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

June 28, 2017

Ms. Tanya Sloma
Licensing, Compliance and Package Technology
Nuclear Fuel Transport
Westinghouse Electric Company, LLC
5801 Bluff Road
Hopkins, SC 29061

SUBJECT: REVISION NO. 10 OF CERTIFICATE OF COMPLIANCE NO. 9297 FOR THE MODEL NOS. TRAVELLER STD, TRAVELLER XL, AND TRAVELLER VVER PACKAGES

Dear Ms. Sloma:

As requested by your application dated February 10, 2016, as supplemented March 20 and May 17, 2017, enclosed is Certificate of Compliance No. 9297, Revision No. 10, for the Model Nos. Traveller STD, Traveller XL, and Traveller VVER packages. Changes made to the certificate are indicated by vertical lines in the margin. The staff's safety evaluation report is enclosed.

The approval constitutes authority to use the package for shipment of unirradiated fissile material and for the package to be shipped in accordance with the provisions of 49 CFR 173.471. Those on the attached list have been registered as users of the package under the general license provisions of 10 CFR 71.17 or 49 CFR 173.471.

If you have any questions regarding this certificate, please contact me or 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
CAC Nos. L25190

Enclosures:
1. Certificate of Compliance No. 9297, Rev. No. 10
2. Safety Evaluation Report
3. Registered Users

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cc w/encls 1 & 2: R. Boyle, Department of Transportation
J. Shuler, Department of Energy, c/o L. F. Gelder
Registered Users

SUBJECT: REVISION NO. 10 OF CERTIFICATE OF COMPLIANCE NO. 9297 FOR THE MODEL NOS. TRAVELLER STD, TRAVELLER XL, AND TRAVELLER VVER PACKAGES, DOCUMENT DATE: JUNE 28, 2017

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UNITED STATES
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SAFETY EVALUATION REPORT
Docket No. 71-9297
Model Nos. Traveller STD, Traveller XL and Traveller VVER
Certificate of Compliance No. 9297
Revision No. 10

SUMMARY

By application dated February 10, 2017, as supplemented March 20 and May 17, 2017, Westinghouse Electric Company, LLC (Westinghouse or the applicant) requested an amendment to Certificate of Compliance (CoC) No. 9297 for the Model Nos. Traveller STD and Traveller XL packages.

Westinghouse completely revised the criticality analysis, with bounding parameters defined now by Categorized Fuel Assemblies (CFA), established a new method for subcriticality, which now includes the evaluation of uncertainties as independent sensitivities and the accumulation of penalties, and updated the code version to SCALE 6.1.2 and the SCALE model of the Traveller packaging.

This amendment request also includes the addition of uranium silicide (U_3Si_2) fuel rods, as a separate content configuration, to be shipped in the Rod Pipe.

As requested by the applicant, this application was reviewed using NUREG-1886, "Joint Canada - United States Guide for Approval of Type B(U) and Fissile Material Transportation Packages."

1.0 General Information

The application has been updated to include a description of the new criticality safety analysis method. Chapter 1 has been updated to discuss that PWR fuel assemblies are organized with similar fuel assemblies into defined bins.

Three Groups define the allowable fuel assembly contents, with each Group containing like bins. The bounding parameters of the fuel assembly contents in a bin are represented by CFAs and each CFA represents the bounding parameters analyzed in the criticality safety analysis for the criticality analyses. All CFAs among the three groups are evaluated and organized by Criticality Safety Indices (CSIs) and Model No. Traveller packaging variants.

The U_3Si_2 fuel rods, a new content to be shipped in the Rod Pipe, are similar to UO_2 fuel rods in several ways, including the same maximum U-235 enrichment of 5 wt%.

The packaging design has not been modified by this amendment request. All changes made in the application either address previous staff's concerns or support the addition of the new criticality methodology.

The application also adjusted package weights and dimensions due to incorrect conversion factors.

2.0 Structural and Materials Evaluations

According to the applicant, the changes that were made to the application consisted of amplifying information that did not modify the licensing basis of the package. The staff reviewed the added information and concludes that no changes were made with respect to the structural design of the package that affects the structural performance or the licensing basis of the package.

