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ASSESSMENT OF AN ALTERNATE APPROACH FOR REMOTE HANDLED TRANSURANIC WASTE DISPOSAL

September 2010

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ISO-2 Project
Carlsbad, NM

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ACRONYMS

ARRA	American Reinvestment and Recovery Act
CH	Contact handled
DOE	U.S. Department of Energy
DSA	Documented safety analysis
H&S	Health and safety
HERE	Horizontal emplacement and retrieval equipment
LWA	Land Withdrawal Act
LWFC	Light-weight facility cask
NMAC	New Mexico Administrative Code
RH	Remote handled
TRU	Transuranic
WIPP	Waste Isolation Pilot Plant
WHB	Waste Handling Building

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I. PURPOSE AND SCOPE

Since disposal of remote handled (RH) transuranic (TRU) waste in Panel 4 at the Waste Isolation Pilot Plant (WIPP) began in 2007, the Department of Energy (DOE) has had difficulty meeting the plans and schedule for disposing this waste. Despite having access to an increased budget from American Reinvestment and Recovery Act (ARRA) funds as of 2009, DOE has yet to make any gains in reducing the RH TRU waste disposal deficit and fulfilling the volumes of RH TRU waste planned for disposal in WIPP. The scope of this task covers all current and planned activities involving operations of the Waste Isolation Pilot Plant (WIPP) related to handling and disposal of RH TRU waste canisters.

The purpose of this report is to assess the feasibility of proposed alternate RH TRU mixed waste emplacement concepts that would enhance available WIPP space capacity by either replacing or augmenting horizontal borehole or shielded container disposal methods. In addition to engineering and operational analyses associated with these proposed emplacement concepts, PECOS also addresses concerns regarding criticality, heat release, and worker exposure to radiation.

II. BACKGROUND

Limits placed on management, storage, and disposal of TRU mixed waste in the WIPP geologic repository are established in the Land Withdrawal Act (LWA)[1] and summarized in the WIPP RH Waste Documented Safety Analysis (DSA), which states the following:

> The WIPP facility is designed to have a disposal capacity for TRU waste of 6.2 million cu. ft. (175,600 cubic meters). It has sufficient capacity to handle the 250,000 cubic feet (7,080 cubic meters) of RH waste that was established in the Record of Decision (46 Federal Register 9162) as a total volume. In addition, the WIPP Land Withdrawal Act (LWA) of 1992 limits the total RH TRU activity to 5.1 million curies. TRU waste with a radiation level between 200 mrem/hr and less than 1000 rem/hr is considered RH waste. [2]

Each RH TRU waste canister accommodates a volume of 0.89 cubic meters, which means approximately 7,955 canisters are required in order to dispose of the 7,080 cubic meters of the RH TRU waste presently authorized for disposal. The LWA prohibits receipt of TRU waste with a surface dose rate in excess of

1,000 rem/hr; no more than five percent by volume of RH TRU waste canisters with surface gamma ray doses of greater than 100 rem/hr can be emplaced in this manner.

The remaining constraints placed on the RH TRU waste disposal capacity of WIPP are established in the Hazardous Waste Facility Permit (HWFP).[3] While the current HWFP allows RH TRU waste disposal of up to 2,230 canisters, the proposed new permit, which is expected to be issued before the end of 2010, will increase this number to 2,960. The new permit therefore prescribes that the approximate maximum RH TRU waste allowed to be emplaced in WIPP—without implementing other RH TRU waste disposal options—will be only 2,634 cubic meters, leaving no available mechanism for use in disposing of the approximately 4,446 remaining cubic meters of RH TRU waste that could still be legally disposed in WIPP.

Present Operations

As described in the 2004 Compliance Recertification Application, WIPP is located within a 2,000-foot-thick bedded salt formation called the Salado Formation and is designed for disposal of TRU mixed waste consisting of contact handled (CH) and RH TRU wastes that are stored in containers. Disposal is conducted in eight underground panels mined perpendicular to the four main access drifts. Each panel consists of seven rooms and two access drifts. Each room measures approximately 13 feet high by 33 feet wide by 300 feet long, and these rooms are separated by pillars 100 feet wide. The main panel access drift to the rooms is 20 feet wide.[4] Under the HWFP, RH TRU waste is currently authorized for disposal in Panels 4 through 7.

