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

December 20, 2018

Mr. Wes Stilwell,
Manager, Global Packaging
and Regulatory Compliance,
Westinghouse Electric Company
Columbia Fuel Fabrication Facility
5801 Bluff Road,
Hopkins, SC 29061

SUBJECT: SPECIAL AUTHORIZATION FOR A ONE TIME SHIPMENT OF THE MODEL NO. TRAVELLER PACKAGE.

Dear Mr. Stilwell:

As requested by your application dated September 4, 2018, as supplemented November 19, 2018, pursuant to Title 10 of the *Code of Federal Regulations* Part 71, Certificate of Compliance (CoC) No. 9297, for the Model No. Traveller package is amended to authorize a shipment of two accident tolerant fuel (ATF) fuel assemblies, as follows:

(1) Authorization is for one shipment of two types of ATF designs, U_3Si_2 pellets and Advanced Doped Pellet Technology (ADOPT) pellets, stacked in separate lead test rods (LTRs) on the periphery of an assembly and arranged in separate lead test assemblies (LTA).

(2) The two LTAs are of a standard 17x17 optimized fuel assembly (OFA) design, meeting specifications of the PWR Group 1 Fuel Assembly, specifically 17 Bin 1, as outlined in Condition No. 5.(b)(1) of the CoC, Revision 10, with the following deviations:

(a) The fuel assembly cladding on any rod in a periphery location of the fuel assembly may include a Chromium coating up to 30 μm thick.

(b) One fuel assembly type may have the UO_2 pellets in any fuel rod on the periphery of the fuel assembly replaced with solid Zircaloy bars and encapsulated U_3Si_2 pellets meeting the following specifications:

(i) Maximum density – 12.2 g/cm^3
(ii) Maximum enrichment – 5 wt% U^{235}
(iii) Minimum pellet diameter, as defined in the proprietary application dated September 4, 2018.

(3) One fuel assembly type may have the UO_2 pellets in any fuel rod on the periphery of the fuel assembly include a Cr_2O_3 concentration up to 700 ppm and an Al_2O_3 concentration up to 200 ppm.

(4) Items (2) and (3) above may not be combined in a single fuel assembly.

(5) If not accepted for loading at the reactor site, this authorization covers the return of the fresh fuel assemblies.

(6) This authorization shall expire on August 1, 2019.

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

Sincerely,

/RA/

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

Docket No. 71-9297
EPID - L-2018-LLA-0234

Enclosure:
Safety Evaluation Report

cc w/encl: R. Boyle, Department of
Transportation
J. Shuler, Department of
Energy c/o L. F. Gelder

SUBJECT: SPECIAL AUTHORIZATION FOR A ONE TIME SHIPMENT OF THE MODEL NO. TRAVELLER PACKAGE, DOCUMENT DATE: December 20, 2018

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UNITED STATES
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Safety Evaluation Report
WESTINGHOUSE ELECTRIC COMPANY
Docket No. 71-9297
Model No. TRAVELLER Package

Westinghouse (or the applicant) requested a special package authorization for transport of two accident tolerant fuel (ATF) fuel assemblies, labeled LTA1 and LTA2, in the Traveller package for a shipment authorization from February 1, 2019 through August 1, 2019.

The two types of ATF designs are U_3Si_2 pellets and Advanced Doped Pellet Technology (ADOPT) pellets, stacked in separate lead test rods (LTRs) on the periphery of an assembly and arranged in separate lead test assemblies (LTA).

For this special authorization, LTA1 includes only U_3Si_2 rods and LTA2 includes only ADOPT rods. Both LTA1 and LTA2 include rods in the periphery of the assembly that are standard UO_2 fuel rods with a 20-30 µm thick chromium spray-on coating on the fuel cladding. LTA1 has four locations in the periphery of the assembly, where the standard UO_2 rods are replaced by U_3Si_2 rods, and LTA2 has four locations in the periphery of the assembly where the standard UO_2 rods are replaced by ADOPT rods. Both LTAs are the standard 17x17 fuel type design that is approved as a categorized fuel assembly (CFA) 17 Bin 1, in Condition No. 5.(b)(1)(i) of the certificate of compliance (CoC). There are no changes to the Model No. Traveller packaging design or to the Operating or Maintenance chapters of the application.