The applicant provided additional information on the performance of several zirconium alloys and identified a standard zirconium alloy with bounding materials performance. The applicant used the bounding mechanical properties to determine the zirconium alloy performance during drop testing. The staff reviewed the information provided on the zirconium alloy mechanical properties and compared the information to mechanical properties published for multiple zirconium cladding materials. The staff determined that the mechanical properties identified by the applicant are conservative and appropriate to bound zirconium alloy performance during drop testing. The applicant revised Section 3.2.1 of the application and the corresponding tables to incorporate additional material property references. No changes were made to the materials or materials properties included in these tables. The staff reviewed the references added to the tables and determined the added references were adequate to support the materials properties of interest.

Based on a review of the statements and representations in the application, the staff concludes that the structural design has been adequately described and evaluated and that the package has adequate structural integrity to continue to meet the requirements of 10 CFR Part 71.

3.0 Thermal Evaluation

The applicant added a statement regarding “the initial ambient temperature of 38^{o}C” and updated the application to address the update of IAEA regulations from TS-R-1 (1996 edition) to SSR-6 (2012 edition), as incorporated by 49 CFR 171.7 and as specified in NUREG-1886. The staff determined that these revisions do not affect the package design and its thermal evaluations and, therefore, the package maintains compliance to thermal requirements of 10 CFR Part 71 and in accordance with NUREG-1886.

The applicant revised Section 3.2.1 and Tables 3-2 and 3-3A of the application to incorporate additional material property references in Notes #3, #4, #5, #6, and #7 in Table 3-2 and Notes #1, #2, and #3 in Table 3-3A. The staff finds that those revisions provide more information on the material properties of the package and have no impact to thermal performance and evaluation of the package.

The applicant included additional details of the condition of the moderator block after fire testing in Section 3.6.5.1, as a justification to support the criticality evaluations defined in Section 6.3.4.3.3 of the application. The applicant compared the weights of the moderator before and after the fire test, as shown in Table 3-6A, and stated that there was no significant loss within the accuracy of the measurements for all blocks; therefore, all blocks retained sufficient hydrogen content. The applicant stated that a visual examination of the shock mounts also indicated that all moderator blocks were all intact.

The staff reviewed Table 3-6A showing moderator block weights before and after the fire test and finds that the maximum weight differences for each block and the total blocks are 0.74% and 0.06%, respectively. The staff determined that the fire test has no significant impact on the moderator block weights, as a justification to support the criticality evaluations.

Based on the statements and representations contained in the application, the staff concludes that the thermal design has been adequately described and evaluated, and the Model Nos. Traveller STD, Traveller XL, and Traveller VVER packages meet the requirements of 10 CFR Part 71 and the guidance on format and content in NUREG-1886 for joint approval in the U.S. and Canada.

6.0 Criticality Evaluation

The applicant requested an amendment to the Certificate of Compliance to (1) completely revise the criticality analysis and (2) add uranium silicide (U_3Si_2) fuel rods in the Rod Pipe as authorized content. The new criticality safety analyses (1) grouped the contents by Categorized Fuel Assemblies (CFA), (2) established a new method for subcriticality, and (3) updated the code version to SCALE 6.1.2 for criticality safety analyses.

6.1 Review Objective

The objective of this review is to determine if the package with the new contents continues to comply with the criticality safety requirements of 10 CFR 71 and SSR-6. The staff conducts its review per the guidance under NUREG-1886, "Joint Canada-United States Guide for Approval of Type B(U) and Fissile Material Transportation Packages." The staff's review consists of a contents evaluation as the applicant has not made any changes to the packaging system design.

6.2 Description of Criticality Design

6.2.1 Design Features

The Traveller packaging system consists of an outerpack and a clamshell. This system includes BORAL® neutron absorber plates located in each axial side of the Clamshell that act in conjunction with ultra-high molecular weight (UHMW) polyethylene moderator blocks, which are affixed to the walls of the Outerpack inner cavity.

The BORAL plates have a minimum ^{10}B areal density of 0.024 g/cm^2. Loose rod contents must be encased in a stainless steel pipe. The package design also inlcudes a unique flux trap system that does not require water in order to function. The applicant made no changes in the package design in this amendment.

The applicant changed its criticality safety analysis method for the package. The components credited by the applicant are discussed in Section 6.4 of this SER.

6.2.2 Summary Table of Criticality Evaluations

The applicant provided a summary of the criticality safety evaluation in Table 6-2 of the application. The data in Table 6-2 shows that, for a single package, the package attains the maximum reactivity for 17 Bin 1 configuration under hypothetical accident conditions.

The maximum keff is 0.93484 as shown in Table 6-26. The staff noted that the maximum keff value, as shown in Table 6-2 for the package, is incorrect.

