



EM Environmental Management

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DOE Packaging Certification Program

**Safety Evaluation Report for
Request to Authorize Uranium-Thorium Carbide
Tristructural-Isotropic and Bistructural-Isotropic Samples
in the ES-3100 Package**

Docket No. 17-06-9315

Prepared by:

James M. Shuler

Date:

2/8/17

James M. Shuler
Manager, Packaging Certification Program
Office of Packaging and Transportation

Approved by:

Joanne D. Lorence

Date:

02/08/2017

Joanne D. Lorence
Headquarters Certifying Official
Director
Office of Packaging and Transportation

This Safety Evaluation Report (SER) documents the U.S. Department of Energy (DOE) Packaging Certification Program (PCP) technical review of the application submitted by the National Nuclear Security Administration (NNSA) Office of Material Management and Minimization to amend DOE Certificate of Compliance (CoC) Number 9315 to authorize highly enriched uranium (HEU) in the form of Uranium-Thorium Carbide (U-ThC) tristructural-isotropic (TRISO) and bistructural-isotropic (BISO) micro fuel particles.

Evaluation

By letter ⁽¹⁾ dated December 16, 2016, as supplemented ⁽²⁾, the NNSA Office of Material Management and Minimization (NA-23) requested the DOE PCP to authorize a content amendment to DOE CoC Number 9315, Revision 10, for highly enriched uranium (HEU) in the form of Uranium-Thorium Carbide (U-ThC) tristructural-isotropic (TRISO) and bistructural-isotropic (BISO) micro fuel particles. This amendment was requested by NNSA for a limited shipping campaign to support the de-inventory of the New Brunswick Laboratory, and not as a permanent change to the CoC.

There were no changes to the packaging design.

DOE CoC, Table 1-3 authorizes 2 kg (max) of TRISO micro fuel particles in the form of Uranium Carbide (UC) with 1,815g (max) of U-235 per package. Since U-ThC is not explicitly addressed in the CoC or the ES-3100 Safety Analysis Report for Packaging (SARP), the NNSA application relies on reasoned evaluation, using reliable and conservative procedures and parameters (49 CFR 173.461), to demonstrate compliance with the SARP and CoC, primarily criticality safety and secondarily combustible gas generation. The U-ThC content does not effect the package containment or shielding analysis because substituting the mass of Th-232 for U-235 is conservative (A_1/A_2 values for Th-232 are "unlimited").

U-ThC at New Brunswick Laboratory is packaged in glass vials approximately 0.5 inch diameter by 2 inches long. The vials are sealed with plastic lids and overpacked in carbon steel crimped cans (i.e., convenience cans authorized in the CoC), and stainless steel scrubbers can be used to fill void space in the convenience can. A mylar tamper indicating device (TID) is applied to each convenience can. Each convenience can may contain up to 16 vials, and the ES-3100 package may be loaded with up to three convenience cans.

The estimated mass of plastic lids and mylar TIDs, based on 48 vials and three convenience cans per package, is 377.4g. These materials can generate hydrogen gas by radiolysis, but comply with the CoC limit of 500g (Condition 7) per containment vessel for off-gassing packing materials. No other materials in the U-ThC content configuration generates combustible gases; nevertheless, for conservatism, the NNSA proposes a condition that the shipment occurs within a 12 month window (i.e., the shipment must occur within 12 months of when the containment vessel is closed). PCP staff concurs that the U-ThC content and packing materials are bounded by the existing gas generation evaluation and meets Condition 7 of the CoC.

NNSA proposed to limit the U-ThC content to 751g of TRISO and BISO micro fuel particles, with up to 60g of U-235 and 232g of Th-232, per package. This material is certified reference material (i.e., samples) and has not been irradiated in a reactor. For conservatism, the Th-232 is counted as U-235 for criticality. Therefore, the maximum total U-235 per package containing U-ThC is 292g, which is considerably less than the currently authorized limit for TRISO fuel of 1,815g U-235. Based on the calculations results for UC, UC₂, and U₂C₃ compounds (SARP Table 6.9.8.8-6a and pages 6-691 through 6-695), UC was shown to be the most reactive and thus would bound UC₂, and U₂C₃ compounds. PCP staff concurs that the criticality safety analysis for UC bounds U-ThC.

Based on the statements and representations in the application, as supplemented, and the conditions listed in the CoC, PCP staff finds the design has been adequately described and evaluated and meets the regulatory requirements of 10 CFR Part 71.

Condition of Approval

PCP staff finds the requested change to ship U-ThC TRISO and BISO fuel samples in the ES-3100 does not affect the ability of the package to meet 10 CFR Part 71 subject to the following conditions to amend the CoC:

- U-ThC TRISO and BISO fuel samples are limited to material loading limits of 751g of U-ThC, of which 60g of U-235 and 232g of Th-232, per package.
- U-ThC TRISO and BISO fuel sample vials shall be in loaded in carbon steel crimped convenience cans. Stainless steel scrubbers may be used to take up void space in the convenience can. No other content, dunnage, or packing material is authorized by this amendment. Each convenience can may contain up to 16 vials, and the ES-3100 package may be loaded with up to three convenience cans.
- Shipment must occur within 12 months of closing the containment vessel.
- All other conditions of the certificate remain the same.

Conclusion

Based on the statements and representations in the application, as supplemented, and the conditions listed above, PCP staff concludes that the Model ES-3100 package design has adequately described and evaluated, and that this changes does not affect the ability of the package to meet the requirements of 10 CFR Part 71.

References

- [1] *Request for U-Th Carbide TRISO Fuel in the ES-3100 Package, CoC USA/9315/B(U)F-96 (DOE)*, Letter William E. Kilmartin, NA-23, to James M. Shuler, EM-4.24, December 16, 2016
- [2] S-SARQ-G-00047, *Q1s for ES3100 New Brunswick Laboratory Carbide Standards Content Letter Amendment for Model ES3100, Docket No. 17-06-9315*, January 25, 2017