SAFETY EVALUATION REPORT

Docket No. 71-9330
Model No. ATR-FFSC Package
Certificate of Compliance No. 9330
Revision No. 11

SUMMARY

By letter dated February 27, 2017, the Department of Energy (DOE or the applicant) requested an amendment to Certificate of Compliance (CoC) No. 9330 for the Model No. ATR-FFSC package. DOE supplemented its application by letter dated May 9, 2017. Revision No. 14 of the Safety Analysis Report “Advanced Test Reactor Fresh Fuel Shipping Container (ATR-FFSC), dated May 2017, supersedes all previous revisions of the application.

The applicant requested an amendment to increase the quantity of packages that can be shipped in a single conveyance. The criticality analysis now evaluates “Conversion of BR-2 Alternative” (COBRA) fuel element plates as intact and arranged in the most reactive configuration.

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 (NCT) and hypothetical accident conditions (HAC).

CoC No. 9330 has been amended based on the statements and representations in the application, and staff agrees that the changes do not affect the ability of the package to meet the requirements of 10 CFR Part 71.

EVALUATION

The U-235 mass limits have been updated to 410.3 grams for HEU and 435.8 grams for LEU respectively to reflect the actual designs of the COBRA type fuels.

For NCT, both the COBRA fuel and the FHE are considered intact while, for HAC, the COBRA fuel is considered as both intact within an intact FHE and also conservatively reconfigured in the absence of an FHE. Since the fuel and FHE are modeled as both intact and as fully reconfigured to the most reactive extent, including a total absence of FHE, a structural evaluation of the COBRA fuel and of the COBRA FHE is not required.

Criticality Evaluation

The number of packages that can be shipped is limited by the Criticality Safety Index (CSI). 10 CFR 71.59 provides the method of calculating the CSI which involves the size of the array used to perform the criticality safety evaluations. The ATR-FFSC package with COBRA fuel was restricted to a CSI of 31.3, which allows 3 ATR-FFSC packages with COBRA fuel elements to be transported per conveyance. The applicant requested a decrease to the CSI to 4.0, which would allow shipment of up to 25 packages loaded with COBRA fuel under exclusive use. Each ATR-FFSC package contains only one COBRA fuel element at a time. The package consists of two primary structural components, a circular inner tube and a square outer tube. The fuel element is transported in the Cobra Fuel Handling Enclosure (CFHE).

The applicant performed a criticality safety evaluation for the ATR-FFSC package to demonstrate that, with an increased array size, the previously approved COBRA fuel elements in the ATR-FFSC package continue to meet the criticality safety requirements of 10 CFR Part 71 under NCT and HAC.

Spent Nuclear Fuel Contents

A COBRA fuel element is either highly enriched uranium (HEU) composed of uranium metal mixed with aluminum enriched up to 94 wt% ^{235}U, or low enriched uranium (LEU) composed of uranium silicide mixed with aluminum and enriched to less than 20 wt% ^{235}U. HEU Cobra fuel may contain Gadolinium or Samarium burnable poison, and the LEU fuel may contain Gadolinium, but all burnable poisons are conservatively ignored in the applicant's analysis.

The U-235 mass limits have been updated to 410.3 grams for HEU and 435.8 grams for LEU respectively to reflect the actual designs of the COBRA type fuels. The configurations of the HEU and LEU fuel elements are geometrically identical except for the fuel composition and enrichment. A COBRA fuel element geometry has six concentric rings of fuel plates with each ring composed of three curved plates separated by aluminum spacers in a trefoil shape. The fuel is described in Section 6.13.2 of the application.

When the COBRA fuel was originally added to the approved contents of the ATR-FFSC package the applicant modeled it using a very conservative homogenized slurry assumption that limited the total array size. To support the increase in array size, the applicant has refined the criticality safety model to more accurately represent the COBRA fuel configuration.

Model Configuration

The applicant modeled the COBRA fuel using the appropriate dimensional tolerances and material compositions. The applicant ignored most packaging details particularly at the ends and conservatively replaced these end regions as full density water.

Normal Conditions of Transport

For NCT, the applicant models the CFHE, inner tube, insulation and outer tube explicitly. The applicant demonstrated that the CFHE would survive NCT with negligible damage and the therefore the applicant models the fuel centered within the CFHE and package cavity.

