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

SAFETY EVALUATION REPORT

Docket No. 71-9330
Model No. ATR-FFSC Package
Certificate of Compliance No. 9330
Revision No. 15

SUMMARY

By letter dated May 3, 2021 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML19052A428), the Department of Energy (DOE or the applicant) requested an amendment of the Certificate of Compliance (CoC) No. 9330 for the Model No. ATR-FFSC package.

The applicant requested to add low enriched uranium (LEU) payloads for several research reactors. The U.S. High Performance Research Reactor (USHPRR) project is in the process of converting the five remaining USHPRRs from highly enriched uranium (HEU) to LEU, and as such, there is a need to ship prototypic, full size LEU-based fuel elements and associated Design Demonstration Elements (DDE). The requested amendment includes the following LEU-based fuel elements:

• Advanced Test Reactor (ATR) fuel element

• Missouri University Research Reactor (MURR), fuel element and DDE

• Massachusetts Institute of Technology Reactor (MITR), fuel element and DDE

• National Bureau of Standards Reactor (NBSR) DDE only

The submittal was evaluated against the regulatory standards in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 71, including the general standards for all packages, standards for fissile material packages, and performance standards under normal conditions of transport and hypothetical accident conditions.

The certificate has been amended based on the statements and representations in the application. The staff agrees that the changes do not affect the ability of the package to meet the requirements of 10 CFR Part 71.

EVALUATION

The applicant has requested the addition of full-size prototype LEU fuel elements and DDEs as authorized payloads in the ATR-FFSC transport package. The DDEs are similar to the already approved versions of the standard fuel elements and are bounded by the already approved fuel designs. The main difference between the DDE and its associated prototypic element is the end fittings, which allow for in-situ measurements to be taken for design verification and testing but are similar in design and configuration with respect to criticality safety.

The ATR-FFSC package is designed to carry one element at a time and maintains this configuration in this amendment request.

Staff evaluated the proposed changes on the ability of the ATR-FFSC transportation package to meet the fissile material requirements of 10 CFR Part 71. Staff reviewed the criticality safety analyses performed by the applicant. The staff's review considered the criticality safety requirements of 10 CFR Part 71, as well as the review guidance presented in NUREG-2216, "Standard Review Plan for Transportation Packages for Spent Fuel and Radioactive Material."

Contents

The new LEU payloads include the following: ATR full size LEU element; MITR full size LEU element and MITR DDE; MURR full size LEU element and MURR DDE; and NBSR DDE. Payloads are enriched up to 20 wt.% ^{235}U. Each element core is composed of a U-10Mo alloy. Both the cladding and the end fittings are the same aluminum alloys used for all of the already approved HEU elements. These requested LEU elements are heavier than HEU elements and require a new Fuel Handling Enclosure (FHE). However, the FHE for the proposed payloads are not relied on to maintain the criticality safety of the ATR-FFSC package, as is the case for the previously approved HEU fuels under this license.

All of the LEU fuel elements and DDEs consist of multiple fuel plates clad in aluminum with a zirconium layer surrounding the fuel. The fuel is composed of U-10Mo, with a molybdenum content of 10 ± 1 wt.%, and the remainder consisting of ^{235}U with an enrichment of 19.75 ± 0.20 wt.%. The fuel density and dimensions vary based on each fuel type, as detailed in section 6.14.2 of the application. Up to 200 g of polyethylene is used for bagging of the fuel elements and DDEs.

Demonstration of Maximum Reactivity

The applicant provided calculations for all of the new fuel types to find the maximum k_{eff} for both single packages and packages in arrays.

The applicant assumed the inner cavity of the ATR-FFSC was filled with the optimal density moderator for both normal conditions of transport (NCT) and hypothetical accident conditions (HAC) evaluations, and optimally moderated within the outer shell of the ATR-FFSC for the HAC evaluations. The applicant varied moderation between fuel plates to simulate the use of polyethylene bags and neoprene dunnage used during transport. The applicant maximized the ^{235}U mass within each fuel plate by maximizing the fuel volume, uranium content, and enrichment without reducing the fuel density.

The applicant minimized fuel plate cladding for all element types and neglected structural components of the ATR-FFSC except for the neoprene, which is kept in the models to account for the contributing moderation. The applicant omits the ends of the ATR-FFSC since their materials would add neutron absorption to the model and fills these spaces with optimal moderation or fuel meat due to movement during NCT and HAC.

Staff finds that the modeling of the packages follows that used for other authorized contents in the ATR-FFSC and that the moderation, fuel densities, uranium content, and reduction in neutron absorbing materials are all conservative and acceptable.

For the NCT evaluation, the applicant maintains fuel plate spacing, but allowed a complete element to move to maximize reactivity. Since the package lid does not contain a seal,

moderation is modeled within the package. The applicant varied the moderation both between the fuel plates and surrounding the fuel elements to find the maximum reactivity of each element type. Staff finds that the applicant's modeling and moderation assumptions are adequate to demonstrate the maximum k_{eff} for each element type.

