CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES

1. a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. DOCKET NUMBER	d. PACKAGE IDENTIFICATION NUMBER	PAGE	PAGE
9330	11	71-9330	USA/9330/AF-96	1 OF	6

2.. PREAMBLE

a. This certificate is issued to certify that the package (packaging and contents) described in Item 5 below meets the applicable safety standards set forth in Title 10, Code of Federal Regulations, Part 71, "Packaging and Transportation of Radioactive Material."

b. This certificate does not relieve the consignor from compliance with any requirement of the regulations of the U.S. Department of Transportation or other applicable regulatory agencies, including the government of any country through or into which the package will be transported.

3. THIS CERTIFICATE IS ISSUED ON THE BASIS OF A SAFETY ANALYSIS REPORT OF THE PACKAGE DESIGN OR APPLICATION

a. ISSUED TO *(Name and Address)*

U.S. Department of Energy
Washington, DC 20585

b. TITLE AND IDENTIFICATION OF REPORT OR APPLICATION

Safety Analysis Report, Advanced Test Reactor Fresh Fuel Shipping Container, ATR FFSC, Revision No. 14, dated May 2017.

4. CONDITIONS

This certificate is conditional upon fulfilling the requirements of 10 CFR Part 71, as applicable, and the conditions specified below.

5.

(a) Packaging

(1) Model No.: ATR FFSC

(2) Description

An insulated stainless steel package for the transport of unirradiated research reactor fuel, including intact fuel elements or fuel plates. The packaging consists of (1) a body, (2) a closure lid, and (3) inner packaging internals. The approximate dimensions and weights of the package are:

Overall package outer width and height	8 inches
Overall package length	73 inches
Cavity diameter	5-3/4 inches
Cavity length	68 inches
Packaging weight (without internals)	240 pounds
Maximum package weight (including internals and contents)	290 pounds

The body is composed of two thin-walled, stainless steel shells. The outer shell is a square tube with an 8-inch cross section, a 73-inch length, and a 3/16 inch wall thickness. The inner shell is a round tube with a 6-inch diameter and a 0.120-inch wall thickness. The inner tube is wrapped with ceramic fiber thermal insulation, overlaid with a stainless steel sheet. At the bottom end, the shells are welded to a 0.88-inch thick stainless steel base plate. At the top end (closure end), the shells are welded to a 1.5-inch thick stainless steel flange.

5.(a)(2) Description (Continued)

The closure is composed of circular stainless steel plates with ceramic fiber insulation. The closure engages the top end flange by way of four bayonets that are rotated and secured by two spring pins. The closure is equipped with a handle, which may be removed during transport. The closure does not have a gasket or seal.

The package internals consist of either a Fuel Handling Enclosure (FHE) for intact Advanced Test Reactor (ATR), Massachusetts Institute of Technology (MIT), University of Missouri Research Reactor (MURR), Conversion Of Belgian Reactor 2 – an Alternative (COBRA fuel-both HEU and LEU), or Rhode Island Nuclear Science Center (RINSC) fuel elements and Small Quantity Payloads, or a Loose Fuel Plate Basket for ATR fuel plates. The RINSC, MIT, MURR, COBRA, and Small Quantity Payload FHE use ball lock pins and end spacers to lock closed while the ATR FHE uses a spring plunger.

(3) Drawings

The packaging is constructed and assembled in accordance with the following Areva Federal Services LLC. or Packaging Technology, Inc., Drawing Nos.:

60501-10, Sheets 1-5, Rev. 3	ATR Fresh Fuel Shipping Container SAR Drawing
60501-20, Rev. 1	ATR Loose Plate Basket Assembly
60501-30, Rev. 1	ATR Fuel Handling Enclosure
60501-40, Rev. 0	MIT Fuel Handling Enclosure
60501-50, Rev. 0	MURR Fuel Handling Enclosure
60501-60, Rev. 0	RINSC Fuel Handling Enclosure
60501-70, Rev. 0	Small Quantity Payload Fuel Handling Enclosure
60501-90, Rev. 0	COBRA Fuel Handling Enclosure

(b) Contents

(1) Type and form of material

Unirradiated Mark IV, V, VI, and VII ATR fuel elements. The 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). The uranium is enriched to a maximum 94 weight percent U-235; the maximum U-234 content is 1.2 weight percent; and the maximum U-236 content is 0.7 weight percent. Intact ATR fuel elements contain 19 curved fuel plates fitted within aluminum side plates, and the maximum channel thickness between fuel plates is 0.087 inch. The fuel meat thickness is a nominal 0.02 inch for all 19 plates, and the fuel meat width ranges from approximately 1.5 inches to 3.44 inches. The nominal active fuel length is approximately 48 inches. The maximum mass of U-235 per intact ATR fuel element is 1200 grams. The ATR fuel element must be contained within the ATR Fuel Handling Enclosure, as specified in 5.(a)(3).