6.2.3 Criticality Safety Index (CSI)

The applicant determined the CSI in accordance with 10 CFR 71.59(b). The staff confirmed that the CSI is consistent with that reported in Section 1, “General Information,” of the application. The applicant specified the value of N for each contents type and presented the CSI in Table 6-3 of the application.

6.3 Fissile Material Contents

The model Traveller is designed to hold a single PWR or VVER fuel assembly or single rod pipe that holds PWR and/or BWR fuel rods. The applicant has not made any changes to actual physical contents requirements for UO_2 fissile material, but has reclassified the contents into non-proprietary categories.

The applicant organized fuel assemblies into three groups, within which the applicant further classified similar fuel assemblies into bins. The applicant’s bins are based on three criteria: array size; number and location of non-fuel lattice locations; and as-designed nominal rod pitch. The applicant presented a summary of its binning and grouping in Table 6-4 of the application. The applicant used a CFA to represent the bounding criticality parameters of any single bin. Since there is no change to the fissile UO_2 contents, staff only reviewed the classification change, which is discussed in Section 6.4.4 of this SER.

The applicant has added U_3Si_2 as an authorized fuel material only in the case where loose fuel rods are packed into a rod pipe. The maximum mass of a loaded rod pipe remains unchanged from the previous amendment. The applicant has shown the U_3Si_2 fuel is less reactive than UO_2. Staff finds this content acceptable as the applicant has shown the Rod Pipe system with either fuel material to remain subcritical.

6.4 General Considerations

6.4.1 Model Configuration

The applicant simplified the model from previous amendments. The applicant modeled the various binned assemblies as an array of fuel rods and un-occupied lattice locations (i.e., ignored guide and instrument tubes). The applicant omitted fuel assembly structural materials in the analysis. These omissions conservatively maximize moderator and eliminate neutron absorptions from the assembly structural components in the model; thus, staff finds the applicant’s simplification of the package acceptable.

The applicant simplified the outerpack model from previous amendments and assumed the outerpack consists of a simple, SS-304 shell without any other features. Staff finds this acceptable as it conservatively minimizes the distance between packages in an array.

The applicant also simplified the components modeled within the outerpack cavity. The applicant modeled the UHMW polyethylene moderator blocks and the features of the clamshell important to safety. The applicant shortened the UHMW blocks to the same length as the BORAL absorber plates in the clamshell. Staff finds this acceptable as it limits the length of the flux trap.

The applicant’s clamshell model consists of the aluminum shell with grooves that contain the Boral absorber material. The applicant omitted the rubber shock mounts from the model. Staff finds this omission acceptably conservative since the shock mounts are made of rubber and have a lower hydrogen density than water. The applicant did maintain the cutouts in the absorber plates through which the shock mounts penetrate the plate. Staff finds this acceptable as it does not assume an increase in absorber material and conservatively increases neutron cross-talk between packages. Staff finds the applicant's models acceptable as they appropriately account for the features important to safety or omit features when doing so is conservative.

For the rod pipe, the applicant determined the peak water-to-fuel ratio and always modeled the rod pipe as flooded. The applicant also modeled more rods than can physically fit into the rod pipe due to packing materials necessary to protect the fuel rods during transport. Staff finds this acceptable since the applicant's model maximizes the reactivity of the contents.

6.4.2 Material Properties

The applicant presented the material assumptions in Section 6.3.2 of the application. Compared to the previously reviewed amendment, the applicant either didn't change or made inconsequential changes to the compositions of UO_2, Zircaloy cladding, water, 304 Stainless steel, and polyethylene.

The applicant made no changes to the BORAL ^{10}B areal density from the previous amendment, which followed the recommendations in NUREG/CR-5661, "Recommendations for Preparing the Criticality Safety Evaluation of Transportation Packages."

The applicant used the isotopic abundances of naturally occurring elements from the SCALE Standard Composition Library. Uranium silicide is a new material in this amendment. The maximum enrichment is the same as for UO_2, and staff finds the applicant's treatment of U_3Si_2 in the criticality analysis appropriate.

6.4.3 Computer Codes and Cross-Section Libraries

The applicant used the KENO-VI (CSAS6) sequence of the SCALE 6.1.2 code package to analyze system reactivity. KENO-VI is a three-dimensional Monte Carlo method software used to calculate neutron multiplication factor, k_{eff}, of systems. The applicant used the materials in the SCALE Standard Composition Library with the ENDF/B-VII continuous energy cross-section library. Both the software and cross-section data have long been used for thermal systems containing fissile uranium. For this reason, the staff finds the applicant's selection of computer code and cross-section libraries acceptable.

