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DOE Packaging Certification Program

**Safety Evaluation Report for
Request to Amend Certificate of Compliance Number 9979
to Authorize a Weight Percentage Increase of U-235 in Low
Enriched Uranium (LEU) and to Add Tri-Structural
Isotropic (TRISO) Fuel and Process Material**

Docket Nos. 17-20-9979 and 18-35-9979

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This Safety Evaluation Report (SER) documents the U.S. Department of Energy (DOE) Packaging Certification Program (PCP) independent technical review of the applications submitted for the Savannah River Operations Office (SR) to amend DOE Certificate of Compliance (CoC) Number 9979 to authorize a weight percentage increase of U-235 in Low Enriched Uranium (LEU) and to add Tri-Structural Isotropic (TRISO) fuel and process materials.

Evaluation

By memorandums ^[1, 2] dated April 3, 2018, SR submitted application requests to amend DOE CoC 9979, to:

- a.) increase U-235 in the low enriched uranium (LEU) from 19.8% to 19.9%, and
- b.) add TRISO fuel and process materials to the CoC Table 1, *Radioactive Content Description* under Payload Category *Non-Combustible* and Material Form *Solid Compounds*.

The technical documents (i.e., the applications) in support of these requests were prepared and submitted for SR by the Savannah River National Laboratory (SRNL).

There were no design changes to the packaging or package operations required for these requested changes to the CoC.

References to the Safety Analysis Report for Packaging (SARP) in this SER are the SARP and supplements referenced in DOE CoC Revision 9.

Increase U-235 in LEU to 19.9% (Docket 17-20-9979)

CoC Table 3, *Content Envelope Limits for LEU Cube or Plates*, limits the weight fractions of U-235 to 0.198 (19.8%) and U-238 to 0.802 (80.2%), and the sum of U-235 and U-238 to 19.192 kg. The applicant evaluated an increase of the weight fraction of U-235 to 0.199 (19.9%) and decreased weight fraction of U-238 to 0.801 (80.1%), with no increase in total mass.

The applicant performed a chapter-by-chapter evaluation ^[3] of the proposed change with respect to the SARP. The evaluation concluded that the proposed change would not effect the safety performance of package. In addition, the nuclear criticality safety evaluation (NCSE, N-NCS-A-00031, Rev. 0) in Appendix 6.2 of the SARP includes LEU with U-235 enrichment up to 19.9%.

PCP staff reviewed Chapter 6 and Appendix 6.2 of the SARP and concurred that the NCSE in Appendix 6.2 of the SARP bounds LEU with U-235 enrichment up to 19.9%; therefore, there are no nuclear criticality safety issues with this content amendment. However, during the review, staff noted and requested the applicant to address and correct inconsistencies between the LEU uranium mass limit in Appendix 6.2, of 19.1 kg, as compared with 19.192 kg in Table 1.3 of the SARP. The applicant subsequently submitted N-NCS-A-00031, Rev 1 ^[4] to increase LEU uranium mass limit to 19.2 kg.

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Based on the statements and representations in the application, SARP, as supplemented by N-NCS-A-00031, Rev 1, and PCP staff's confirmatory evaluation, staff finds that increasing LEU with a U-235 enrichment to a maximum of 19.9% does not affect the performance of the package and will provide reasonable assurance that the regulatory requirements of 10 CFR Part 71 have been met.

Addition of TRISO Fuel and Process Materials (Docket 18-35-9979)

PCP staff performed an acceptance review of the application ^[5] submitted with the request from SR dated April 3, 2018, to authorize use of the Model 9979 packaging for shipment of the TRISO fuel and process materials. This initial application lacked sufficient detail for staff to perform an independent technical review; consequently, the PCP Manager issued Q0s (i.e., Q0s are the initial questions from a completeness review) by memorandum ^[6] on April 24, 2018, to SR for additional information needed to continue the review. On June 20, 2018, SRNL submitted responses ^[7] and a revised application ^[8], on behalf of SR, to address the Q0s.

The revised application consisted of a chapter-by-chapter evaluation of the proposed change with respect to the existing nine chapter SARP and a nuclear criticality safety assessment (NCSA). ^[9] The NCSA was submitted to demonstrate TRISO fuel and process materials are bounded by the criticality evaluation in the SARP.

The physical forms of the TRISO fuel and process materials are fuel rods, pellets, powder, and miscellaneous forms of laboratory waste. The chemical forms include UO₂, ThO₂, coated particles containing Thorium and/or Uranium compounds, ThUC₂, UCO, UC₂, U₃O₈, ThUO₂, carbide beads and various other oxide and carbide fuel forms. A complete list of TRISO fuel and process materials and where the materials were produced is included in Tables 2-1 through 2-6 of the NCSA.

PCP staff reviewed the SARP, N-NCS-A-00031, Rev 1 (submitted with Docket 17-20-9979), and the NCSA, including a NCSA reference, *Calculated Criticality of Water Moderated Oxides of Uranium-233, Thorium-232, and Carbon Mixtures*, Y-DR-107, April 1973. Y-DR-107 examined the reactivity effects of adding carbon and thorium to water-moderated oxides of U-233. Staff concurs that the NCSE in the SARP bounds the TRISO fuel and process materials and that there are no criticality safety issues associated with the TRISO contents.

