Waste Disposition Issues and Resolutions at the TRU Waste Processing Center at Oak Ridge TN - 9253

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ABSTRACT

This paper prepared for the Waste Management Conference 2009 provides lessons learned from the Transuranic (TRU) Waste Processing Center (TWPC) associated with development of approaches used to certify and ensure disposition of problematic TRU wastes at the Waste Isolation Pilot Plant (WIPP) site. The TWPC is currently processing the inventory of available waste TRU waste at the Oak Ridge National Lab (ORNL). During the processing effort several waste characteristics were identified/discovered that did not conform to the normal standards and processes for disposal at WIPP. Therefore, the TWPC and ORNL were challenged with determining a path forward for this problematic, special case TRU wastes to ensure that they can be processed, packaged, and shipped to WIPP. Additionally, unexpected specific waste characteristics have challenged the project to identify and develop processing methods to handle problematic waste.

INTRODUCTION

As background, the TWPC processes both Remote Handled (RH) and Contact Handled (CH) waste for disposal at Waste Isolation Pilot Plant (WIPP). Both low level and mixed low level wastes are also handled at the TWPC and are shipped to the Nevada Test Site for disposal.

WIPP, as everyone is aware, has a well defined prohibited items list in the WIPP Waste Acceptance Criteria (WAC). The WAC provides detailed requirements for disposal as related to the container, radiological, physical and chemical properties of the waste. As part of developing the required Acceptable Knowledge (AK) documents and physical processing/repackaging of waste several problematic and special case TRU wastes have been identified. Theses issues include:

- High Neutron Dose Rate – Dose rates resulting from both Californium and Curium in the waste stream challenge the RH-TRU 72-B limit for dose rate measured from the side of the package under normal conditions of transport, as specified in Chapter 5.0 of the RH-TRU 72-B SAR (i.e., ≤10 mrem/hour at 2 meters).
- Difficult to Process Waste – Listed code assignment from AK results in daughter waste drum processing and handling difficulties included problems associated with the disposition of prohibited items that fall out of the waste stream such as liquids, aerosol cans, etc.
- Development of AK and associated Dose-to-Curie Models – Multiple waste streams require characterization and AK due to the mission of the labs at ORNL challenge the ability to generate dose-to curie models for the waste.

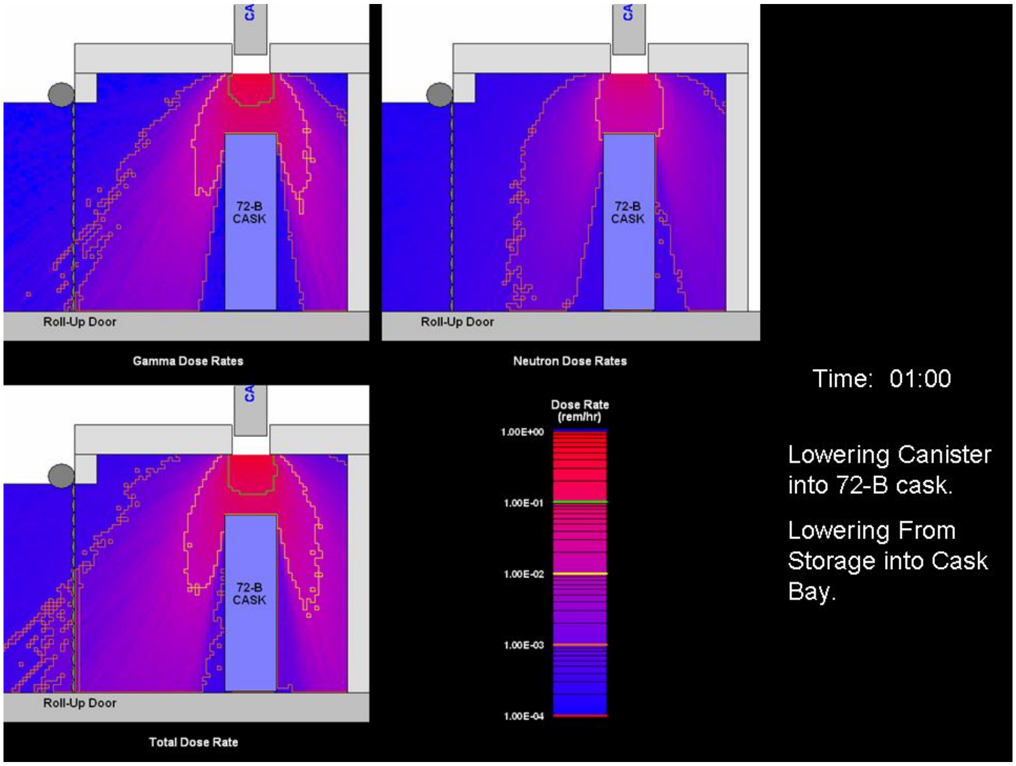
The TWPC and ORNL are committed to determining the disposition path for waste exhibiting these issues/problems. Several solutions to the above issues are currently in process or planned.

