SAFETY EVALUATION REPORT

Docket No. 71-9330
Model No. ATR-FFSC Package
Certificate of Compliance No. 9330
Revision No. 10

SUMMARY

By letter dated July 19, 2016, 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 December 1, 2016. Revision No. 12 of the Safety Analysis Report "Advanced Test Reactor Fresh Fuel Shipping Container (ATR-FFSC), dated December 1, 2016, supersedes all previous revisions of the application.

The applicant requested an amendment to add "Conversion of BR-2 Alternative" (COBRA) fuel assembly and its compatible fuel handling enclosure (FHE) to the authorized contents of the Model No. ATR-FFSC package. COBRA fuel includes both (i) High Enriched Uranium (HEU), Uranium Aluminide (UAlx) and (ii) Low Enriched Uranium (LEU), Uranium Silicide (U_3Si_2), as fuel elements. DOE also requested air transport as an authorized mode of transportation for all payloads, i.e., fuel elements and associated loose plates.

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

In its request for adding the COBRA fuel assembly and its corresponding FHE as authorized contents of the package, the applicant does not take credit for the presence of the FHE for structural integrity purposes, and any and all potential damage to the COBRA fuel assembly is accounted for in the criticality evaluation, as verified by staff. Furthermore, the mass of the COBRA fuel assembly is bounded by the mass of previously authorized contents, and the general construction arrangement of the FHE is similar in both geometry and materials of construction to those previously approved. Accordingly, the staff finds that adding the COBRA fuel assembly as authorized contents does not modify the existing structural analyses that remain valid.

The COBRA FHE, utilized for both HEU and LEU fuel elements, is of aluminum and neoprene rubber fabrication. The COBRA fuel elements, FHE and materials of construction are similar to various other previously approved ATR fuel types. Therefore, the staff finds that the addition of the COBRA fuel elements and FHE, as authorized contents of the package, assures that the existing material analyses in the application remain binding.

The package with the COBRA fuel element payload was not thermally modeled; instead, the applicant discussed a qualitative thermal analysis by comparing the MURR and COBRA fuel payloads. Due to (i) the similarity of the total weight of the MURR and Cobra payloads (45 and 48 lb, respectively) with their respective FHEs, (ii) the MURR and COBRA FHEs being fabricated from the same material, and (iii) the fuel plates having a comparable thermal mass and geometry, the applicant states that the COBRA payload maximum temperatures, for both NCT and HAC, will be bounded by the temperatures calculated with the MURR payload in Table Nos. 3.6-5 and 3.6-7 of the application. The staff accepts this qualitative thermal analysis for the COBRA payload along with the large thermal margin.

The staff notes that Section 3.4.5, "Accident Conditions for Air Transport of Fissile Material" of the application explicitly addresses the thermal requirements for air transport. The applicant does not take any credit for the fact that the fire would destroy any organic moderating material; the applicant assumes that the packaging would be destroyed and that the fissile material would be in the worst possible configuration, i.e., a sphere of uranium, as analyzed in the criticality evaluation. Thus, the staff agrees that the effects of a fire event, per 10 CFR 71.55(f)(1)(iv), do not have to be specifically evaluated since the criticality analysis shows that the subcriticality requirements of 10 CFR 71.55(f) are met.

The COBRA fuel type increases the U^{235} content from 400g for previously authorized fuel types to a maximum of 450g U^{235}. The COBRA fuel plates utilize a layered design similar to that used by other fuel types previously authorized for transport in this package. LEU COBRA fuel plates are composed of an Uranium silicide enriched up to 20 wt.% with a Gadolinium burnable poison, while HEU Cobra fuel plates are composed of a UAl_x fuel enriched up to 94 wt% with a Gadolinium or Samarium burnable poison. The applicant states that it utilized conservatisms in the modeling of the COBRA fuel elements to support the criticality safety analysis, including homogenizing the fuel, ignoring the FHE aluminum and structural materials, and emulating a cylindrical geometry within the inner circular structure of the package. The applicant's model also ignored the presence of gadolinium, samarium, and boron neutron absorbers to drive the calculated reactivity higher. The package was modeled assuming up to 100g of polyethylene to account for the bagging of the fuel elements, and up to 4kg of neoprene or cellulosic material used as padding. In response to staff's request for additional information on the use of neoprene or cellulosic material and how this might affect moderation in the model, the applicant explicitly addressed the moderation concerns by revising Table Nos. 6.11-7 and 6.11-8 of the application, and ignored both neoprene and cellulosic material since they are a less effective moderator than water.

The applicant utilized a modeling approach similar to that previously used for other fuel types allowed in the package. The applicant utilized MCNP5 v. 1.30 code with the ENDF/B-VII cross section library to conduct the evaluation, and performed analyses for both NCT and HAC in accordance with 10 CFR 71.55(d) and 10 CFR 71.55(e). In response to staff's request for additional information on the benchmarking analysis due to the fact that the COBRA fuel is closer to a fast or intermediate system and appeared to be outside the original benchmarking analysis completed for much lower enriched thermal system fuels, the applicant added 21 additional fast and intermediate benchmarks to the analysis to account for the COBRA HEU and LEU type fuels, which increased the calculated USL to 0.9248. For this analysis of the COBRA fuel elements, the applicant used the lower USL of 0.9209 for conservatism.