The applicant's determined convergence by examining the "average k-effective by generation" plot, the "average k-effective by generation skipped" plot, and the "frequency for generations" plot. These three plots are created in the KENO-VI output file and provide a visual indication of the statistical behavior of the calculation. Since convergence issues can be quickly observed with these plots, staff finds the applicant's method acceptable.

6.4.4 Demonstration of Maximum Reactivity

The applicant conducted three studies to determine the most reactive configuration. First, the applicant found the most reactive configuration for each bin. The applicant's next two analyses modeled the CFAs with the packaging to demonstrate compliance for arrays and single packages. The applicant's second analysis determined the bounding CFA-package variant combinations for each group for both NCT and HAC. The applicant performed a third analysis which evaluated sensitivity studies of selected parameters independently.

6.4.4.1 CFA Determination

To determine the bounding CFA of each bin, the applicant evaluated a combination of three secondary parameters, fuel pellet diameter, fuel-clad gap, and cladding thickness. The applicant determined the range of the secondary parameters from the design variation and respective tolerances of the assembly designs that were categorized into that bin. For example, if there is only one fuel pellet diameter, then the range is simply spans the tolerance of the nominal value. If there are more than one, then the range spans the smallest value minus its tolerance, to the largest value plus its respective tolerance. The applicant added two equally spaced intervals into the parameter range if more than one assembly design was categorized into that bin. The applicant evaluated every combination of these parameters to ensure the fuel assembly permutations span each of the secondary parameter range.

The applicant found that the minimum values of the secondary parameters were most reactive since fuel assemblies are designed to be under-moderated. The characteristics for each of the CFAs are summarized in Tables 6-97 through 6-99 of the application. Staff reviewed the applicant's information and finds there is adequate range to cover the variations for each CFA.

6.4.4.2 Baseline Case Determination

For the fuel assembly groups, the applicant then determined a baseline for each NCT and HAC cases for each content and package variant combination. Each baseline case is a bounding combination of the content and package variant for each transport condition. The applicant used the baseline configuration on the effects of modeling a CFA or rod pipe in the packaging, axial positioning of the content within the clamshell, and flooding configurations as applicable to each condition of transport.

The applicant compared each CFA package variant to determine a baseline case. The applicant assumed the following: an increase in active fuel length of one fabrication tolerance; no lattice pitch expansion for NCT and lattice pitch expansion for 20 in. from the end for HAC (See Section 2.12.5.3 of the SAR); nominal fuel assembly rests on the bottom of the clamshell; all regions flooded for a single package; all floodable regions are assumed dry under NCT; the fuel-clad gap, fuel assembly envelope, and clamshell inner cavity modeled as flooded with all other floodable regions modeled as dry under HAC; close, full water reflection surrounding the single package and package arrays. Considering this is a step towards determining a baseline which will then be further evaluated, staff finds the applicant's modeling assumptions reasonable and acceptable.

Within Group 1, there are two bins where the maximum active fuel length can only fit in the Traveller XL. These are 16 Bin 2 and 17 Bin 1. For the CFA-package variant comparison, the applicant broke the bins up into two separate CFAs. For the Groups 1 and 2 single package evaluations under NCT, the applicant chose 16 Bin 1 and 18 Bin 1 in the Traveller XL as the most reactive variants for evaluation in the baseline case determination. For Groups 1 and 2 single package HAC, the applicant selected the 17 Bin 1, 17 Bin 1a (the longer fuel assembly), and 17 Bin 2 in the Traveller XL as the most reactive CFA-package variants for evaluation in the baseline case determination. Since there is only one fuel design in Group 3, there is only one possible CFA-package variant combination.

The applicant evaluated the most reactive CFA-package variants at different axial offsets to determine the baseline case. The applicant determined that there is not a significant trend in axial positioning of the fuel on system keff for the CFAs evaluated under both NCT and HAC. The applicant selected the baseline case under NCT for Groups 1 and 2 based on the 18 Bin 1 being the more reactive of the two CFAs evaluated. The applicant chose the 17 Bin 1 in the Traveller XL as the baseline case for Groups 1 and 2 under HAC despite it being a shorter fuel variant. The applicant was not able to definitively determine a most-reactive assembly as the ranges of the three CFAs evaluated overlap at different axial positions, as shown in Table 6-116 of the SAR. For Group 3, the applicant selected the only bin, VV Bin 1 as the baseline case. All the baseline cases chosen by the applicant are with the fuel assembly relatively centered axially in the clamshell. Staff reviewed the applicant's results for this evaluation and finds the choice of fuel assembly baseline cases acceptable.