HIGH NEUTRON WASTE ISSUE

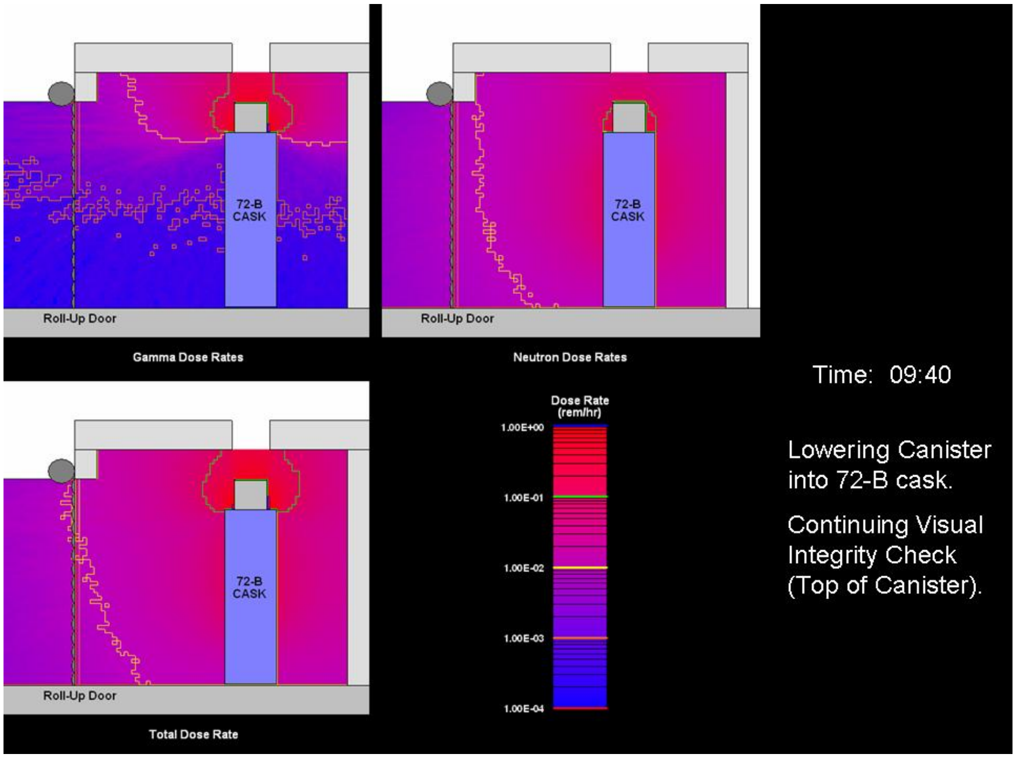
To date, the TWPC has identified several waste containers that present issues or contain items that do not meet the requirements for disposal. For example, newly repackaged RH waste containers have exceeded dose rate limits for transportation in the RH TRAMPAC for the 72-B Cask even though the container meets WIPP requirements for disposal. High neutron dose rates result from both Californium and Curium in the waste stream.

This waste also presents problematic decay heat values which also impacts the ability to load the 72-B Removable Lid Canister. As a result, RH drums required a transportation flame-gas sample to be collected in addition to the required head space gas samples.

Graphically, the following picture sequence (Pictures 1-4) shows the 72-B Canister being loaded into the 72-B Cask. As the Canister is lowered from the Canister Storage Room the gamma and neutron dose rate field expands. As the 72-B Canister enters the Cask the gamma field significantly decreases while the neutron field stays relatively constant. After full insertion it is clear that the 72-B Cask very effectively reduces the gamma field and has minimal effect on the neutron field. The final picture shows the effect of the IV lid.



Pic. 1, Lowering Canister from Room 222

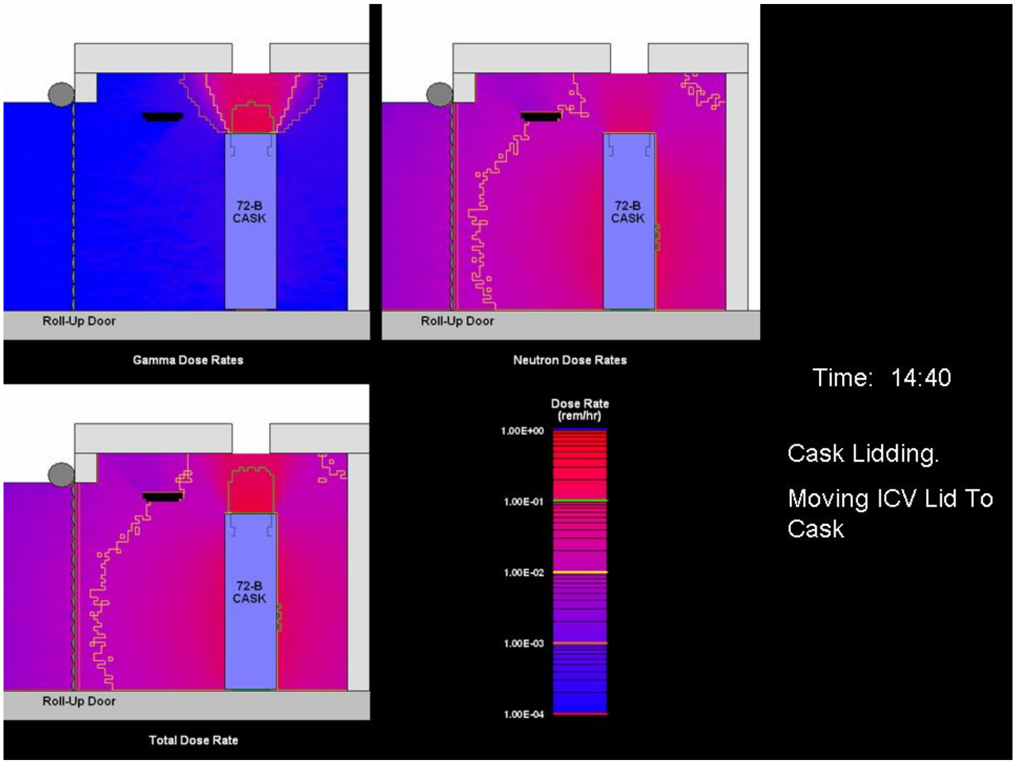


Time: 09:40

Lowering Canister into 72-B cask.

Continuing Visual Integrity Check (Top of Canister).

