid-fueled vehicle collision and fire at waste face (pool fire)	WTS 2010b
E-01D-CH/RH-UG	RH waste handling equipment collides into CH waste face involving CH and RH waste (pool fire)	WTS 2010b
E-01E-CH/RH-UG	Large pool fire in waste shaft	WTS 2010b
E-01G-CH/RH-UG	Lube truck collides into CH waste array with subsequent fuel pool fire	WTS 2010b
E-02A-CH/RH-OA	Small fire in waste container (internal waste container fire)	WTS 2010b
E-02A-CH/RH-UG	Small fire in waste container (internal waste container fire)	WTS 2010b
E-02A-CH/RH-WHB	Small fire in waste container (internal waste container fire)	WTS 2010b
E-02A-CH-WHB	Small fire following a collision involving electric forklift/Facility Transfer Vehicle	WTS 2010b
E-02B-CH/RH-OA	Small fire adjacent to waste containers	WTS 2010b
E-02B-CH/RH-UG	Small fire adjacent to waste container(s)	WTS 2010b
E-02B-CH/RH-WHB	Small fire adjacent to waste container(s)	WTS 2010b
E-02C-CH/RH-WHB	Fire in WHB/Hot Cell HEPA filters	WTS 2010b
E-03-CH-WHB	Waste container fire inside the shielded storage room	WTS 2010b
E-04A-CH/RH-WHB	Fire external to CH and RH Bays propagates to waste handling areas and impacts CH and RH waste	WTS 2010b
E-04A-CH-UG	Fire outside of the active disposal room (e.g., construction, mining, north ventilation circuit) propagates to active disposal room or disposal route	WTS 2010b
E-04A-CH-WHB	Large CH Bay fire involving ordinary combustibles	WTS 2010b
E-04B-CH/RH-WHB	Tanker truck fire in outside area propagates into waste handling areas and impacts CH and RH waste	WTS 2010b
E-04C-CH/RH-WHB	Large fire in Waste Hoist Tower results in waste conveyance drop	WTS 2010b
E-04C-CH/RH-WHB	Large fire in Waste Hoist Tower results in waste conveyance drop	WTS 2010b
E-04E-CH-WHB	Collision of two electric powered vehicles with	WTS 2010b

Event Number	Event Description	Reference Document
	subsequent fire	
E-05A-CH/RH-OA	Boiling Liquid Expanding Vapor Explosion/Vapor Cloud Explosion (BLEVE/ VCE) of liquefied gas cylinder near WHB	WTS 2010a
E-05A-CH/RH-UG	BLEVE/ VCE of liquefied gas cylinder during transport in the underground	WTS 2010a
E-05A-CH/RH-WHB	BLEVE/ VCE of liquefied gas cylinder in WHB	WTS 2010a
E-05B-CH/RH-OA	Explosion of compressed gas cylinders near WHB	WTS 2010a
E-05B-CH/RH-UG	BLEVE/ VCE of liquefied gas cylinder in the UG at the waste face	WTS 2010a
E-05B-CH/RH-WHB	Explosion of compressed gas cylinder in CH or RH bay	WTS 2010a
E-05C-CH/RH-UG	Compressed gas cylinder explosion during waste transport or at the waste face	WTS 2010a
E-05C-CH/RH-WHB	Forklift battery explosion	WTS 2010a
E-05D-CH/RH-UG	Electric powered vehicle explosion during charging in the UG	WTS 2010a
E-05E-CH/RH-UG	Flammable gas explosion in filled panel	WTS 2010a
E09-B-CH/RH-UG	Underground vehicle collides with waste array	WIPP DSA Rev. 1, Chapter 3
E-09C-CH/RH-UG	Forklift tines puncture waste containers in UG	WTS 2010a
E-09C-CH-WHB	Waste container impacted by forklift tines	WTS 2010a
E-10A-CH/RH-WHB	Inadvertent fire arm discharge punctures waste container	WTS 2010a
E-10B-CH/RH-UG	Roof/Rib bolt punctures waste container	WTS 2010a
E-10C-CH-WHB	Elevated material falls or drops on waste containers	WIPP DSA Rev. 1, Chapter 3
E-10D-CH/RH-UG	Waste shaft conveyance failure leads to conveyance/ waste containers dropping down shaft.	WTS 2010a
E-13A-CH/RH-OA	Excess direct radiation exposure from waste containers	WIPP DSA Rev. 1, Chapter 3
E-13A-CH/RH-UG	Direct radiation exposure from waste containers	WIPP DSA Rev. 1, Chapter 3
E-13A-CH/RH-WHB	Direct radiation exposure from waste containers	WIPP DSA Rev. 1, Chapter 3
E-13B-CH/RH-UG	Direct contamination on waste containers	WIPP DSA, Rev. 1, Chapter 3
E-13B-CH/RH-WHB	Direct contamination on waste containers	WIPP DSA, Rev. 1, Chapter 3
E-14A-CH/RH-UG	Criticality in waste shaft sump following waste conveyance failure	WIPP DSA, Rev. 1, Chapter 3 and WIPP-025, Rev. 1
E-14B-CH/RH-OA	Criticality in closed shipping container	WIPP DSA, Rev. 1, Chapter 3 and WIPP-025, Rev. 1
E-14B-RH-WHB	Criticality in stored waste	WIPP DSA, Rev. 1, Chapter 3 and WIPP-025, Rev. 1
E-14B-CH/RH-UG	Criticality in disposed waste	WIPP DSA, Rev. 1, Chapter 3 and WIPP-025, Rev. 1
E-25-CH/RH-OA	Seismic event results in upending tractor/trailer	WIPP DSA, Rev. 1,