Based on the statements and representations in the application, SARP, as supplemented by N-NCS-A-00031, Rev 1, and PCP staff's confirmatory evaluation, staff finds that adding the TRISO fuel and process materials as authorized contents does not affect the performance of the package and will provide reasonable assurance that the regulatory requirements of 10 CFR Part 71 have been met.

Condition of Approval

The 9979 certificate revision was changed from Revision 9 to Revision 10, with the following changes:

- 5.(b)(1) *Type and Form of Radioactive Material Contents*
 - Moved “Tables 3 and 4 define the radioactive limits for both forms of LEU.” to 5.(b)(2), *Maximum Quantity of Radioactive Material per Package*
 - Added description for Tri-Structural Isotropic (TRISO) fuel and process materials.
- 5.(b)(1) *Table 1, Radioactive Content Description*
 - Added TRISO fuel and process materials to:
 - Payload Category - Non Combustible
 - Materials Form - Solid Compounds and Metal
 - General Description - TRISO fuel and process materials.
 - Revised the Table Notes as follows:
 - Table Note 1 - Non-radioactive contents include all secondary containers, wrapping, shoring, convenience cans, plastic bagging, polyurethane foam, and other dunnage material.
 - Table Note 2 - The Payload Category “Combustible” may also include “Non-Combustible” Material Forms.
- 5.(b)(2) *Maximum Quantity of Radioactive Material per Package*
 - Added “Table 2 defines the radioactive limits for TRISO fuel and process materials.”
 - Moved “Tables 3 and 4 define the radioactive limits for both forms of LEU.” from 5(b)(1).
- 5.(b)(2) *Table 3, Content Envelope Limits for LEU Cube or Plates*
 - Revised U-235 Weight Fraction and Mass (kg) to 0.199 and 3.819 respectively.
 - Revised U-238 Weight Fraction and Mass (kg) to 0.801 and 15.373 respectively.
 - Revised Note to “Low Enriched Uranium less than or equal to 19.9 weight percent U-235 and 80.1 weight percent U-238. Limits are based on U-235 enrichment: weight fraction and mass of U-238 may be higher when U-235 weight fraction and mass is lower than shown in the Table.”
- 5.(d)(14) Added “...Revision 9 of this certificate may be used until October 31, 2019.”
- 5.(e) *Supplements*. Added:
 - (8) *Application for Contents Amendment for Shipping Low Enriched Uranium with 19.9 wt.% U-235 in 9979 Packaging (Docket No. 17-20-9979)*, SRNL-L4500-2018-00003, March 14, 2018.
 - (9) *Nuclear Criticality Safety Evaluation: LEU Cube and Plates in a 9979 Type AF Shipping Package*, N-NCS-A-00031, Revision 1, October 2018.
 - (10) *Application for Contents Amendment for Shipping TRISO Fuel in 9979 Packaging*, SRNL-L4500-2018-00004, Rev. 1, June 20, 2018.
 - (11) *Nuclear Criticality Safety Assessment: Uranium - Thorium in a 9979 Shipping Package*, N-NCS-G-00174, Revision 1, March 2018.

Conclusion

Based on the statements and representations in the applications, SARP, and PCP staff's confirmatory evaluation, staff finds that these contents changes do not affect the performance of the package and will provide reasonable assurance that the regulatory requirements of 10 CFR Part 71 have been met, subject to the conditions above.

References

- [1] *Submittal of the Savannah River National Laboratory (SRNL) Application for Contents Amendment for Low Enriched Uranium 9979 Safety Analysis Report for Packaging, Revision 4*, Memorandum, D.S. Nicholson, to J.M. Shuler, April 03, 2018.
- [2] *Submittal of the Savannah River National Laboratory (SRNL) Application for Contents Amendment for Shipping TRISO Fuel in 9979 Packaging, SRNL-L4500-2018-00004, March 14, 2018*, Memorandum, D.S. Nicholson, to J.M. Shuler, April 03, 2018.
- [3] *Application for Contents Amendment for Shipping Low Enriched Uranium with 19.9 wt.% U-235 in 9979 Packaging (Docket No. 17-20-9979)*, SRNL-L4500-2018-00003, March 14, 2018
- [4] *Nuclear Criticality Safety Evaluation: LEU Cube and Plates in a 9979 Type AF Shipping Package*, N-NCS-A-00031, Revision 1, October 2018.
- [5] *Application for Contents Amendment for Shipping TRISO Fuel in 9979 Packaging*, SRNL-L4500-2018-00004, March 14, 2018.
- [6] *Application for Content Amendment to Department of Energy Certificate of Compliance Number 9979 – Additional Information Needed*, Memorandum, J.M. Shuler to D.S. Nicholson, April 24, 2018 (with Attachment, *QOs for 9979 Package Review for TRISO Content Amendment*).
- [7] *RE: QOs for 9979 Package Review of TRISO Content Amendment Request*, SRNL-L4500-2018-00057, June 20, 2018.
- [8] *Application for Contents Amendment for Shipping TRISO Fuel in 9979 Packaging*, SRNL-L4500-2018-00004, Rev. 1, June 20, 2018
- [9] *Nuclear Criticality Safety Assessment: Uranium - Thorium in a 9979 Shipping Package*, N-NCS-G-00174, Revision 1, March 2018.