Pic. 2, Canister 90% inserted into Cask

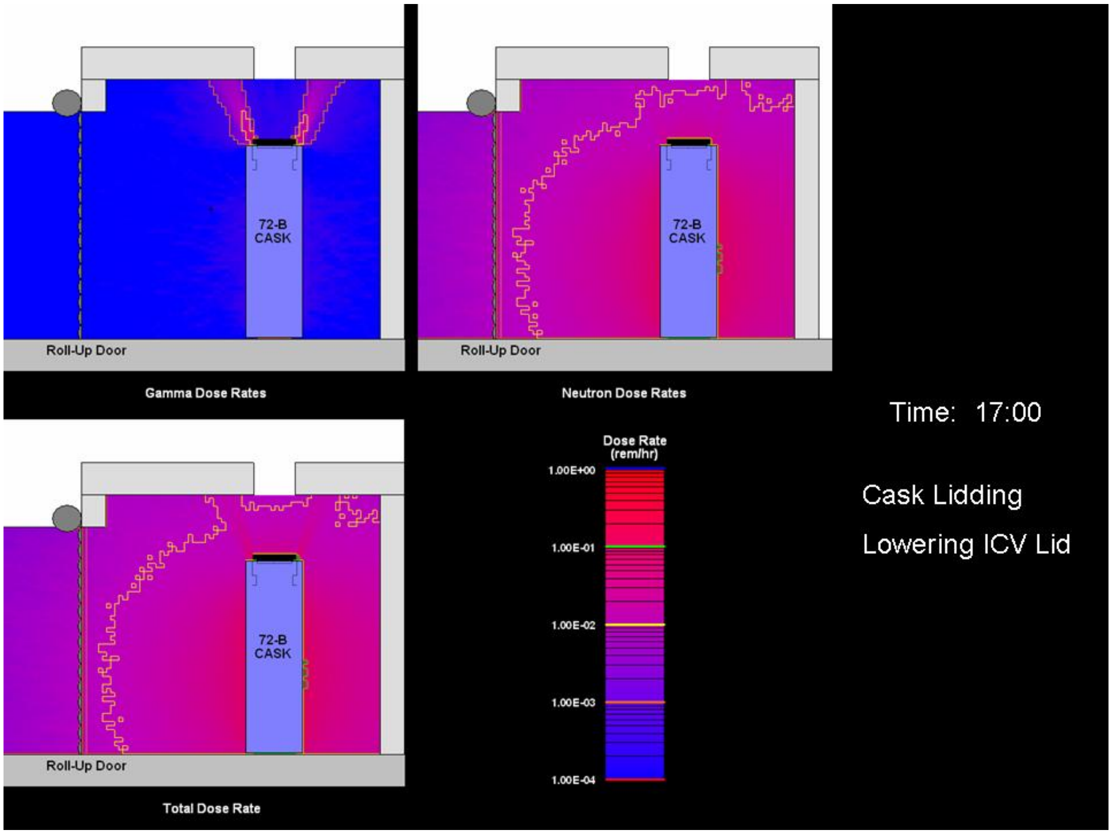


Time: 14:40

Cask Lidding.

Moving ICV Lid To Cask

Pic. 3, Loaded, ready for IV Lid



Pic. 4, IV in position above Cask

Background on Neutron Dose Rate Issue

The TWPC measures gamma and neutron dose rates at one-meter using Thermo Scientific FH40 radiation detection equipment. Data is collected at 90 degree increments (four data points) on each RH drum. The gamma measurements collected implement CCP-TP-504, Dose-to-Curie Survey Procedure for RH TRU Waste, for determination of Plutonium Equivalent Curies (PE-Ci) and Fissile Gram Equivalent (FGE) on the RH drum. The dose rates measured at one-meter ($DR_{\text{1 meter Dose Rate}}$) are subsequently used to calculate the surface dose rate equivalents ($DR_{\text{Surface Dose Rate}}$) in accordance with T-RH-FW-C-RP-006, Dose Rate 1-Meter Measurements. The conversion factor (CF) for the 1 meter neutron dose rate measurement to a surface reading is 7.13. The gamma conversion factor for determining the contact dose rate from the 1 meter reading is 15.5. The gamma CF is higher due to the differences between detector center line and the gamma measurement correction factor is not adjusted for neutron backscatter influence on the 1-meter reading as is the neutron reading. The simple equation for the CF is shown in Equation 1:

$$DR_{\text{Surface Dose Rate}} = DR_{\text{1 meter Dose Rate}} * CF \qquad \text{(Eq. 1)}$$

For example: A measured neutron dose rate at one meter of 10.8 mrem/hr is equivalent to 77.0 mrem/hr contact (77.0 rem/hr = 10.8 mrem/hr * 7.13)

As a note, in the development of the projects conversion factor we initially were very conservative and did not compensate for backscatter reactions in the relatively small enclosed space where the measurements are collected. Monte Carlo (MCNP) runs were subsequently used estimated neutron backscatter influence on the “as measured” one-meter dose rate measurements. This factor was then field verified by collecting actual contact readings where the backscatter reactions would have a minimal effect. Field measurements confirmed the MCNP model and subsequently the conversion factor was modified (i.e., reduced from 10.6 to the current 7.13 conversion factor).

With the neutron dose rate conversion calculations validated the project needed to determine the threshold (i.e., go-no-go) reading at one-meter that would potentially result in a failure to comply with the transportation requirements. That is, the 200 mrem/hr contact reading and the ≤10 mrem/hr at 2 meters reading from the 72-B shipping cask.