STRUCTURAL EVALUATION

The staff reviewed the structural performance assessment to determine the effect of replacing standard UO_2 rods with ATF test rods on the criticality safety evaluation. The Type LTA1 U_3Si_2 test rod is comprised of three rod segments: a short middle segment containing the U_3Si_2 pellets and two solid Zircaloy bar end segments. The middle segment is encapsulated in a chromium-coated standard UO_2 rod cladding. The Type LTA2 test rod is configured by replacing the UO_2 pellets with chromium-doped UO_2 pellets in a full length rod in standard 17x17 PWR fuel assemblies approved previously by the staff. The cladding for both test rod types is chromium-coated.

Appendix A, Section 2, “Mechanical/Structural Assessment,” of the request states that, “[T]he current Traveller SAR justifies that “Standard Zirconium Alloy” fuel cladding is the bounding fuel cladding since it possesses the lowest strain energy absorption capability of all current fuel cladding licensed.” In the Materials evaluation, below, the staff determined that there is reasonable assurance for the chromium-coated cladding to be as capable in absorbing strain energy associated with the geometry changes of the fuel assembly subject to the 9-m hypothetical accident condition (HAC) end drop test. Thus, the structural performance of the chromium-coated LTA2 test rod would be bounded by that of the standard fuel rods in the previously approved Traveller package CoC. It follows that, as discussed in the criticality evaluation below, the previously approved fuel array geometry modeling parameters will continue to be maintained for the criticality evaluation of the LTA2.

Enclosure

In the November 19, 2018, responses to the staff's request for additional information, the applicant evaluated the structural details of the middle segment of the LTA1 U_3Si_2 test rod by comparing its bending moment and axial compression resistance capabilities with those of the fuel rods of the previously approved 17x17 RFA. The evaluation examines the middle segment structural design attributes, including end plug and the threaded joint of the end plugs. For the flexural rigidity of the cladding, the evaluation indicates a reduced outside diameter but increased wall thickness to result in a slightly higher area moment of inertia than that of the fuel rods of the 17x17 robust fuel assembly (RFA). This design attribute comparison demonstrates that the U_3Si_2 test rods are stronger in lateral bending and axial compression capabilities than the actual drop tested 17x17 RFA fuel rods. Additionally, the evaluation shows that the lower end plug joint of the middle segment is being placed in an axial location much above the grid spacer below, for which the 17x17 FRA had experienced some geometry changes considered in the prior package approval. This indicates that no substantial bending loads are expected on the middle segment threaded sections based upon actual testing. Hence, the staff has reasonable assurance that the U_3Si_2 fuel rods are expected to be in at least the same condition after the drop testing when compared to the tested 17x17 RFA cladding.

On the basis of the review above, the staff concludes that the proposed LTA test rod designs would not affect their structural capability to maintain the fuel geometry licensing basis considered in the criticality evaluation for meeting the 10 CFR Part 71 requirements.

MATERIALS EVALUATION

The staff reviewed the structural-materials assessment provided in the request for special authorization. The staff's conclusion on reasonable assurance compliance with 10 CFR Part 71 regulations did not rely on the material mechanical properties discussed in this assessment; rather, it has relied on the evaluation of the consequences of lattice expansion and fuel rod rearrangement, as discussed in the criticality and structural sections of this SER. The staff does not make any judgement on the adequacy of the material mechanical properties in the structural assessment of the request for special authorization for transport of any lead test assemblies or batch assemblies.

The staff reviewed the applicant's justification that the thermal material properties of the cladding remain unchanged, as a result of the applied coating. The staff considers the justification to be acceptable since: (1) the base cladding material remains unchanged from prior approvals, and (2) the maximum measured cladding temperature during the regulatory fire test is an order of magnitude lower than any credible eutectic melting temperature for the cladding material and the coating material.

The applicant clarified that the uranium silicide fuel pellets have different thermal properties than the uranium dioxide fuel pellets, i.e. lower melting temperature, thermal conductivity and heat capacity. However, the applicant concluded the impact to be negligible because (1) the maximum measured cladding temperature during the regulatory fire test is an order of magnitude less than the uranium silicide fuel pellet melting temperature and (2) of the limited mass of uranium silicide fuel pellet mass relative to the uranium dioxide fuel pellet mass. The staff considers the justification to be acceptable for the uranium silicide contents in these lead test assemblies. Additional analyses may be needed for batch loading at higher uranium silicide loadings.

