UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

July 7, 2020

Dr. James M. Shuler
Manager, DOE Packaging Certification Program
U.S. Department of Energy
Office of Packaging and Transportation
EM-4.24, 270CC - Rm 3113
Washington, DC 20585

SUBJECT: CERTIFICATE OF COMPLIANCE NO. 5797, REVISION NO. 21, FOR THE MODEL NO. INNER HFIR UNIRRADIATED FUEL ELEMENT SHIPPING CONTAINER, AND OUTER HFIR UNIRRADIATED FUEL ELEMENT SHIPPING CONTAINER

Dear Dr. Shuler:

As requested by your application dated May 28, 2020, enclosed is Certificate of Compliance No. 5797, Revision No. 21, for the Model No. Inner HFIR unirradiated fuel element shipping container and outer HFIR unirradiated fuel element shipping container package. Changes made to the enclosed certificate are indicated by vertical lines in the margin. The U.S. Nuclear Regulatory Commission staff's safety evaluation report is also enclosed.

The approval constitutes authority to use the package for shipment of radioactive material and for the package to be shipped in accordance with the provisions of Title 49 of the *Code of Federal Regulations* 173.471.

If you have any questions regarding this certificate, please contact Pierre Saverot of my staff at 301-415-7505.

Sincerely,

John B. McKirgan

Digitally signed by John B. McKirgan
Date: 2020.07.07 14:29:32 -04'00'

John McKirgan, Chief
Storage and Transportation Licensing Branch
Division of Fuel Management
Office of Nuclear Material Safety
and Safeguards

Docket No. 71-5797
EPID - L-2020-LLA-0119

Enclosures 1: Safety Evaluation Report
2: Certificate of Compliance

cc w/encl: R. Boyle, Department of Transportation

SUBJECT: CERTIFICATE OF COMPLIANCE NO. 5797, REVISION NO. 21, FOR THE MODEL NO. INNER HFIR UNIRRADIATED FUEL ELEMENT SHIPPING CONTAINER, AND OUTER HFIR UNIRRADIATED FUEL ELEMENT SHIPPING CONTAINER, DOCUMENT

DATED: July 7, 2020

DISTRIBUTION: SFST r/f ADimitriadis, RI; BDesai, RII; DHills, RIII; GWarnick, RIV

This closes EPID L-2020-LLA-0119

G:/SFST/PART71CASEWORK/71-5797.R21.LTRSER.doc and 71-5797.R21.doc

ADAMS Accession No.: ML20189A267 ***via email**

OFFICE	NMSS/DFM	NMSS/DFM	NMSS/DFM	NMSS/DFM	NMSS/DFM
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DATE:	06/25/2020	06/25/2020	06/25/2020	07/06/2020	07/7/2020

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UNITED STATES
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Safety Evaluation Report
U.S. Department of Energy
Docket No. 71-5797
Model No. Inner HFIR Unirradiated Fuel Element Shipping Container,
and Outer HFIR Unirradiated Fuel Element Shipping Container

BACKGROUND

The High Flux Isotope Reactor (HFIR) Unirradiated Fuel Element Shipping Container is a type B(U)F package, with contents described as U_3O_8-Al cermet, enriched up to 95% in U^{235}, and clad in aluminum. U^{234} and U^{236} have both a corresponding A_2 value of 6.0 x10^{-3} TBq, with the remaining U^{235} and U^{238} being unlimited with respect to A_2, as shown in 10 CFR Part 71 Appendix A, Table A-1.

During a recent review by ORNL of the Safety Analysis Report (SAR) of the Model No. Inner HFIR Unirradiated Fuel Element Shipping Container, and Outer HFIR Unirradiated Fuel Element Shipping Container (Docket No. 71-5797), non-conservative values were identified in association with the hypothetical accident conditions (HAC) thermal test damage conditions for the side plates of both the inner and outer HFIR fuel elements. ORNL identified that the pre-machined plate thickness was used, instead of the final thickness, in the analysis for the side plates of both the inner and outer HFIR fuel elements. As such, the reduced thickness increases both the exposure time to melt the fuel cladding and the fraction of exposed/unclad fuel, and consequently the A_2 results.

The Department of Energy (DOE) notified the NRC by letter dated March 4, 2020, of this calculation error in the thermal analysis. Based on the staff's review of the applicant's evaluation, the NRC issued a Letter of Authorization, dated March 18, 2020, which authorized the use of the HFIR package until July 31, 2020.