Disposal of RH TRU waste at WIPP is accomplished through emplacement of RH TRU waste canisters in boreholes drilled horizontally into the walls of disposal rooms and certain panel access drifts. As a result of geotechnical engineering and equipment limitations, DOE developed a borehole configuration design of a maximum of 730 boreholes per panel. (The HWFP limited the number of these boreholes in Panels 4, 5, & 6.) These boreholes are 30 inches in diameter and are drilled horizontally 17 feet deep on eight-foot centers about mid-height in the long sides of the disposal room. The first borehole is positioned 34 feet from the projected corner of the salt pillars separating the disposal rooms. Radiation from filled boreholes is shielded from the room by a shield ring and a shield plug.

Currently, canisters containing RH TRU mixed waste are shipped to WIPP in RH-72B shipping containers. When they arrive at the Waste Handling Building (WHB), they are removed from the shipping container into the WHB hot cell, where they are transferred into the facility cask. The facility cask is then transferred from the WHB to the underground via the waste handling shaft, at which point a 41-ton forklift transports the facility cask to the disposal panel. The cask is then placed on the horizontal emplacement and retrieval equipment (HERE), which is used to emplace the RH TRU mixed waste canister into the borehole. The emplacement process includes placement of the shield plug in order to close the borehole after the canister is pushed in place inside. The shield plug reduces the radiation dose rate of 30 cm from the closed borehole to less than 10 mrem/hour for a canister surface dose rate of up to 100 rem/hr.

Present operations require emplacement of RH TRU waste canisters to be completed in a room prior to emplacement of CH TRU waste containers in that room. The major basis for this approach involves the difficulty of moving borehole drilling equipment and HERE in and out of a room in order to accommodate sequential disposal of both TRU waste types in a room. As a result, if deliveries of RH TRU waste to WIPP are not sufficient to fill all boreholes in a room before the room is needed for CH TRU waste, then any unfilled boreholes in that room are bypassed. Thus, there are several reasons why an alternative disposal method would be advantageous for RH TRU waste streams with activities of less than 100 rem/hour. Borehole drilling is limited to one to two boreholes per shift, and those boreholes must be drilled and filled before any CH TRU waste can be deposited in front of them. Disposal operations are time-consuming: A single RH TRU waste canister evolution—from receipt in a 72-B shipping cask to emplacement in the wall of the underground disposal room—requires more than 10 hours. These operational restraints result in a practical limit of six RH TRU waste canister emplacements per week at WIPP if all authorized boreholes are used in each room; however, other operational issues at the complex (e.g., the fact that it is more difficult and time-consuming to characterize and repackage RH TRU waste than CH TRU waste), have resulted in an approximate average of only two RH shipments per week.

An alternative proposed for disposal of RH TRU waste is to use containers lined with one-inch-thick lead liners so as to minimize surface dose rate to 200 mrem/hr or less. This would allow personnel to handle these shielded containers as CH TRU waste using a disposal method similar to that used for other CH TRU waste. DOE estimates these shielded containers can accommodate no more than 25 to 30 percent of the remaining RH TRU waste. Further, it appears that the maximum RH TRU waste container surface dose rate for disposal in shielded containers is only three to four rem/hr.

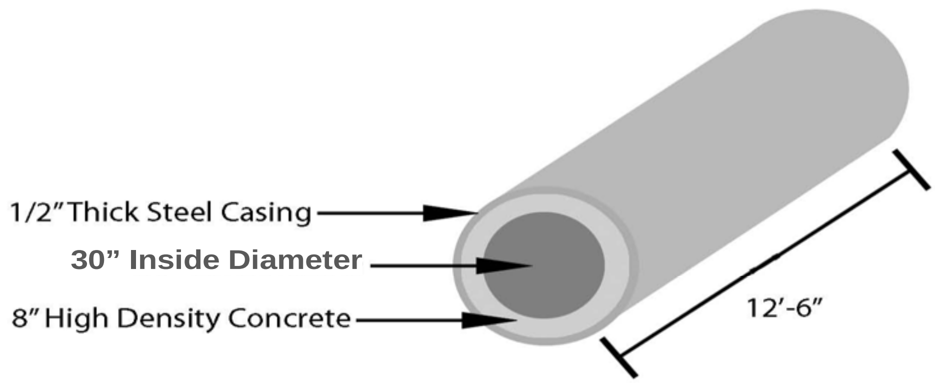
Another improvement that would enhance disposal of RH TRU waste is the projection of a new light-weight facility cask (LWFC) expected to be in use at the facility this year.[5] Empty, the LWFC weighs 46,233 pounds; therefore, it is likely WIPP will augment the 41-ton forklift with newer, more maneuverable forklifts to accommodate the LWFC, which should accelerate the disposal process.