Hypothetical Accident Conditions

The HAC model is similar to that for NCT. The applicant replaced all insulation and void spaces with full density water. The condition of the CFHE is unknown after HAC therefore to bound all possible CFHE damage scenarios the applicant developed HAC models both with and without the CFHE. In addition the applicant did not drop test the ATR-FFSC with a COBRA fuel element and therefore assumes that damage could occur to the COBRA fuel element.

To bound the potential fuel damage in the HAC models, the fuel plate pitch is allowed to expand uniformly until constrained by the inner diameter of the package. This pitch expansion increases the moderation and the reactivity.

Computer Codes and Cross Section Libraries

MCNP5v. 1.30 code was used by the applicant to model the more detailed COBRA fuel configuration using the ENDF/B-VII cross section library with an appropriate benchmarking analysis.

Demonstration of Maximum Reactivity

The applicant modeled the COBRA fuel using water at optimum moderation, and performed parametric studies to determine the maximum reactivity of the fuel in both the HEU and LEU configurations. The applicant varied the active fuel length, cladding thickness, fuel thickness, fuel arc length, and the presence or absence of aluminum spacers. Based on these studies, the applicant determined that the most reactive case was HEU fuel at minimum active fuel length, minimum cladding thickness, minimum fuel thickness, maximum fuel arc length, and no aluminum spacers.

The applicant conservatively ignored the aluminum and structural material of the enclosure and ignored the neoprene pads, which consist of material that would absorb neutrons, attached to the CFHE. The applicant modeled the package using 12-in of full density water reflection. Analyses were performed by the applicant for both NCT and HAC in accordance with 10 CFR 71.55(d) and 10 CFR 71.55(e).

Confirmatory Analyses

The NRC staff performed selected confirmatory analyses on the most reactive configurations of COBRA fuel elements as described in the application. The SCALE 6.2 computer software package was used as an alternate independent code to the MCNP code used by the applicant for the analyses of the ATR FFSC, and were performed with the CSAS26 criticality sequence using KENO-VI geometry.

In the NRC staff's evaluation of the applicant's analysis assumptions, the staff determined that the additional detail added to the model compared to the original homogenized model greatly reduced the overall multiplication factor in all instances.

Using the most reactive scenarios identified by the applicant, staff modeled similar configurations to ensure that the maximum reactivity peaks were captured and, in all instances, staff calculations agreed well with the applicant's results.

Single Package Evaluation

For the NCT single package analysis, the applicant calculated a maximum k_{eff} $+2\sigma = 0.40321$. For the HAC single package analysis, the applicant calculated a maximum k_{eff} $+2\sigma = 0.49961$ at a pitch expansion of 0.5cm. Therefore, the most reactive cases as determined by the applicant for both the NCT and HAC single configurations are below the USL of 0.9209.

Evaluation of Package Arrays under Normal Conditions of Transport

For the array configurations, the NCT array is modeled as a 9x9x1 lattice of NCT single packages and reflected with 12-inches of full density water and varying water density within the cavity of the CFHE.

The applicant determined the most reactive NCT configuration as full density water within the fuel element and CFHE, and void between the CFHE and ATR-FFSC package inner diameter, and calculated a k_{eff} +2σ = 0.73887.

Evaluation of Package Arrays under Hypothetical Accident Conditions

The applicant modeled the HAC array in a 5x5x1 array and found that the most reactive HAC array case was with a pitch expansion of 0.5 cm and 0.8 g/cc water between the fuel element and the ATR-FFSC package cavity and calculated a k_{eff} +2σ =0.76431.

Results

The applicant determined the most reactive cases for both the NCT and HAC single package and array configurations and they are all below the USL of 0.9209. Based on the applicant's analysis and the requirements of 10 CFR 71.59, the CSI is 4.0, which would allow up to 25 packages under exclusive use. For air shipment, the COBRA fuel elements are still bounded by the analysis performed in Section 6.7 of the application.

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 Cobra fuel elements in the larger array sizes due to the decreased CSI of the more refined COBRA fuel model.

CONDITIONS

The following changes are included in Revision No. 11 to Certificate of Compliance No. 9330:

Item No. 3(b) identifies Revision No. 14 of the Safety Analysis Report, dated May 2017, as the application.

Condition No. 5(b)(1) has been revised to update the U-235 mass limits for the COBRA fuels.

Condition No. 5(c) has been revised to change the criticality safety index of the COBRA fuel.

Condition No. 11 authorizes the use of Revision No. 10 of this certificate for approximately one year.

The expiration date of the certificate is not changed.

The Revision No. 14 of the application, dated May 2017, is referenced in the Reference 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. 11,
on June 28, 2017.