By letter dated May 28, 2020, DOE requested an amendment to the Certificate of Compliance (CoC) and submitted a corrected HAC thermal analysis.

EVALUATION

As stated in Enclosure 1 of the amendment request, "Evaluation of the Error and Proposed Path Forward," the applicant incorrectly assumed the pre-machined side plate thickness instead of the final thickness for the HAC thermal analysis to predict the percentage of the fuel-bearing material that would be melted if a fuel assembly was directly exposed to the HAC fire without the benefit of the container. The applicant used the pre-machined side plate thicknesses of 0.377 inch for the inner fuel assembly and 0.408 inch for the outer fuel assembly and predicted that approximately 13% of the fuel-bearing material for both inner fuel assembly and outer fuel assembly would be melted under the HAC fire.

DOE/ORNL subsequently determined that this calculation error is not safety significant and that the results from the revised HAC thermal analysis do not change any of the CoC conditions because no loss of radioactive contents exceeds one A_2 per week under HAC.

Material Properties and Component Specifications

The applicant stated in Appendix B of the SAR Rev. 12 that the average specific heat for the side plates, made of 6061 aluminum, is about 0.247 Btu/lbm-°F from 169°F to 1080°F, and the fusion heat of the aluminum cladding is 171 Btu/lbm. The applicant referred to a report by M. W. Wendel and D. G. Morris, "High Flux Isotope Reactor System RELAPS Input Model, Report ORNL/TM-11647, Draft 12-20-90" to state that: (a) the content for the inner side plates is 77 wt% aluminum with an average specific heat of 0.218 Btu/lbm-°F from 169°F to 1220°F and an average density of 176 lbm/ft^3, and (b) the content for the outer side plates is 71 wt% aluminum with an average specific heat of 0.207 Btu/lbm-°F from 169° F to 1220°F and an average density of 186 lbm/ft^3.

The staff reviewed this ORNL report, and the aluminum material source book, and confirmed that the thermal properties of the 6061 aluminum, used by the applicant in the revised thermal analysis, are acceptable.

Normal Conditions of Transport (NCT)

The applicant stated in Section 3.4 of the SAR Rev. 12 that (a) the previous assessments and over 20 years of in-service operations demonstrate that, for the thinner side plates of the inner and outer fuel assemblies, the package is adequate for normal conditions of transport (NCT) and (b) there are no thermal gradients sufficient to cause any significant thermal stress in the package.

The staff reviewed the SAR Rev. 12 and agrees that the use of the thinner side plates with final/correct thicknesses for the inner and outer fuel assemblies has no significant effects either on the package thermal performance or on the maximum thermal stresses under NCT. This is because the thinner side plates will not cause significant changes in the temperatures of the package metallic components under NCT and, therefore, the previous NCT thermal evaluation and its stress calculations remain acceptable and in compliance with 10 CFR 71.51(a)(1).

Hypothetical Accident Conditions (HAC)

<u>Melt of the Fuel Side Plates for Inner Fuel Assembly and Outer Fuel Assembly</u>

The applicant described the revised HAC thermal analysis and the related parameters in Appendix B of the SAR Rev. 12:

- the thinner side plates with final/correct thicknesses (0.105 inch for the inner fuel assembly and 0.128 inch for the outer fuel assembly), and
- the HAC initial temperature of 169°F for the package, the melting point of 1080°F for the fuel cladding material 6061 aluminum (outer cladding) and the melting point of 1220°F for the side plates (77 wt% aluminum) of the inner fuel assembly and for the side plates (71 wt% aluminum) of the outer fuel assembly.

The applicant first derived the nominal melt rate of 1.90 inch/hour into clad material 6061 aluminum, and then the melting rates of 1.63 inch/hour for the inner side plate and 1.64 inch/hour for the outer side plate, and finally the melts of 0.668 inch for the inner side plate and the 0.672 inch for the outer side plate. Correspondingly, the calculated melted fractions of the fuel-bearing material are 21.8% for the inner fuel assembly and 24.4% for the outer fuel assembly, as shown in Appendix B of the SAR Rev. 12.

The staff reviewed the revised HAC thermal analysis for melting of the fuel inner side plate and the fuel outer side plate and finds the assumptions, parameters, and methodology used in the analysis to be reasonable. The staff confirmed that less than 25% of the fuel-bearing material of a HFIR fuel assembly would melt if the fuel assembly were exposed to a 1475°F fire for 30 minutes.