5.(b)(1) Type and Form of Material (continued)

Unirradiated ATR U-Mo fuel elements. The ATR U-Mo fuel element consists of a mixture of high-enriched uranium aluminide (UAl_x) fuel plates and low-enriched uranium and molybdenum alloy (U-Mo) fuel plates, with a maximum mass of U-235 per U-Mo fuel element of 1,240 grams. The ATR U-Mo fuel element contains 19 curved plates fitted within aluminum side plates; plates 1 through 4, and 16 through 18, contain high-enriched UAl_x fuel; plates 5 through 15 contain low-enriched U-Mo fuel; and plate 19 is an aluminum alloy plate. The maximum channel thickness between fuel plates is 0.087 inch. For the high-enriched UAl_x fuel plates, the uranium is enriched to a maximum 94 weight percent U-235; the maximum U-234 content is 1.2 weight percent; and the maximum U-236 content is 0.7 weight percent. For the low-enriched U-Mo fuel plates, the molybdenum content is a nominal 10 weight percent; the uranium is enriched to a maximum 20 weight percent U-235; the maximum U-234 content is 0.26 weight percent; and the maximum U-236 content is 0.46 weight percent. For the high-enriched UAl_x fuel plates, the fuel meat thickness is a nominal 0.02 inch; the fuel meat width ranges from approximately 1.5 inches to 3.44 inches; and the nominal active fuel length is approximately 48 inches. For the low-enriched U-Mo fuel plates, the fuel meat thickness is a nominal 0.013 inch, with a nominal 0.001 inch thick zirconium interlayer present between the fuel meat and the aluminum cladding layer; the fuel meat width ranges from approximately 2.25 inches to 3.28 inches; and the nominal active fuel length is approximately 48 inches. The ATR U-Mo fuel element must be contained within the ATR Fuel Handling Enclosure, as specified in 5.(a)(3).

Unirradiated MIT fuel element. The MIT fuel material is composed of uranium aluminide (UAl_x). The uranium is enriched to a maximum of 94 weight percent U-235; the maximum U- 234 content is 1.2 weight percent; and the maximum U-236 content is 0.7 weight percent. Each MIT fuel element contains 15 flat fuel plates fitted within aluminum side plates and the maximum channel thickness between fuel plates is 0.090 inch. The fuel meat thickness is a nominal 0.03 inch for all 15 plates and the fuel meat width ranges from approximately 1.98 inches to 2.17 inches. The nominal active fuel length is 22.375 inches. The maximum mass of U-235 per intact MIT fuel element is 515 grams. The MIT fuel element must be contained within the MIT Fuel Handling Enclosure, as specified in 5.(a)(3).

Unirradiated MURR fuel element. The MURR fuel material is composed of uranium aluminide (UAl_x). The uranium is enriched to a maximum of 94 weight percent U-235; the maximum U- 234 content is 1.2 weight percent; and the maximum U-236 content is 0.7 weight percent. Each MURR fuel element contains 24 curved fuel plates fitted within aluminum side plates and the maximum channel thickness between fuel plates is 0.090 inch. The fuel meat thickness is a nominal 0.02 inch for all 24 plates and the fuel meat width ranges from approximately 1.71 inches to 5.72 inches. The nominal active fuel length is 24 inches. The maximum mass of U-235 per intact MURR fuel element is 785 grams. The MURR fuel element must be contained within the MURR Fuel Handling Enclosure, as specified in 5.(a)(3).

Small Quantity Payloads (RINSC fuel elements, ATR Full-size plate In Flux Trap Position (AFIP) elements, U-Mo foils, Design Demonstration Elements (DDEs) and similar test

5.(b)(1) Type and Form of Material (continued)

elements, MIT, COBRA or MURR loose fuel element plates) where the maximum mass of U-235 is 400 grams and maximum U-235 enrichment is 94 weight percent. Aluminum plates, shapes, and sheets, miscellaneous steel or aluminum fasteners, and cellulosic material such as cardboard may be used as dunnage to fill gaps between the small quantity payloads and the small quantity FHE. Loose plates may be separated by kraft paper and taped or wire tied together. Dunnage shall be used to limit motion of the small quanity payload within the FHE to ¼" or less. 1/8" neoprene strips may be used between the small quantity FHE and small quantity payloads and/or between the optional aluminum dunnage and the small quantity payload. The 1/8" neoprene strips shall not be stacked in more than two layers between the small quantity payload and any interior face of the small quantity FHE.

Unirradiated RINSC fuel element. The RINSC fuel material is composed of uranium silicide (U_3Si_2) dispersed in aluminum powder. The uranium is enriched to a maximum of 20 weight percent U-235; the maximum U- 234 content is 0.5 weight percent; and the maximum U-236 content is 1.0 weight percent. Each RINSC fuel element contains 22 flat fuel plates fitted within aluminum alloy side plates and the maximum channel thickness between fuel plates is 0.096 inch. The fuel meat thickness is a nominal 0.02 inch for all 22 plates. The maximum mass of U-235 per intact RINSC fuel element is 283 grams. The RINSC fuel element must be contained within the RINSC Fuel Handling Enclosure, as specified in 5.(a)(3).