III. SUMMARY OF FINDINGS

Based on the number of allowed boreholes in the current HWFP and assuming all remaining boreholes through Panel 8 are used, a large amount of remaining RH TRU waste would still need to be disposed (up to 4,446 cubic meters per the LWA and approximately 4,676 cubic meters per the 2009 Annual TRU Waste Inventory Report). Of this estimated RH TRU waste remaining to be disposed, not more than 30 percent is projected to be suitable for disposal in shielded containers. Other identified proposed solutions include conversion of main access drifts for RH TRU waste disposal in horizontal boreholes, addition of rooms to Panels 6, 7 & 8, or incorporation of additional panels. PECOS, however, has also evaluated the feasibility of other alternate disposal approaches for RH TRU waste.

Proposed Alternate Operations

In order to potentially fill the gap between RH TRU waste suitable for shielded containers and the RH TRU waste with surface dose rated up to 100 rem./hour, PECOS proposes that an RH TRU waste canister (weighing approximately 6,000 lbs) be transferred at WIPP into a new disposal container in the form of a hollow concrete cylinder capped at one end with a shield plug at the other end, where it can be disposed of on the floor of rooms/panels in lieu of being emplaced into a borehole at the disposal panel using the HERE emplacement equipment. The disposal container will measure 30 inches inside diameter by approximately 12.5 feet long and will be fabricated of high-density concrete of sufficient thickness to limit surface dose rate to 200 mrem/hr or less (*Figure 1*). The disposal container could be handled as CH TRU waste and could be disposed within the rooms rather than in horizontal boreholes.



Notes:

1. RH-TRU 72-B canister is 10' 1" long x 26" diameter.
2. Shield plug is approximately 29" diameter x 18" long.

Figure 1. Disposal Container Construction (*not to scale*).

As shown in more detail in *Figure 2,* this disposal container will be fabricated as a cylinder closed at one end with the other end remaining open to receive the RH TRU waste canister. A shield plug is then placed to cover the open end of the disposal container, allowing it to be handled as CH TRU waste. This procedure is similar to current operations for disposal of a RH TRU waste canister in a borehole. Since the activity of the canisters to be loaded into this new disposal container will be 100 rem/hr or less, it is estimated the thickness of the shield plug would not have to exceed one- to one-and-a half feet to achieve dose reduction of 200 mrem/hr or less.

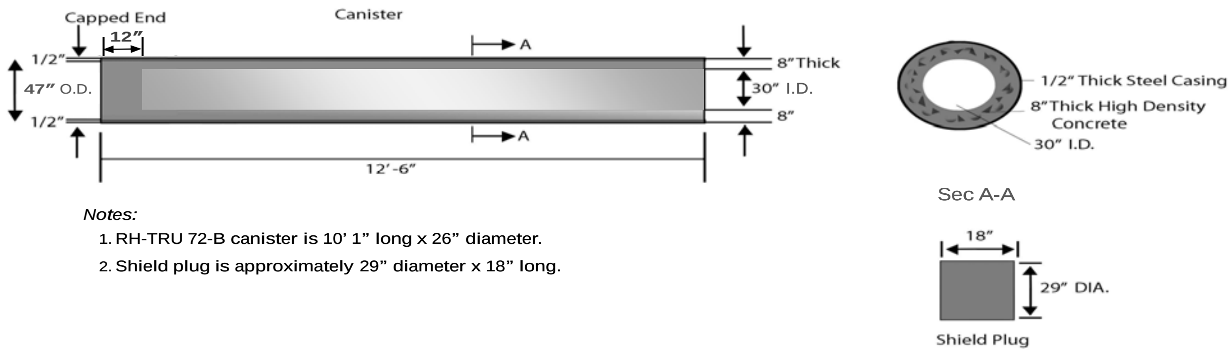


Figure 2. Disposal Container Detail (*not to scale*).

The construction of a disposal container as described above must address four considerations: 1) shielding, 2) physical integrity, 3) dimensions/weight, and 4) operational requirements.

Shielding: PECOS considered ordinary portland cement concrete, high-density concrete, and steel. Following preliminary evaluation, we did not choose ordinary portland cement concrete since the disposal container would have been too large in diameter. Steel was not chosen based upon the anticipated difficulty in locating a fabrication facility as well as its high cost. Thus, high-density concrete, 5.2 grams per cubic centimeter, was assumed for the purpose of concept development and used as the basis of other assumptions and evaluations. All gamma radiation was represented by Cs-137 with energy 0.662 MeV. It is noted that at this energy level as well as those up to near 10 MeV, the mass attenuation coefficient is essentially inversely proportional to density. Flat plate radiation was assumed—with the curvature of a cylinder ignored—and we used ordinary concrete properties, including density corrections in cases where high-density concrete data were unavailable.