Modeling Neutron

TWPC performed calculations (Reference T-RH-FW-C-RP-010, RH Cask Shielding Evaluation) using spontaneous fission of Cf-252 as the primary neutron contributor. The MCNP runs used the build in Watt spectrum parameters provided in MCNP – A General Monte Carlo N-Particle Transport Code, LA-UR-03-1987, Appendix H, part B, “Constants for Watt Fission Spectrum.”

MCNP runs indicated that the 2 meter dose rate limit was the limiting condition and that the highest 2 meter dose rate was located adjacent to the axial center of the middle drum. Because the geometry and shielding differs with each drum based on its position in the 72-B Canister MCNP models were generated to determine each drums contribution to the dose rate at the highest 2 meter dose rate location.

Table I shows the dose point contribution with 1 neutron per second activity in each drum.

Table I. Dose Rate Contribution for Each Drum in a 72-B Cask

Drum	Rem/hr	Dose Rate Fraction (DRF)
Bottom	3.0615E-11	2.4852E-01
Middle	4.9222E-11	3.9957E-01
Top	4.3351E-11	3.5191E-01

MCNP Geometry

The 55 gallon drum used in the unshielded drum geometry and the 72-B cask geometry was modeled as a right circular cylinder with a radius of 28.575 cm and a height of 84.455 cm with a corresponding volume of 2.16E+5 cm^3. The drum was assumed to contain 59 kg of hydrogenous material resulting in an effective density of 0.2 g/cm^3. This density is consistent with the mass seen during initial RH packaging operations in the hot cell.

The source activity was distributed homogeneously throughout the drum which is more conservative than assuming a discrete activity distribution. The 72-B Cask and 72-B Canister were modeled consistent with the dimension and materials of construction denoted in the available WIPP and TRAMPAC documents.

Figure 1 provides a cutaway view of the 72 B Cask. Figure 2 represents the 72-B Canister used to load up to three 55 gallon drums of RH Waste for shipment to WIPP.