CRITICALITY EVALUATION

The ATF LTAs consist of modified 17x17 pressurized water reactor (PWR) fuel assemblies, currently approved in the Certificate of Compliance (CoC) as 17 Bin 1 fuel assemblies [USA/9297/AF-96, Section 5(b)(1)(i)]. The requested modifications to these assemblies include the replacement of standard rods in the peripheral row of the assembly with test rods containing either: 1) uranium silicide (U_3Si_2) pellets in a secondary cladding, or 2) chromium-doped UO_2 pellets. The actual number of standard rods replaced with test rods will be no more than four, but in order to allow them to be placed in any location on the periphery of the assembly, the applicant considered all periphery rods replaced.

U_3Si_2 LTAs

The U_3Si_2 fuel consists of a PWR fuel rod with a reduced pellet diameter to facilitate placement of the fuel in a secondary zircaloy cladding, which fits inside standard fuel rod cladding, and is held in place axially by solid zircaloy bars. Although the theoretical density of U_3Si_2 is higher than UO_2 (12.2 grams per cubic centimeter for U_3Si_2 versus 10.96 grams per cubic centimeter for UO_2), the reduction in pellet diameter and for the U_3Si_2 rods means that the amount of fissile material is reduced (approximately 12 percent less for a full-length rod).

The applicant evaluated the Model No. Traveller package with LTAs containing U_3Si_2 rods using the hypothetical accident conditions array model used for previously approved PWR fuel contents, as this was the bounding model for those contents. The applicant replaced standard 17x17 fuel assembly rods in the peripheral row of the assembly with U_3Si_2 rods. The active length for the U_3Si_2 rods is significantly reduced compared to a full length standard rod.

In addition to modeling the fuel with the actual intended active length, the applicant also modeled the U_3Si_2 rods with the standard active length. Additionally, although the applicant intends to transport LTAs with four U_3Si_2 rods on the periphery, the applicant modeled the package with LTAs with all peripheral rods replaced with U_3Si_2 rods. The applicant maintained all other modeling parameters (internal and external moderation, packaging changes due to hypothetical accident conditions, etc.) the same as was previously determined by the applicant to result in highest package reactivity.

The applicant's results are summarized in Table 3 of the letter authorization request dated September 4, 2018. As expected, modeling the Model No. Traveller package with four peripheral U_3Si_2 rods or all peripheral U_3Si_2 rods, with full or reduced active length, results in a reduction in effective multiplication factor (k_{eff}) compared to the results for the standard 17x17 fuel assembly. For the LTA configuration with all peripheral rods replaced with U_3Si_2 rods, the reduction in k_{eff} is significant (greater than 4%). For the LTA configuration that the applicant intends to transport (four reduced active length peripheral U_3Si_2 rods), the reduction in k_{eff} is approximately 0.003. The applicant's results demonstrate that the Model No. Traveller package will remain subcritical under both normal conditions of transport and hypothetical accident conditions, when peripheral standard 17x17 PWR fuel assembly rods are replaced with any number of U_3Si_2 rods.

The applicant used the same code and cross section library that was used to demonstrate subcriticality for the previously approved 17x17 PWR contents: SCALE 6.1.2 with the KENO VI three-dimensional Monte Carlo code and the ENDF/B-VII.0 continuous energy cross section library. The applicant did not revise the benchmarking analysis to include experiments with

U_3Si_2 material or provide an evaluation demonstrating that the new fuel materials are within the range of applicability of the previously approved benchmarking analysis.

The staff believes that the applicant's criticality results are appropriate, however, for the following reasons:

1) the results are consistent with the expected behavior of the system with the proposed changes (i.e., reduction in fissile material content on the periphery of the assembly, with no additional moderator due to additional zirconium in the rod, results in a decrease in k_{eff}); and

2) the new fuel material is located on the periphery of the fuel assembly, where it is less likely to contribute significantly to the code bias and bias uncertainty for the system.

Based on the discussion above, the staff found the applicant's proposed changes to the CoC, with respect to transporting 17x17 PWR fuel assemblies with U_3Si_2 rods located on the periphery of the assembly, would not affect the ability of the Model No. Traveller package to meet the criticality safety requirements of 10 CFR Part 71.