The fuel was modeled by the applicant as HEU homogenized with water at optimum moderation, and assumed a package length of 48 inches. The Model No. ATR-FFSC package uses a cylindrical inner payload area that is surrounded by a square outer tube, and the homogenized fuel mixture was modeled in the payload area at varying heights and water densities. Parametric studies were performed by the applicant by varying the moderation levels under fully flooded conditions, for both NCT and HAC scenarios, to demonstrate the maximum reactivity of the COBRA fuel.

For the NCT single package analysis, this homogenized mixture with 100g polyethylene within the package was determined, in the applicant's analysis, to have a maximum k_{eff} +2σ = 0.66215. For the HAC single package, this same mixture was used in the applicant's analysis with the addition of full density water, both above the fuel and in the insulation areas of the package, to maximize neutron reflection in accordance with 10 CFR 71.55(b), and was determined to have a maximum k_{eff} +2σ = 0.7409. For the determination of the criticality safety index (CSI), the maximum array condition, used for the NCT model, was 8 packages in an optimally spaced 3x3x1 lattice with one missing package in the corner, which was found to be more reactive than a 2x2x2 array, and fully reflected by water. This configuration yielded a k_{eff} +2σ = 0.89519. The HAC array was modeled as 4 optimally spaced packages in a 2x2x1 array, fully flooded and reflected, and the applicant calculated a k_{eff} +2σ = 0.84001. Therefore, the applicant determined that the most reactive cases, for both the NCT and HAC single and array configurations, are well below the USL of 0.9209.

To support shipment of the COBRA fuel, and of other previously authorized types of fuels, the applicant performed a bounding analysis to cover all fuel types, by utilizing the ATR U-Mo demonstration element analysis with additional conservatisms applied. The U-Mo demonstration element utilizes HEU at up to 94 wt.% U^{235}, with an evaluated payload of 2000g that is modeled as a sphere fully reflected with water. The modeled sphere omits all non-uranium and structural materials, and allows up to 100g of polyethylene for bagging of fuel elements, and up to 4000g of neoprene and cellulosic material, which is not used in the COBRA packaging. The applicant states that these parameters are bounding for the COBRA fuel since the modeled mass of HEU (i) is over four times that allowed in a COBRA FHE, (ii) uses an optimum spherical geometry, and (iii) is fully reflected by water. The most reactive configuration for the U-Mo fuel was calculated by the applicant to be k_{eff} +2σ = 0.60739, which is also well below the USL of 0.9209.

The applicant's analysis determined a CSI, based on the requirements of 10 CFR 71.59, and calculated a CSI of 31.3, which allows for up to 3 packages containing COBRA fuel elements to be transported per conveyance.

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 its evaluation of the applicant's analysis assumptions, the staff determined the homogenization of the fuel is a very conservative modeling approach since, for uranium enrichments greater than 5 wt%, the reactivity is significantly greater than using a direct geometry model. Also, ignoring the aluminum and structural materials eliminates the potential for parasitic neutron absorption as well as decreases the size of the fissile material volume to achieve the same H/U ratio, both of which drive reactivity higher in the analysis. Using the most reactive scenarios identified by the applicant, staff modeled similar configurations altering the heights of the fissile mixtures and the water density of the regions between the fuel to ensure that the maximum reactivity peaks were captured and, in all instances, staff calculations agreed well with the applicant's results.

Based on the statements and representations in the application, and the conditions listed in the CoC, the staff concludes that the changes made in this amendment request for the transport of COBRA fuel do not affect the ability of the package to meet the structural, material, thermal, or criticality requirements of 10 CFR Part 71.

CONDITIONS

The following changes are included in Revision No. 10 to Certificate of Compliance No. 9330:

Item No. 3(b) identifies Revision No. 12 of the Safety Analysis Report, dated December 2016, as the application.

Condition No. 5(a)(2) has been modified to add the Fuel Handling Enclosure (FHE) specific to the COBRA fuel as part of the description of the packaging.

Condition No. 5(a) (3) has been modified to add the licensing drawing for the COBRA fuel FHE.

Condition No. 5(b)(1) has been revised to (i) specify that, for small quantity payloads, loose plates may be separated by kraft paper and taped or wire tied together, (ii) describe the composition of COBRA HEU and LEU fuel elements, their maximum enrichments, masses and weights, and (iii) describe the COBRA loose fuel element plates that are transported as small quantity payloads. An error was also corrected in the description of the Mark fuel material: unirradiated Mark IV fuel material is composed of U_3O_8, while the Mark V, VI, and VII ATR fuel material is composed of uranium aluminide (UAl_x).

Condition No. 5(b)(2) has been revised to specify a maximum quantity of one COBRA fuel element per package.

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

Condition No. 6 has been revised to specify the maximum weight of the polyethylene wrap and tape, and of neoprene and cellulosic material per package.

Condition No. 8 has been added to authorize air transport of the contents. All other subsequent conditions were renumbered.

Condition No. 11 (previously Condition No. 10) authorizes the use of Revision No. 9 of this certificate for approximately one year.

The expiration date of the certificate is not changed.

The Revision No. 12 of the application, dated December 2016, 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. 10, on March 28, 2017.