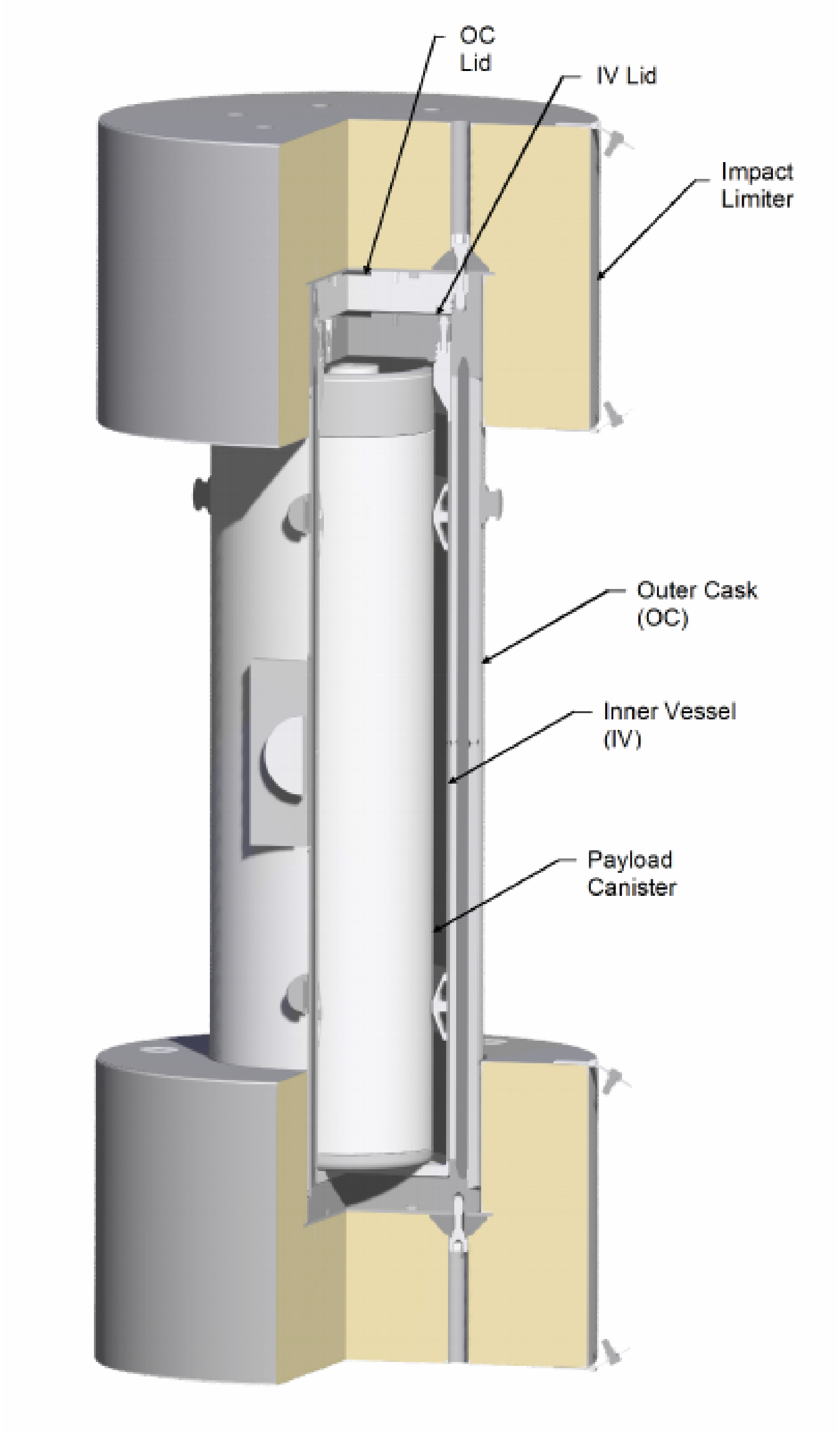


Fig. 1, 72 B Cask

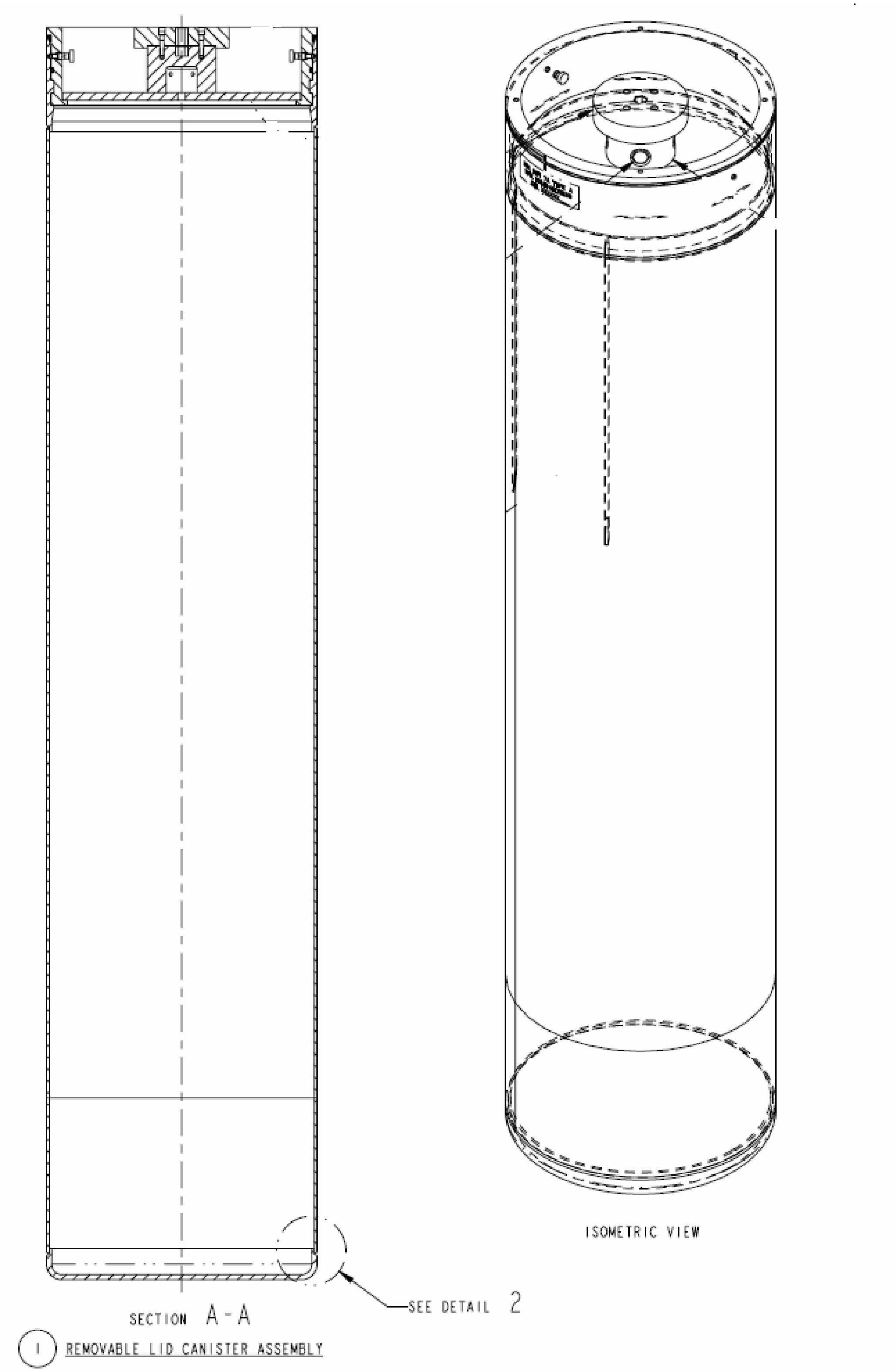


Fig. 2, 72-B Canister

The dose rate tally for the drum was modeled as a 15” diameter sphere with the center 1-meter from the radial surface centered vertically on the drum. The dose rate tally for the drum was modeled as a 15” diameter sphere with the center 1-meter from the radial surface centered vertically on the drum.

The dose rate tallies for the cask modeled as 15” diameter spheres placed at two locations.

Refer to Figure 3 for the relative position of the tally locations.

- At 2 meters from the surface of the cask aligned with the axial center of the 3 drums in the 72-B canister.
- At 1 cm from the cask concurrent with the axial center of the middle drum.

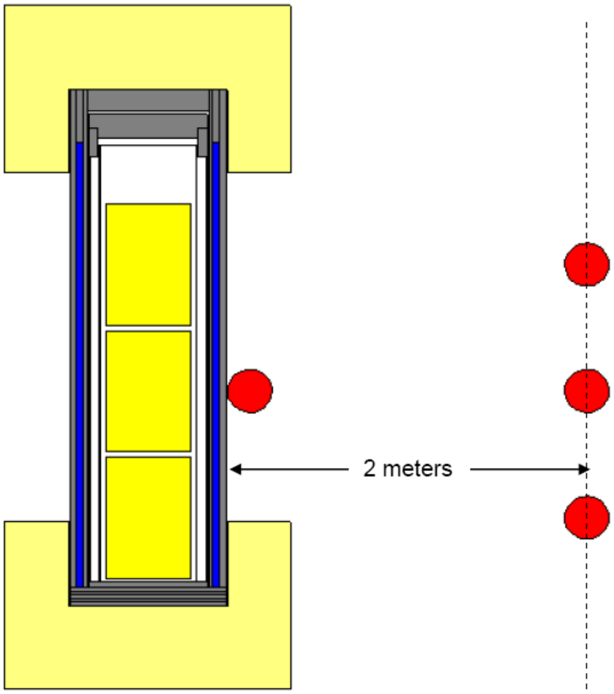


Fig. 3, 72-B Cask MCNP Geometry and Tally Location

Using these tally locations two conditions were analyzed. First, because the geometry and shielding differences associated with each drum differs the MCNP models were generated to determine each drums contribution to the dose rate at the highest 2 meter dose rate location (i.e., center axis of middle drum).