For the HAC evaluation, the applicant used models similar to the NCT evaluation, but allowed the fuel plates to move independently and varied their positioning to determine the most reactive spacing from each other. Variable moderation is modeled both within the package and as well as within the outer shell of the ATR-FFSC, and the applicant replaced insulation with optimal moderation water since this insulation could be missing during a hypothetical accident. Similar to the NCT evaluation, the applicant varied the moderation both between the fuel plates and that surrounding the fuel elements in order to determine the optimum moderation for maximizing the k_{eff} during HAC. Staff finds that the applicant's modeling and moderation assumptions, coupled with the relative positioning of the elements within the package during HAC are adequate to demonstrate the maximum k_{eff} for each element type.

A summary table of the maximum multiplication factors for both NCT and HAC can be found in the SAR, Table 6.14-1. Since these packages contain only one fuel element, all the k_{eff} are substantially below the Upper Subcritical Limit (USL) for all cases, with the ATR LEU package array under HAC having the highest k_{eff} of 0.87986, which is approximately 5% below the USL.

Air Transport

The applicant also requested air transport of loaded ATR-FFSC packages under 10 CFR 71.55(f). In this evaluation, the applicant assumed that all structural materials of the package are destroyed and consolidated all of the fissile material contained in a fuel element into a spherical configuration. The fissile sphere is assumed to be moderated by the packaging materials and reflected by the packaging materials and water. This approach is consistent with the previous air transport approval and the staff finds its use appropriate.

The staff also finds that the applicant used bounding quantities of materials in this model. These include 2000g ^{235}U at a density of 18.76 g/cm^3, 1500g neoprene, 200g polyethylene, and 4000g of wood, which are conservative assumptions given the actual capacity of the ATR-FFSC and fuel composition of the elements. Although the neoprene mass is based on the actual mass present in a package, the applicant modeled neoprene without the chlorine present to limit neutron absorption.

The applicant modeled two different configurations:

> The first configuration introduced increasing amounts of moderating materials into the sphere to optimize the moderation.
>
> In the second configuration, the applicant divided the fissile sphere into a central optimally mixed fuel and moderator sphere surrounded by a fuel only sphere, keeping the masses constant with the first configuration.

Staff finds that the two spherical models are conservative in contents and configuration, and maximize the mass of uranium while limiting the escape of neutrons from the modeled system, which demonstrates the maximum k_{eff} during air transport.

The results of this analysis, presented in Table 6.14-46 of the SAR, demonstrate that the single region spherical model is under moderated, and yields a maximum $k_{eff} + 2\sigma = 0.69452$. The

second, two-region spherical model demonstrates that the k_{eff} increases initially, and peaks at a $k_{eff} + 2\sigma = 0.71171$. Both of these maximum k_{eff} are well below the USL of 0.90868 for air transport.

Evaluation Findings

The staff reviewed the applicant's calculations for the ATR full size LEU element, MITR full size LEU element and MITR DDE, MURR full size LEU element and MURR DDE, and NBSR DDE, and finds that the applicant has identified the most reactive conditions for each configuration at an enrichment of up to 20 wt.% 235U for single package, NCT arrays, HAC arrays, and air transport. Staff finds the applicant has demonstrated that the new proposed contents to the ATR-FFSC package will remain subcritical under NCT and HAC in a single package and array configurations per the requirements of 10 CFR 71.55 and 10 CFR 71.59. The staff finds that the air transport limits proposed above are conservative, and that there is reasonable assurance ATR-FFSC package will remain subcritical per the fissile material air transport requirements of 10 CFR 71.55(f).

Conclusion

Based on the statements and representations in the application, and the conditions listed in the CoC, the staff concludes that the design has been adequately described and evaluated, and will continue to meet the requirements of 10 CFR Part 71 with the transport of the FUTURE-HFIR plates.

CONDITIONS

The following changes are included in Revision No. 15 to Certificate of Compliance No. 9330:

Item No. 3.b was revised to identify the latest application Revision No. 16, dated May 2021.

Condition No. 5(a)(2) was revised to specify that the NBSR DDE does not utilize a FHE.

Condition No. 5(a)(3) was revised to include the new licensing drawings for the ATR LEU and MURR LEU fuel handing enclosures.

Condition No. 5(b)(1) was revised to include the description of the new LEU fuel elements authorized for transport, i.e., ATR, MURR, MITR, NBSR, and re-written to clarify the description of some elements.

Condition No. 5(b)(2) was revised to mention the new elements in the maximum quantity of materials per package.

Condition No. 5(c) was revised to include the Criticality Safety Index (CSI) of 4 for the ATR HEU, MIT HEU, MURR HEU fuel elements or ATR loose fuel plates, as well as NBSR DDE.

Condition No. 6 was revised to mention the newly authorized elements vis a vis the maximum weight of the polyethylene wrap and tape.

Condition No. 11 authorizes the use of the previous revision of this certificate for approximately one year. The expiration date of the CoC is not changed.

The Safety Analysis Report, Advanced Test Reactor Fresh Fuel Shipping Container (ATR FFSC), Revision No. 16, dated May 2021, has been added to the References section of this certificate.

CONCLUSION

Based on the statements and representations in the application, and the conditions listed above, the staff concludes that the Model No. ATR-FFSC package design has been adequately described and evaluated and that these changes do not affect the ability of the package to meet the requirements of 10 CFR Part 71.

Issued with Certificate of Compliance No. 9330, Revision No. 15, for the Model No. ATR-FFSC.