AFIP fuel element. The AFIP fuel element is composed of uranium molybdenum alloy in an aluminum-silicon matrix or uranium molybdenum alloy coated with a thin zirconium interlayer. The uranium is enriched to approximately 20 weight percent U-235. Each AFIP element contains 4 curved fuel plates fitted within 6061 aluminum side plates. The maximum mass of U-235 AFIP element is 365 grams. Loose plates from an AFIP fuel element are also permitted. The AFIP fuel element must be contained within the Small Quantity Payload Fuel Handling Enclosure, as specified in 5.(a)(3).

COBRA fuel element. The COBRA HEU fuel element is composed of uranium aluminide (UAl_x) dispersed in aluminum powder, with the uranium enriched to a maximum of 94 weight percent U-235. The COBRA LEU fuel element is composed of uranium silicide (U_3Si_2) dispersed in aluminum powder, with the uranium enriched to a maximum of 20 weight percent U-235. The maximum mass of U-235 is 410.3 grams in the HEU configuration or 435.8 grams in the LEU configuration. The COBRA fuel element weighs a maximum of 20 lb, is bagged, and must be contained within the COBRA Fuel Handling Enclosure, as specified in 5.(a)(3).

U-Mo Foils. The U-Mo foils are composed of uranium molybdenum alloy in an aluminum-silicon matrix or uranium molybdenum alloy and may contain a zirconium coating. The uranium is enriched to a maximum of 94 weight percent U-235. The maximum mass of U-235 is 160 grams. More than one U-Mo foil type may be transported at a time. The U-Mo foils must be contained within the Small Quantity Payload Fuel Handling Enclosure, as specified in 5.(a)(3).

5.(b)(1) Type and Form of Material (continued)

DDEs and similar test elements. The DDEs and similar test elements are composed of uranium molybdenum alloy in an aluminum-silicon matrix or uranium molybdenum alloy. The uranium is enriched to a maximum of 94 weight percent U-235. The maximum mass of U-235 is 365 grams. Loose plates from a DDE or similar test element are also permitted. The DDEs or similar test elements must be contained within the Small Quantity Payload Fuel Handling Enclosure, as specified in 5.(a)(3).

MIT and MURR loose fuel element plates. MIT and MURR loose plates may either be flat or curved and may be banded or wire-tied in a bundle. The MIT and MURR loose plate payload is limited to 400 grams of U-235. The approximate mass of U-235 of each MIT fuel plate is 34.3 grams.

The approximate mass of U-235 per each MURR fuel plate is 19 to 46 grams. A mixture of MIT and MURR fuel plates may be shipped together. The fuel plates must be contained within the Small Quantity Payload Fuel Handling Enclosure, as specified in 5.(a)(3).

Mark IV, V, VI, and VII ATR loose fuel plates: ATR loose plates may either be flat or curved and may be banded or wire-tied in a bundle. The ATR loose plate payload is limited to 600 grams of U-235. Additional aluminum plates may be used as dunnage to fill gaps between the fuel plates and the basket payload cavity. The fuel plates must be contained within the ATR Loose Fuel Plate Basket, as specified in 5.(a)(3).

COBRA loose fuel element plates: COBRA loose plates may either be flat or rolled to the geometry required for assembly into the fuel element and may be taped or wire-tied together. The U-235 content per COBRA loose plate is variable and may be HEU or LEU, but the total payload is limited to 400 grams of U-235. COBRA loose plates are transported as Small Quantity Payloads.

(2) Maximum quantity of material per package

The maximum total weight of contents and internals, including dunnage and other secondary packaging, is 50 lbs. Radioactive contents are not to exceed a Type A quantity.

For intact ATR, ATR U-Mo, MURR, RINSC, COBRA, and MIT fuel elements: One fuel element.

For ATR loose fuel plates: A maximum of 600 grams U-235.

For Small Quantity Payloads: A maximum of 400 grams U-235.

(c) Criticality Safety Index (CSI):

For ATR, ATR U-Mo, MURR, MIT fuel elements or ATR loose fuel plates: 4.0

For Small Quantity Payloads: 25

For COBRA fuel elements: 4.0

6. Fuel elements and fuel plates may be bagged or wrapped in polyethylene. The maximum weight of the polyethylene wrap and tape shall not exceed 100 grams per package. The maximum weight of neoprene plus cellulosic material shall not exceed 4 kg per package.

7. Types of small quantity payloads cannot be mixed in a single Fuel Handling Enclosure.

8. Air transport of fuel elements or loose plates is authorized.

9. In addition to the requirements of 10 CFR 71 Subpart G:

   (a) The package must be loaded and prepared for shipment in accordance with the Package Operations in Section 7 of the application.

   (b) The package must be tested and maintained in accordance with the Acceptance Tests and Maintenance Program in Section 8 of the application.

10. The package authorized by this certificate is hereby approved for use under the general license provisions of 10 CFR 71.17.

11. Revision No. 10 of this certificate may be used until June 30, 2018.

12. Expiration date: May 31, 2019.

REFERENCES

Safety Analysis Report, Advanced Test Reactor Fresh Fuel Container (ATR FFSC), Revision 14, dated May 2017.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

John McKirgan

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

Date: June 28, 2017

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. 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 $k_{eff} + 2\sigma = 0.73887$.

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 $k_{eff} + 2\sigma = 0.76431$.

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.