At 2 meters the contribution from the top drum was determined to be 35%, the middle drum 40% and the bottom drum 25% (effect of impact limiter poly filler). Refer to Figure 4. Figure 5 shows the second condition. Here, each drum is loaded such that the drums contribute the same fraction (33%) to the 2 meter dose rate.

This allowed determination of the maximum activity that could be contained in a particular drum location (i.e., top, middle or bottom). This method indicated that the top drum could contribute 0.32 neutrons per second (nps), the middle 0.28 nps and the bottom 0.45 nps.

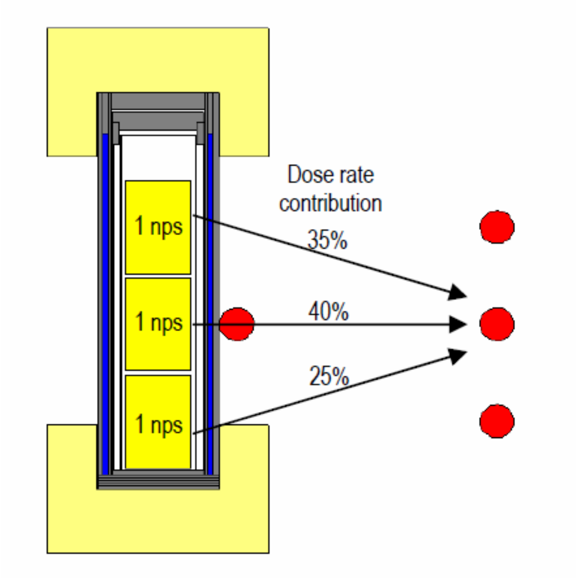


Fig. 4, Tally with Equal Activity

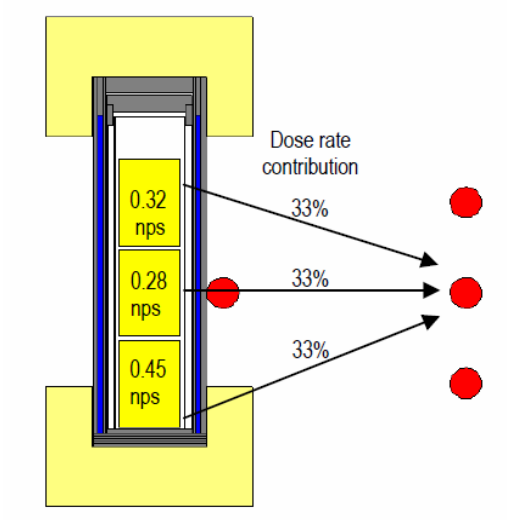


Fig. 5, Tally with Equal DR Distribution

Using the calculated drum activities from the previous step the next step was to determine the 1-meter unshielded drum dose rate that would result in a dose of 10 mrem/hr at 2 meters from the 72-B Cask.

Because the actual dose rate measurements for dose-to-curie are conducted inside the DTC Alcove at TWPC, a correction factor for this geometry and room effects was determined. The first MCNP run was a distributed source drum with an activity of 1 nps loaded in the DTC room with the tally location (detector) located 1-meter from the drum surface. A 3-D representation of the geometry is shown in Figure 5 (with the modeled 6” shield door removed for clarity). Figure 6 is a view of the actual Alcove at the TWPC.

