Disposition of Chicago Pile 5 (CP-5) Converter Tubes in the 10-160B Cask – 16632

Daniel Pancake *, Christopher Brandjes **, Jeff England ***,
Cynthia Rock ****, Dale Dietzel *****
* ANTECH / Argonne National Laboratory
** Ameriphysics
*** Savannah River National Laboratory
**** Argonne National Laboratory
***** US DOE

ABSTRACT

This paper will focus on the unique characterization, packaging, and transportation issues associated with the disposition of the two CP-5 Converter Tube assemblies from Argonne National Laboratory. The converter tubes were constructed of combinations of HEU and alloys of zirconium, and were part of the original research facilities attached to the CP-5 reactor during operating evolutions. These assemblies were heavily irradiated during their operational lifetime, and were segregated from the balance of irradiated test specimens when the reactor was deactivated and slated for Decontamination and Demolition (D&D). In addition, the substantial contribution of fissile material to the assemblies' inventory made the potential disposition pathways extremely challenging.

As a result, these items became part of Argonne's legacy "nuclear footprint", and were added to the Nuclear Footprint Reduction Project scope for disposition. The Project was responsible for the size reduction and characterization of these items, as well as the ultimate disposition. After negotiating a disposal pathway for these tubes, there were significant transportation issues that required a small team to overcome, in order to successfully ship these items to the Nevada National Security Site (NNSS).

The Project team at Argonne, technical support from transportation specialists, licensing support from the 10-160B license owner, the Savanah River National Lab (SRNL) Packaging Certification Team (PCT, and the DOE EM-33 staff contributed to license and safety analysis report amendments that eventually authorized the shipment of the material. The paper will identify the organizations, and the specific actions, required to successfully make three "one of a kind" shipments of irradiated test specimen material. This will include the unique packaging configurations, contents modification for the cask license (via the Amendment process), criticality evaluations, and associated review and approval processes.

INTRODUCTION

Figure A - CP5 Converter Tubes in Shielded Overpack

CP-5 was a thermal-neutron reactor using highly enriched uranium as fuel and heavy water as coolant and as a neutron moderator. The reactor produced neutrons for use in research. The converter tubes, also comprised of highly enriched uranium (while functioning as an external research facility to the reactor), were used to "convert" the thermal neutrons to fast neutrons for additional studies at the reactor facility. From a characterization standpoint, the convertors have similar attributes to the fuel inventory for CP-5. The radiological composition of the converter tubes is very similar to that of other irradiated fuel test specimens in the AGHCF. The original fuel matrix for many of the early EBR-II, FFTF and TREAT Oxide fuels included highly enriched uranium (92% - 94%), which is in the same enrichment range as the converters (~95%). The burnups for the converter tubes also lie within the range of values for the irradiated HEU fuel specimens currently in the AGHCF inventory (which range from ~3% to 16%).

More specifically, the converter tubes were made of uranium and zirconium alloy, and each tube weighed approximately 20 pounds. The CP-5 reactor had two irradiation facilities (VT-47 and VT-53) adjacent to the reactor vessel. Each facility contained a subcritical, fast flux converter tube. Thermal neutrons produced from the reactor caused fission of the 235U in the converter tubes, resulting in fast neutrons being produced inside the two facilities. Due to the relatively small mass of each of the converter tubes, and the relatively large quantity of TRU isotopes (i.e., 238Pu, 239Pu, 240Pu, and 241Am), each of the tubes theoretically met the definition of TRU waste prior to size reduction and packaging operations. The calculated values for each tube included TRU radionuclide concentrations of 126 nCi/gram and 983 nCi/gram, and dose rates between 40 R/hr and 75 R/hr at the 1 foot.

The CP-5 converter tubes were integral components of the VT-47 and VT-53 irradiation facilities at Argonne. The tubes were irradiated for the purpose of producing fast neutrons for the conduct of research and development. The converter tubes were necessary to provide the fast neutrons as part of the experiment and did not fuel the nuclear reaction in the reactor in any way. They were not, in any sense, fuel for the reactor nor were they targets utilized for the production of nuclear material such as plutonium, tritium, or neptunium. As such, these converter tubes became simply radioactive waste when they were no longer utilized for the experiments for which they were designed.