Fractions for the Unclad Fuel Assembly

The applicant described the revised HAC thermal analysis and the related parameters in Chapter 4 of the SAR Rev. 12:

- the radionuclides of U^{234}, U^{235}, U^{236}, and U^{238} contained in unirradiated HFIR fuel,
- the specific activities of 2.3×10^{-4} TBq/gram for U^{234} and 2.4×10^{-6} TBq/gram for U^{236} and the unlimited A_2 values for U^{235} and U^{238}, per 10 CFR 71, Appendix A, and
- the loading limits of 2630 grams and 6880 grams, respectively, for U^{235} in the inner fuel assembly and the outer fuel assembly.

The applicant stated in Chapter 4 of the SAR Rev. 12 that the HFIR fuel is highly enriched U^{235} with a weight 93.164% and therefore is characterized as a mixture of isotopes U^{234}, U^{235}, U^{236} and U^{238} to determine the A_2 value for the mixture. The applicant provided the data of specific activity, weight %, and fraction of activity for these isotopes in Appendix B of the SAR Rev. 12.

The staff referred to 10 CFR Part 71 Appendix A (Table A-1) and agrees that the data (e.g., A_2 values, specific activities, and weight percentages of U^{234}, U^{235}, U^{236} and U^{238} used in the revised HAC thermal analysis are consistent with U^{234}, U^{235}, U^{236} and U^{238} numbers listed in Table A-1 of the Part 71 Appendix A and are acceptable for the revised calculation.

The applicant calculated an A_2 of 1.65×10^{-1} Curies (Ci) for the uranium fuel mixture and the uranium fuel activities of 1.83×10^{-1} Ci and 4.79×10^{-1} Ci, respectively, for the inner fuel assembly and the outer fuel assembly. As shown in Appendix B of the SAR Rev. 12, the applicant, using these activities, concludes that an amount of fuel bearing material exceeding 90% of uranium in the inner fuel assembly or exceeding 34% of uranium in the outer fuel assembly constitutes a quantity exceeding A_2 value. The applicant concluded, in SAR Amendment Enclosure 2, that the amount of fuel which melts in the regulatory fire is more than the previously assumed (13% increasing to approximately 25%); however, based on revised calculations for the amount of fuel which can melt prior to releasing an A_2 value in one week, the applicant found that there is still a positive margin of safety against the release of radioactive material.

The staff reviewed the applicant's calculation and agrees that greater than 90% of the fuel-bearing material in the inner fuel element or greater than 34% of the fuel-bearing material in the outer fuel element must melt before the regulatory limit defined in the 10 CFR 71.51(a)(2) would

be exceeded. Therefore, the staff determines that the HAC fire would not result in a release of an A_2 value in one week, in compliance with 10 CFR 71.51(a)(2).

EVALUATION FINDINGS

- The fraction of unclad fuel for the thinner side plate (after-machining, with a final thickness of 0.105 inch) is 21.8% for the inner fuel assembly and is below the HAC limit of 90% which corresponds to the limit defined in 10 CFR 71.51(a)(2).
- The fraction of unclad fuel for the thinner side plate (after-machining, with a final thickness of 0.128 inch) is 24.4% for the outer fuel assembly and is below the HAC limit of 34% which corresponds to the limit defined in 10 CFR 71.51(a)(2).

Based on these findings listed above, the staff has reasonable assurance that, for both inner fuel assembly and outer fuel assembly, there will be no escape of radioactive material exceeding a total amount of A_2 in one week under the HAC fire and, thus, the package is in compliance with 10 CFR 71.51(a)(2). The CoC No. 71-5797 does not need to be modified and stays as issued.

CONDITIONS

The following changes were made to the CoC:

Item No. 3(b) identifies now correctly the application, as supplemented.

Condition No. 11 extends the use of Revision No. 20 of the CoC by approximately one more year.

The References section of the certificate was updated to include the supplement dated May 2020 (Revision No. 12 of the application -pages changes).

CONCLUSION

Based on the statements and representations in the application, the staff finds that these changes do not affect the ability of the Model No. Inner HFIR Unirradiated Fuel Element Shipping Container, and Outer HFIR Unirradiated Fuel Element Shipping Container package to meet the requirements of 10 CFR Part 71.

Issued with CoC No. 5797, Revision No. 21.