Chromium-doped UO_2 pellet LTAs

Chromium-doped UO_2 fuel consists of standard UO_2 pellets in zirconium alloy cladding, where the pellets include up to 700 parts per million (ppm) chromium oxide (Cr_2O_3) and 200 ppm aluminum oxide (Al_2O_3) powders. All fuel dimensions are the same as 17 Bin 1 fuel assemblies identified in the current CoC.

The applicant evaluated the Model No. Traveller package with LTAs containing chromium-doped UO_2 rods with the hypothetical accident conditions array model used for previously approved PWR fuel contents, as this was the bounding model for those contents. The applicant replaced standard 17x17 fuel assembly rods in the peripheral row of the assembly with either four (the actual number intended to be replaced in the LTA design) or all chromium-doped UO_2 rods. The applicant maintained all other modeling parameters (internal and external moderation, packaging changes due to hypothetical accident conditions, etc.) the same as was previously determined by the applicant to result in the highest package reactivity.

The applicant's results are summarized in Table 5 of the letter authorization request dated September 4, 2018. Modeling the Model No. Traveller package with four peripheral chromium-doped UO_2 rods or all peripheral chromium-doped UO_2 rods results in changes to system k_{eff} within the statistical uncertainty of the calculation. This indicates that there is essentially no change in system reactivity with the addition of small amounts of Cr_2O_3 and Al_2O_3.

The applicant's results demonstrate that the Model No. Traveller package will remain subcritical under both normal conditions of transport and hypothetical accident conditions, when peripheral standard 17x17 PWR fuel assembly rods are replaced with any number of chromium-doped UO_2 rods.

The applicant used the same code and cross section library that was used to demonstrate subcriticality for the previously approved 17x17 PWR contents: SCALE 6.1.2 with the KENO VI three-dimensional Monte Carlo code and the ENDF/B-VII.0 continuous energy cross section library. The applicant did not revise the benchmarking analysis to include experiments with chromium-doped UO_2 material or provide an evaluation demonstrating that the new fuel material is within the range of applicability of the previously approved benchmarking analysis. The staff believes that the applicant's criticality results are appropriate, however, for the following reasons:

1) the results are consistent with the expected behavior of the system with the proposed changes (i.e., the addition of small amounts of materials with relatively low absorption cross sections should not significantly affect system reactivity); and

2) the new fuel material is located on the periphery of the fuel assembly, where it is less likely to contribute significantly to the code bias and bias uncertainty for the system.

Based on the discussion above, the staff found the applicant's proposed changes to the CoC, with respect to transporting 17x17 PWR fuel assemblies with chromium-doped UO_2 rods located on the periphery of the assembly, would not affect the ability of the Model No. Traveller package to meet the criticality safety requirements of 10 CFR Part 71.

CONDITIONS

The staff finds that the requested ATF shipment in the Model No. Traveller package is in compliance with 10 CFR Part 71 provided the following conditions are met:

(1) The two LTAs are of a standard 17x17 optimized fuel assembly (OFA) design, meeting specifications of the PWR Group 1 Fuel Assembly, specifically 17 Bin 1, as outlined in Condition No. 5.(b)(1) of the CoC, Revision 10, with the following deviations:

  (a) The fuel assembly cladding on any rod in a periphery location of the fuel assembly may include a Chromium coating up to 30 μm thick.

  (b) One fuel assembly type may have the UO_2 pellets in any fuel rod on the periphery of the fuel assembly replaced with solid Zircaloy bars and encapsulated U_3Si_2 pellets meeting the following specifications:

    (i) Maximum density – 12.2 g/cm^3
    (ii) Maximum enrichment – 5 wt% U^{235}
    (iii) Minimum pellet diameter, as defined in the proprietary application dated September 4, 2018.

(2) One fuel assembly type may have the UO_2 pellets in any fuel rod on the periphery of the fuel assembly include a Cr_2O_3 concentration up to 700 ppm and an Al_2O_3 concentration up to 200 ppm.

(3) Items (1) and (2) above may not be combined in a single fuel assembly.

(4) If not accepted for loading at the reactor site, this authorization covers the return of the fresh fuel assemblies.

(5) This authorization shall expire on August 1, 2019.

CONCLUSION

Based on the statements and representations in the application dated September 4, 2018, as supplemented November 19, 2018, the staff agrees that the use by Westinghouse Electric Company of the Model No. Traveller package for this ATF shipment meets the requirements of 10 CFR Part 71, subject to the conditions listed above.

Issued on December 20, 2018.