Using the following formula as presented in the scientific text book "Atoms, Radiation, and Radiation Protection," and a desired attenuation of 100 rem/hr to 200 mrem/hr, the required thickness was calculated to be approximately nine inches.[6]

$I = I_o B e^{-\mu x}$ where

I and I_0 = required and source intensity respectively

B = the Build-up factor

μ = the linear attenuation coefficient, and

x = the shield thickness

Physical Integrity: Given the structural damage potential of concrete, the concept was modified to include a half-inch outer steel skin, which reduced the concrete thickness required to attenuate radiation to eight inches. Thus, the final configuration is a cylinder with eight-inch-thick, high-density concrete walls enclosed on one end and encased in a half-inch steel skin. The open end is constructed to mate with the HERE. This combination of an eight-inch-thick concrete cylinder with a half-inch-thick exterior steel casing is estimated to attenuate the surface dose rate from 100 rem/hr at the RH TRU canister surface to 200 mrem/hr or less on the surface of the disposal container. In considering the heat release from the proposed eight-inch-thick concrete with half-inch steel-lining disposal container, the RH TRU Waste Study (Section 3) stated that "The RH-TRU radionuclide inventory in appendix B was used to estimate an initial average heat output of less than 1 Watt per canister, much less than the 300 W allowed by the WIPP WAC. A 300 W heat output corresponds to a formation temperature increase of less than 10 degrees C (Molecke et al., 1993)."[7] Based on this study, the potential for canister temperature increase from heat release would be insignificant.

Dimensions/Weight: The disposal container would be 30 inches internal diameter and 47 inches outside diameter with an overall length of approximately 12.5 feet. The calculated empty weight (without shield plug and end cap) is approximately 28,800 pounds, which is approximately 38,900 pounds lighter than the facility cask (67,700 pounds empty weight). It is also projected to be approximately 17,400 pounds lighter than the new LWFC (46,200 pounds empty weight). Thus, either the current 41-ton forklift or any forklift that will handle the LWFC will handle the overall weight of the new disposal container containing a 6,000-pound RH waste container.

Operational Considerations: The objective of this proposed concept is to provide an alternate means of transferring the RH TRU waste canisters to the new disposal containers and then dispose of those containers in the repository in a place other than boreholes.

PECOS initially evaluated the approach of transferring the RH TRU waste canisters into the new disposal containers, placing them longitudinally on a modular steel rack along the length of the disposal room or alternatively, placing the disposal containers on a modular steel rack transversely along the length of the disposal room. However, neither arrangement is efficient for the transfer of RH TRU waste canisters to the ultimate emplacement site within a disposal panel, because both approaches require extensive maneuvering of the HERE equipment and the 41-ton forklift. Consequently, we evaluated two other approaches to transferring waste from the shipping cask to the new disposal container prior to emplacement:

Alternative 1: **Transfer RH TRU waste canisters to new disposal containers in the hot cell in the WHB prior to moving underground.** While this approach is beneficial from some perspectives, we estimate it will require significant modifications to the hot cell and handling equipment—possibly a Class 3 modification to the HWFP—and it would possibly increase the potential for radiation exposure. This alternative was therefore given no further consideration.

Alternative 2: **Transfer RH TRU waste canisters to the new disposal containers underground.** This alternative provides a staging area located underground, either near the waste handling shaft or at the head of each panel, where personnel could transfer an RH TRU waste canister into a disposal container (*Figure 3*). The RH TRU waste container would be transported underground in the facility cask, as is the current practice, and then transferred from the facility cask to the new disposal container using the existing 41-ton forklift and the HERE emplacement equipment. The HERE, or similar equipment, is then placed where it could be accessed for receiving the facility cask and transferring the RH TRU waste canister to the disposal container. The disposal container in turn is placed on a cradle so as to be connected (mated) to the HERE, and the transfer is accomplished in a manner similar to the current method of transferring canisters into boreholes. Following transfer, the disposal container is sealed with a shield plug, similar to the current practice employed at the borehole. The disposal container is then ready for transport for final disposal in a panel.