METHODS

Planned Disposition vs Actual Disposition

Disposition pathway planning for the converter tubes began early in the early 1990's, as Argonne pursued various options to transfer the CP-5 converter assemblies to another appropriate DOE facility for storage and ultimate processing/disposal. The options included:

1. Ship the units to the Idaho Chemical Processing Plant (ICCP) for reprocessing. This avenue was revisited in 2008, but was unsuccessful, as the converter assemblies were ultimately not classifiable as spent fuel.
2. Ship the units to the Savannah River Plant (SRP) for reprocessing. This was not acceptable because the SRP would not accept zircaloy-clad materials for reprocessing.

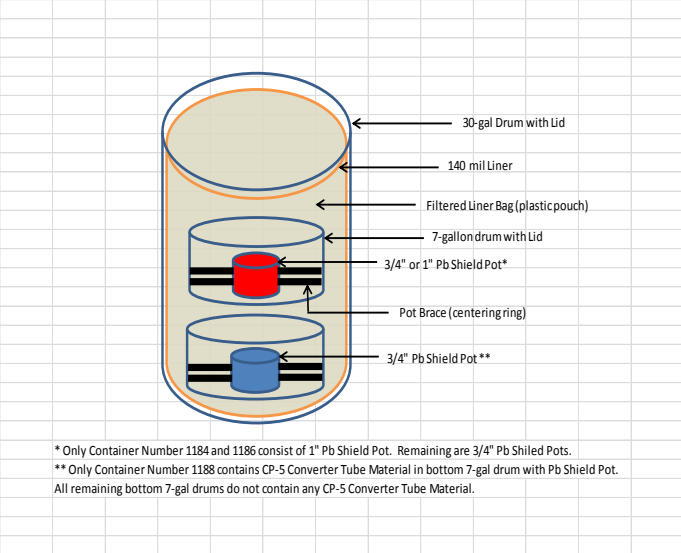

Figure B 30-Gallon Drum containing CP-5 Payload 1

Based on the origin of the material, TRU content & concentration, and that no other DOE facility would accept the materials for processing, the decision was made to add this material to the Argonne RH TRU Project scope in 2011.

The primary support activity required to include these materials in the Argonne RH TRU waste stream was to describe the characteristics of the CP-5 Converter Tubes that established them as a sub-population of the Fuel Examination Waste (FEW) in the AGHCF. The illustration of these characteristics was made by demonstrating that there was similar CP-5 FEW currently inside the AGHCF, and by demonstrating that the physical and radiological characteristics of the tubes is extremely similar to other FEW material inside the AGHCF. This made the proposed work tantamount to transferring other remaining irradiated fuel specimens into the hot cell for disposition as RH TRU Waste. The inventory of actinides and fission products in the converters also matched that of the existing inventory, so the required size reduction of the individual tubes will not alter the current, valid characterization model for RH TRU inside the AGHCF.

Figure C - Cut Section of VT-47

During processing, CP-5 Converter Tube number VT-53 was cut into eight sections ranging from 2.3 inches to 3.2 inches. CP-5 Converter Tube number VT-47 was cut into fourteen sections ranging from 0.8 inches to 2.85 inches. CP-5

Converter Tube material was packaged into thirteen (13) lead shield pots (either ¾" or 1" thick lead) that were centered into thirteen (13) 7-gallon non-sealed carbon steel drums. These thirteen 7-gallon non-sealed drums were then packaged into twelve (12) vented and lined 30-gallon carbon steel drums (see Figure B for diagram of packaging configuration for 30-gallon drum containing CP-5 Converter Tube Material) in accordance with ANL's RH TRU program under the direction of WIPP Central Characterization Project (CCP) personnel and the national program.

During the waste stream characterization review process, CCP recalculated the total activity associated to the CP-5 converter tubes using ORIGEN2.2. This code is currently used throughout the DOE complex for the characterization of RH TRU waste. Since the analysis performed by CCP was completed using a more current version of the ORIGEN software, and was used as the basis for the characterization of the converter tubes within the RH TRU program, these results are recognized as the final isotopic characterization of the CP-5 Converter Tubes, in addition to scaling in the isotopes identified in the original ANL characterization but not included in the CCP analysis.