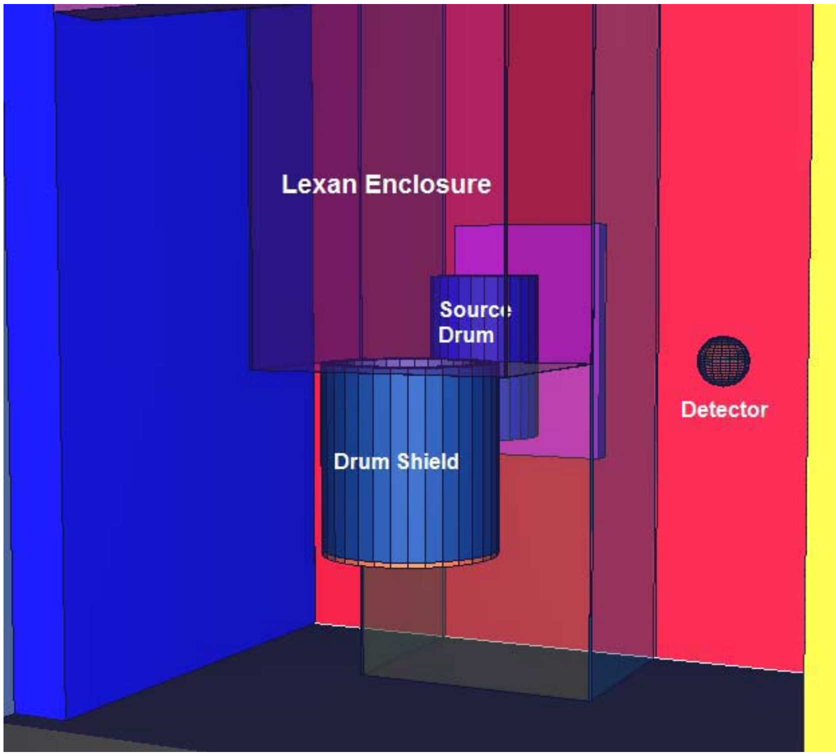


Fig. 6, MCNP Modeling

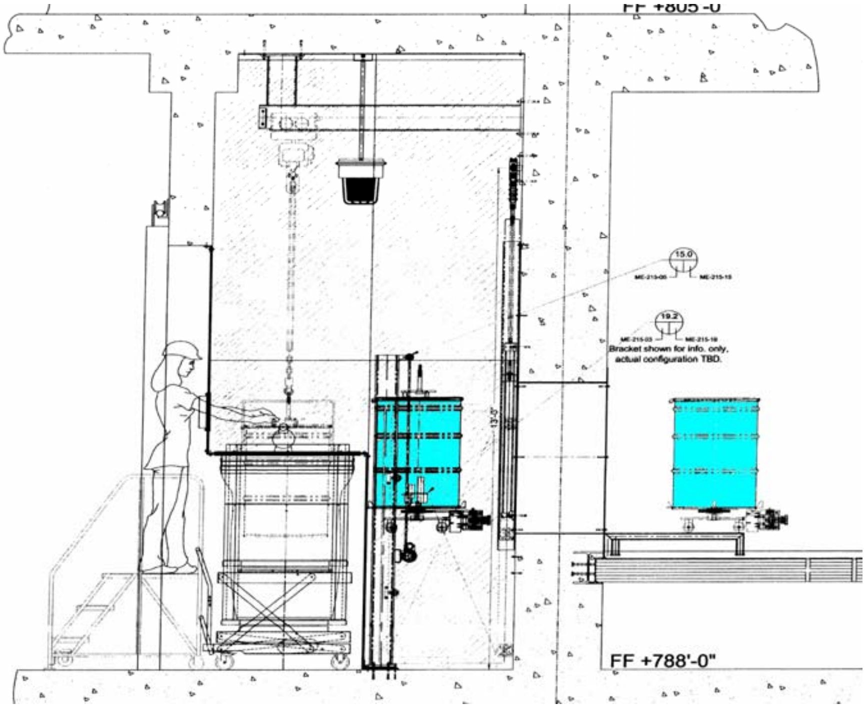


Fig. 7, Alcove Cutaway

The Dose Rate correction factor for the backscatter (CF_{bks}) is equal to the Dose Rate in Air (DR_{Air}) divided by the Dose Rate measured in the DTC Alcove (DR_{DTC}). Refer to Equation 2. The final calculated backscatter conversion factor was determined to be 0.673.

$$DR_{Air}/DR_{DTC} = CF_{bks} \qquad \text{(Eq. 2)}$$

$$DR_{Air}/DR_{DTC} = 0.673$$

Next, combining these factors we calculated the final recommended dose rates for each drum position, as measured 1-meter from the drum, which would ensure compliance with the 2 mrem/hr at 2 meters limit in the shipping condition, were determined. These values are provided in Table II, Dose Rate Limits for Each RH Drum.

Table II, Dose Rate Limits for Each RH Drum

Drum Position	**1 Meter dose Rate Limit**
Bottom	45 mrem/hr
Middle	28 mrem/hr
Top	32 mrem/hr
All 3 with equal activity	32 mrem/hr

High Neutron Dose Drum Solutions

Repackaging is one solution to the high neutron dose rate issue. In parallel, an effort is underway to request a change to the TRAMPAC requirements to allow shielding in the drum or canister to reduce the impact of the high neutron dose rates. Carlsbad is currently looking at two different thicknesses of liners that would allow some neutron shielding in the canister.

The packaging at TWPC would have to be changed from the current drum configuration to a 30 or 15 gallon RH drum. Currently the TWPC direct loads 55-gallon drums in the hot cell.

DIFFICULT TO PROCESS WASTE

Currently the TWPC is processing Pre 79' REDC RH waste from casks that were buried for a period of time prior to retrieval. RCRA listed code assignment from the AK and difficult to process waste results in daughter waste drum processing and handling difficulties. Additionally, the Pre 79' waste casks contain ground water which makes processing difficult and time consuming.

Processing difficulties include:

- Pumping the ground water (how and with what)
- Collection and Sampling of the ground water for analysis
- Disposition of the ground water (treatment)
- Control and maintenance as RCRA liquid
- Treatment of the wetted waste (waste in contact with the waster matrix)
- Package CH containers for assay

Pumping liquids in the hot cell presents several issues and challenges. Issues that had to be resolved included; adding an intrinsically save pump and hoses to the hot cell, development of sample analysis plan, development of the interim collection area, and development of long term solutions and options.

The best option to process the large quantities of ground water collected from the cask is to transfer the ground water to the ORNL liquid waste system. However, with the ground water in physical contact with the waste matrix the listed codes assigned in the AK to the debris waste would potentially transfer of the ground water and the ORNL liquid waste system is not able to take RCRA liquids. Initial samples of the ground water are positive and indicate that the ground water meets the criteria for getting a "no longer contains" ruling from the state. Therefore, it is expected that the ground water will ultimately be transferred to ORNL.

The wetted waste presents unique issues for the hot cell operators. Retrieval is difficult using the PaR manipulator. Excess and incidental liquids must be poured or collected for handling with the ground water.

The resultant wetted waste must be treated to remove the water as the RH waste must meet 100% Visual Examination criteria and the waste loaded out as CH will be subject to Real Time Radiography.