Event Number	Event Description	Reference Document
	resulting in pool fire involving CH or RH waste shipping containers	Chapter 3
E-25-CH/RH-UG	Seismic event results in fire involving CH and RH waste	WIPP DSA, Rev. 1, Chapter 3
E-25-CH/RH-WHB	Seismic event damages WHB resulting in fire involving CH and RH waste	WIPP DSA, Rev. 1, Chapter 3
E-30-CH/RH-UG	Roof fall impacts waste containers	WIPP DSA, Rev. 1, Chapter 3

Shielded Container's Impact on the Probability of Occurrence of a Malfunction of Equipment

Existing CH waste handling equipment will be used to handle, process, and emplace the SCAs. Handling and emplacement of SCAs does not change the safety classification of the handling equipment. (This is relevant because equipment classified as important to safety (EIS) is credited with preventing or mitigating accidents.) Handling and emplacement of SCAs also does not change the frequency of use of any EIS, or create a new failure mechanism for any EIS. Therefore, there is no increase in the probability of occurrence of a malfunction of any EIS.

Shielded Container's Impact on the Consequences of a Malfunction of Equipment

There is no increase in the material-at-risk in a SCA versus a CH TRU 55-gallon container. The SCA will have the same limits on Plutonium-equivalent (PE) Curies and Fissile Gram Equivalent mass as a direct loaded CH TRU drum (WTS 2009, Section 2.1). The SCA is qualitatively judged to be at least as structurally robust as an overpacked container for all hazard events scenarios except fires. Therefore, when subjected to the WIPP DSA hazardous events, the SCA is given the same damage ratio as an overpacked container for all events except fires. For fires, the SCA are damaged more than overpacked containers (WIPP-032), but the total material released is less than that of TRU waste drums (WIPP-031). Finally, if a piece of equipment important to safety were to fail, there would be no increase in consequence due to handling and emplacing SCAs. It follows that there is no increase in the consequences from a SCA for any of the accident scenarios considered in the WIPP DSA.

Shielded Container's Impact on the Possibility of an Accident not Previously Included in the Documented Safety Analysis

The use of SCAs at WIPP will not increase the probability of occurrence of an accident not previously included in the WIPP DSA because the SCAs will be handled and emplaced in the disposal rooms in the same manner as what is currently used for CH waste containers. No new initiating events result from the handling and emplacement of SCAs.

Shielded Container's Impact on the Possibility of a Malfunction of Equipment

Existing CH waste handling equipment will be used to handle, process, and emplace the SCAs. Handling and emplacement of SCAs does not change the classification of equipment that prevents or mitigates accidents, the frequency of use of any EIS, or create a new failure mechanism for any EIS. Therefore, there is no increase in the probability of occurrence of a malfunction of any EIS previously evaluated.

Conclusion

The use of SCAs at WIPP will be bounded by the existing accident scenarios for 55-gal TRU drums described in the WIPP DSA. Consequences to the public (i.e., the maximally exposed offsite-individual) and to the on-site (facility) worker will not increase with the use of the SCAs.

References

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