Figure D - Introducing Tubes Into the Hot Cell

In performing the TRU Alpha Activity Concentration determination (TRU determination) it was identified by CCP that none of the twelve drums containing the CP-5 Converter Tube material met the minimum definition of TRU Waste – more than100 nCi/g of alpha-emitting TRU isotopes with half-lives greater than 20 years. In accordance with Sections 3.3.3 and 4.3.3 of the WIPP WAC for CH/RH TRU "TRU waste payload containers shall contain more than 100 nCi/g of alpha-emitting TRU isotopes with half-lives greater than 20 years. Without taking into consideration the TMU (Total Measurement Uncertainty), the TRU alpha activity concentration for a payload container is determined by dividing the TRU alpha activity of the waste by the weight of the waste. The weight of the waste is the weight of the material placed into the payload container (i.e., the net weight of the container). The weight of the waste is typically determined by subtracting the tare weight of the payload container (including the weight of the rigid liner and any shielding external from the waste, if applicable) from the gross weight of the payload container. In the event waste containers (e.g., 55-gallon drums) that have been radioassayed are overpacked in a payload container (e.g., in an SWB), sites shall sum the individual TRU alpha activity values of the individual waste containers and divide by the sum of the individual net waste weights (i.e., less container, shielding, and liner weights as appropriate) to determine the activity per gram for the payload container. Waste containers selected for payload management shall comply with the policy for the management of TRU alpha activity concentration. Loading a 55-gallon pipe overpack with cans is considered direct loading, not overpacking, for the purposes of calculating the weight of the container."

Based on the characterization performed by CCP, the TRU Alpha Activity Concentration values reported by CCP range from approximately 1.15 to 19.7 nCi/g, thus not meeting the minimum definition of TRU waste.

On February 2, 2014, CCP issues a Non-Conformance Report (NCR) identifying each of the twelve drums containing CP-5 Converter Tube Material as not containing "greater than 100 nCi/g of alpha-emitting TRU isotopes", thus not meeting the requirements of DOE/WIPP-02-3214, Revision 3, Section 2.2.5. Based on this determination, CCP has rejected these twelve containers out of the RH-TRU program. Since CCP rejected the CP-5 Converter Tube material from the RH TRU program for not meeting the minimum definition of TRU waste, from an activity/concentration standpoint, the material was successfully evaluated against the waste acceptance criteria for the Nevada National Security Site (NNSS). An evaluation of the CP-5 Converter Tube material was performed and compared against the NNSS Waste Acceptance Criteria, and it was determined that this material met the requirements of the NNSS WAC.

Once the revised disposition pathway was established, the Argonne Waste Management Operations (WMO) group negotiated the addition of this material to an approved waste stream profile. This process satisfied the disposal site selection and waste certification components of the revised path forward. The transportation component of the converter tube disposal presented several new challenges. First, the converter tube waste drums were packaged for characterization and transport in the RH-72B cask, in compliance with the C of C and contents requirements for the cask. Second, there were no type B certified casks for use by DOE that included the unique waste form present in the converter tube inventory. The solution to the problem coalesced around the execution of a contents modification to the 10-160B cask, allowing for the CP-5 materials, and the license change to include the specific configuration of each waste package. This included the unique packaging configurations, contents modification for the cask license (via the Amendment process), criticality evaluations, and associated review and approval processes.

Argonne began working with the license holder for the 10-160B (Energy Solutions (ES)), and the Packaging and Certification Team at Savannah River National Lab (SRNL), to begin the process of generating the license amendment and having the amendment successfully reviewed and sent to EM-33 Approval Authority for approval. Significant activities included the following evaluations performed by ES:

1. Review of the existing Certificate of Compliance (CoC) and Consolidated Safety Analysis Report (CSAR) to determine if the CP-5 Converter Tube waste materials complies with the existing CSAR/CoC in accordance with Chapter 7, Attachment 1 "Determination of Acceptable Activity.
2. Review of the existing CoC and CSAR to determine if the Fissile material associated with the CP-5 Converter Tube material complies with the existing CSAR/CoC.
3. Review of the existing CoC and CSAR to determine if the packaging configuration of the CP-5 Converter Tube materials complies with the existing

CSAR/CoC, with special attention be placed on Section 6.2 "No more than 25% by volume hydrogenous material".