Several waste items in the RH waste processed in the hot cell includes 1 gallon paint cans filled with poly. The poly was originally articles (poly bottles, bags etc,) melted into the can on a hot plate after use in the ORNL glovebox. As seen in Figure 8 and Figure 9, the poly filled cans were difficult to open and had to be cut in half to ensure that they contained no hidden prohibited items.

Fig. 8, Paint Can with Poly in Hot Cell

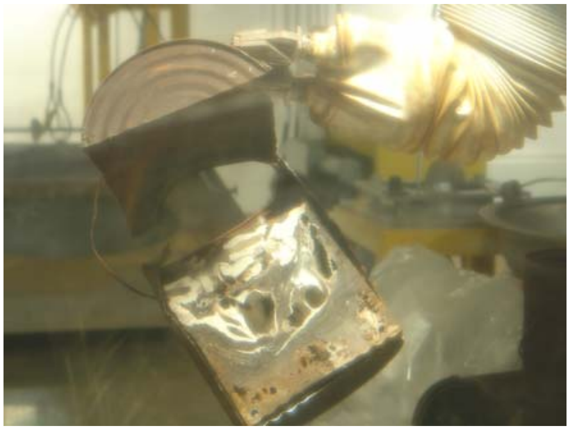


Fig. 9, Poly Block Cut with Band-saw

Other items are difficult to handle with the manipulators. Figure 10 shows an example of the type of waste that comprises the REDC hot cell waste. This particular package held a large amount of string.

Fig. 10, RH Waste on Work Table

One of the most difficult items to size reduce in the hot cell was an equipment rack (See Figure 11). The weight of the rack exceeded the PaR lift capacity. Note the Working Load Limit (WLL) posted on the PaR. In lieu of using the PaR, the Operators were able to lift the rack from the cask using the hot cell 5-ton hoist.

The rack was eventually located on the work table where the manipulators could reach it to start size reduction. It was soon determined that the material of construction included hastiloy and stainless steel.

Both are very difficult and time consuming to cut into pieces small enough to fit a 55-gallon drum. Nearly 40 hours of cutting was performed on the rack alone to achieve the required size reduction.

Fig. 11, Equipment Skid

DEVELOPMENT OF AK AND ASSOCIATED DOSE-TO-CURIE MODELS

Multiple waste streams require characterization and AK due to the mission of the labs at ORNL challenge the ability to generate dose-to curie models for the waste. AK for RH waste only supports a limited population of containers. The total population includes 341 casks, 14 boxes and 3 drums. It was anticipated that REDC, which makes up 77% of the casks, would be the first waste steam (allowing 241 casks to be selected for processing).

Contrary to the base plan the REDC waste stream was then divided into 3 waste steams (Pre 79’, 79’ to 91’, and Post 91’). As a result only 34 casks of the 241 casks were available (i.e., casks from period 3, the Post 91’ REDC) for processing. The Post 91’ casks comprised the newly generated waste and contains high neutron dose rates that present the issues mentioned in the first section of this paper. Because of the high neutron dose rate issues the TWPC is now faced with processing lower dose rate casks from the Pre 79’ period. These casks contain a higher percentage of CH than RH.

On the down side, the Pre 79’ casks were initially buried at ORNL in the SWSA trenches and subsequently recovered for processing. During the time the casks were buried they were subject to intrusion by ground water. The ground water seen to date has been between 20 gallons and 250 gallons per cask.

The TWPC must process at least one cask from each year of production to enable characterization to determine the isotopic ratios for the dose-to-curie models, develop the appropriate NDA letter for the CH portion of the waste and to support a Tier 1 submittal to the EPA. The only audited portion of the REDC waste stream was the Post 91' portion.

To have sufficient information for the Tier 1 submittal the TWPC must process Pre 79' period 1, REDC (Waste from 7020). During that period no CH drums are available from the hot cell to support the effort. Parallel, the project is running NDA on existing CH drums for the 79' to 91' period 2, REDC (Waste from 7020) and, as needed, will process RH casks to support development of the Tier 1 submittal for the 79' to 91' period. This middle period presents its own issues in that the casks, though they won't contain ground water as the Pre 79', are currently enclosed in the storage area and some work must move up on the base line schedules to support recovery. TWPC is working with ORNL to prepare the 79' to 91' for transfer to TWPC for processing.

SUMMARY

The TWPC has several issues that have challenged the projects ability to process RH Waste. High Neutron Dose Rate resulting from both Californium and Curium in the waste stream challenge the RH-TRU 72-B limit for dose rate measured from the side of the package under normal conditions of transport, as specified in Chapter 5.0 of the RH-TRU 72-B SAR (i.e., ≤10 mrem/hour at 2 meters). Difficult to process waste in the hot cell has introduced processing and handling difficulties included problems associated with the disposition of prohibited items that fall out of the waste stream such as liquids, aerosol cans, etc. Lastly, multiple waste streams require characterization and AK challenge the ability to generate dose-to curie models for the waste.

Repackaging is one solution to the high neutron dose rate issue. In parallel, an effort is underway to request a change to the TRAMPAC requirements to allow shielding in the drum or canister to reduce the impact of the high neutron dose rates. Due diligence on supporting AK efforts is important in ensuring adequate AK and approval of defense waste determinations. Subject matter experts need assignment to support AK development and the need to limit application of listed codes and unreasonable waste definition.

The TWPC will continue to succeed even with the challenges described above. Waste processing, especially legacy and prepackaged waste will always present issues that challenge processing efforts.

REFERENCES

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Scott Byers, T-RH-FW-C-RP-010, RH Cask Shielding Evaluation

CCP-AK-ORNL-500, Central Characterization Project Acceptable Knowledge Summary Report For Oak Ridge National Laboratory Radiochemical Engineering Development Center Remote-Handled Transuranic Waste