Following transfer, the disposal container is moved by the same forklifts used to transport CH TRU waste to the panel currently being filled to augment RH TRU waste disposal, or perhaps to Panels 9 and 10 to substitute for drilling boreholes at those locations. The new disposal containers could be placed on the floor perpendicular to the length of the room, two in a row, with approximately 75 rows per room or 150 disposal containers per room, which would enable disposal of at least 1050 RH TRU waste canisters per panel without using panel access drifts. A platform could be constructed above the new disposal containers to allow the remainder of the space in the room to be used for more waste disposal—either normally packaged CH TRU waste or other rows of new disposal containers as appropriate. Further, the small number of RH TRU waste canisters with surface dose rates of between 100 and 1000 rem/hr could still be disposed in horizontal boreholes prior to disposing the remaining

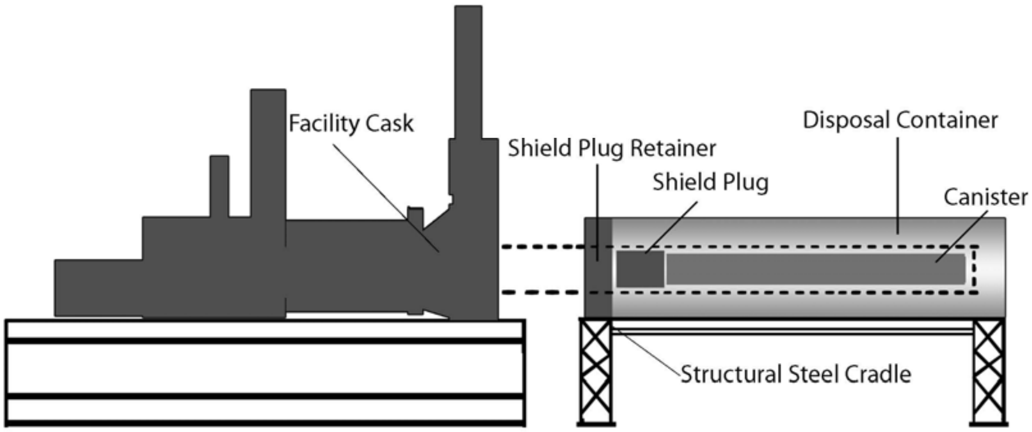


Figure 3. Canister Transfer to Disposal Container (*not to scale*).

RH TRU waste in the new disposal containers on the floors of the rooms.

PECOS has considered potential health and safety (H&S) impacts of each step of the alternative arrangements, comparing them with existing operations, but requires a more detailed assessment than that provided herein, as well as a more complete and detailed assessment of associated technical aspects.

V. CONCLUSIONS

The concept, development, and use of a disposal container as described above could be potentially advantageous for disposing a substantial quantity of RH TRU waste at WIPP. Specific advantages include the following:

- Provision of a disposal means for RH TRU waste containers with surface dose rates between four and 100 rem/hour.
- Provision of a way to dispose of RH TRU waste currently stored in 55-gallon drums, thus eliminating the hazard associated with repackaging this waste in other containers.
- No requirement for NRC approval for a new shipping container.
- Supplemental means of disposing RH TRU waste in Panels 6-8 in addition to the boreholes.
- No necessity to drill boreholes if RH TRU waste could be deposited in access drifts (Panels 9 & 10).

Establishment of a “staging area” as described above appears to be the most practical approach to disposing of RH TRU waste canisters, as it uses existing equipment—including the HERE and the 41-ton forklift—and follows many current H&S procedures. This approach also appears to require the least amount of new equipment or procedures.

A disposal container in the form of a cylinder with a 30-inch inside diameter fabricated from a combination of high-density concrete pipe with walls eight inches thick and a half-inch-thick exterior steel casing appears to be a potential alternate method for permanently disposing RH TRU waste canisters in other than horizontal boreholes.

The proposed alternative disposal method will help increase operational efficiency primarily because emplacement of RH TRU waste canisters in disposal containers in a staging area will mitigate the need to move the HERE equipment in the limited space in the disposal room following any initial emplacement of higher activity RH TRU waste canisters in boreholes in a room.

V. RECOMMENDATIONS

The following actions are recommended to ensure all issues, questions, assumptions, and concerns are adequately addressed in using cylindrical disposal containers as an alternate method for safe disposal of RH TRU waste canisters:

1. DOE should conduct a conceptual evaluation of the proposed alternative to confirm the descriptions and conclusions presented above.
2. DOE should evaluate H&S impacts of the proposed alternative.
3. As an alternative to a steel plate liner, DOE should consider using tungsten shielding material to control surface dose rates.
4. DOE should perform an economic comparison study comparing the cost of using the proposed new disposal container and disposal methods to the cost of drilling horizontal boreholes and filling them with RH TRU waste canisters.
5. If the results of the above recommendations are favorable, DOE should prepare technical, operational, and safety documentation and proceed with required regulatory change requests.

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