4. Review of all remaining sections of the CoC and CSAR to determine if the packaging configuration of the CP-5 Converter Tube materials complies with the existing CSAR/CoC.

DISCUSSION

A preliminary evaluation determined that that the CP-5 Converter Tube material, in its entirety, complies with the activity limits in accordance with Chapter 5 and Chapter 7, Attachment 1 of the CSAR. However, there were two concerns as to whether the CP-5 Converter Tube material currently complies with the Chapter 6 of the CSAR/CoC. Due to the radiological makeup and packaging configuration, ANL-NWM questioned whether the current packaging configuration containing the CP-5 Converter Tube material met Section 6.2 of the CSAR, specifically "no more that 25% by volume hydrogenous material". In the existing packaging configuration, each 30 gallon drum contains approximately 205 in^3 of hydrogenous material consisting of one 140 mil polyethylene liner and one 200 mil plastic pouch. The volume of fissile material (CP-5 Converter Tube material) in each drum ranges from approximately 2.373 in^3 to 12.833 in^3. Thus the ratio of fissile material to hydrogenous material far exceeded the 25% by volume of hydrogenous material as identified in Section 6.2 of the CSAR. This indicated that the amendment would include an evaluation of the increased amount of hydrogenous material.

In addition, Chapter 6 of the CSAR refers to fissile material as being Transuranic (TRU) waste, thus limiting all fissile material shipments to only TRU waste. Though the CP-5 Converter Tube material contained TRU isotopes, its concentration of TRU isotopes in relation to the net mass of the each package did not meet the minimum definition of TRU waste: "more than 100 nCi/g of alpha-emitting TRU isotopes with half-lives greater than 20 years". The maximum concentration of TRU isotopes contained in one CP-5 Converter Tube drum is approximately 19.7 nCi/g. The maximum quantity of fissile material that will be shipped in any one shipment, consisting of four 30-gallon drums, is anticipated to be approximately 288 Pu-239 Fissile Gram Equivalents (PuFGE), thus being less than the 325 PuFGE that was currently authorized in the 10-160B CSAR/CoC. A change in verbiage associated to the CSAR/CoC needed to be made to allow for the shipping of Fissile Non-TRU waste material in the 10-160B cask as long as all other criteria are met. ANL worked with the license holder to prepare this amendment, and it was then submitted to SRNL PCT for review.

As the materials were scheduled to be shipped from a DOE Site to another federal site, it was determined that the DOE Package Certification Program should be the reviewer of the CoC Amendment and the issuer of the CoC for these shipments. The DOE Package Certification Program will provided the review of the amendment submittal, and prepared an approval issued by the DOE Package Certification Program Headquarters Certifying Official in the DOE-EM-33 office.The process was successfully executed, and the revised CoC was issued to support the shipments to

NNSS in the 10-160B cask.

CONCLUSIONS

Successful Shipping Campaign

The three shipments from Argonne to NNSS were successfully executed on 5/5/2015, 6/2/2015, and 6/9/2015. Each shipment utilized the standard 5-drum pallet inserts for the 10-160B, including a second pallet for dunnage. The final shipment of these materials signaled the end of a 29 year process at Argonne National Laboratory of managing the converter tubes through all regulatory requirements to disposition in Nevada.

Figure E - Drums Loaded In The 10-160B

Figure F - Loaded 10-160B Drum Pallet

Figure G - 10-160B Shipment 1

REFERENCES

1. DOE/WIPP-02-3122, Transuranic Waste Acceptance Criteria for the Waste Isolation Pilot Plant, Revision 7.4, 04/22/2013.
2. DOE/NV-325, Nevada National Security Site Waste Acceptance Criteria, Revision 10, June, 2013.

ACKNOWLEDGEMENTS

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