For the rod pipe, the applicant evaluated both UO_2 and U_3Si_2 rods. The applicant selected a range of fuel outer radii to cover the variation in H/U ratio, which is presented in Tables 6-16 and 6-17 of the SAR. The applicant varied the pitch from close packed, which corresponds to the NCT case, to an optimally moderated case. In expanding the loose rod pitch, the applicant modeled fewer than the maximum number of fuel rods, which considers partial loadings and ensures peak H/U ratio has been achieved. For this reason, staff finds the applicant adequately evaluated the range of loading and pitch to determine the maximum reactivity of a rod pipe.

6.4.4.3 Sensitivity Studies

The applicant conducted sensitivity studies on other parameters, such as packing materials and positioning within the package. These studies are discussed in Section 6.3.4.3 of the application with the applicability summarized in Table 6-18 of the application. If the applicant discovered an increase in reactivity when compared to the baseline case, then the applicant tallied the positive difference in $k_{eff} + 2\sigma$ and summed for all parameters with a positive impact on k_{eff}. The applicant did not take any credit for sensitivity studies that yielded a negative change in reactivity. Staff finds this approach acceptable as it conservatively ignores negative effects on neutron multiplication and accounts for conditions that may increase reactivity.

The applicant evaluated the effect of the following on system reactivity: annular fuel pellet blanket; clamshell, assembly or rod pipe shift; moderator block density; package outer diameter; the presence of polyethylene packing materials; PWR fuel assembly axial rod displacement; PWR assemblies with stainless steel replacement rods; the presence of a steel nozzle; extended active fuel length; and rod pipe flooding under HAC. The applicant also evaluated variations in clad and fuel pellet diameter, and fuel rod pitch within the manufacturing tolerances. Staff reviewed the applicant's sensitivity studies and finds the parameters the applicant considered acceptable as it covers a range of variable package configurations and conditions that can reasonably be expected.

6.4.5 Confirmatory Analyses

Staff modeled each of the fuel arrays in the groups and verified the bin maximum reactivity within group 1. Staff results could not definitively discern a significant difference in reactivity between the two bins within group 2. Group 3 only has 1 bin. Staff modeled both UO_2 and U_3Si_2 and found uranium oxide to be more reactive of the two materials given the differences in pin diameter.

Staff perturbed the applicant's primary group and bin limits in both directions and found the limits to appropriately represent a bounding permitted value (i.e., reactivity decreases as the parameter is varied within allowed range). For this reason, staff finds the three primary parameters with the limits the applicant selected for its CFA in each bin acceptable.
Staff conducted its own analysis of arrays of fuel pins inside a rod pipe.

The staff model consisted of hexagonal arrays of bare UO_2 and U_3Si_2 pins in a flooded and reflected single package and an array of packages under HAC. Staff found that maximum reactivity occurs with a fissile mass that represents a partially loaded rod pipe with the fuel in a regularly spaced lattice. Staff did not conduct evaluation on enough different lattice pitches to determine the exact pitch of maximum reactivity, but the staff values did fall in the same range as the maximally reactive pitch determined by the applicant. The values of k_{eff} that the staff found around this most reactive condition did not differ significantly enough to suggest further study was needed. Staff finds sufficient assurance that a rod pipe filled with loose fuel rods will remain subcritical under any conceivable condition.

Staff modeled assemblies with expanded pitch. Staff's results confirmed reactivity increases with pitch as far as expansion is possible within the clamshell cavity. Staff evaluated the preferential flooding scenarios presented by the applicant. Staff results confirmed that the most reactive array condition is when the clamshell cavity and all interior fuel assembly space is flooded and empty space external to the clamshell is modeled as void.

Staff reviewed the applicant's sensitivity studies for NCT and HAC. The dominant contributing factors to an increase k_{eff} are also primary attributes that define each CFA. The limiting configuration for the overlapping attributes is consistent with the results of the staff's initial bounding bin analysis and was not repeated.

Staff did evaluate rod displacement. Staff modeled an array with rods axially shifted by lengthening the array so each unit cell extended beyond the normal fuel length as a water-filled cuboid above the fuel cylinder. A separate unit cell was created with the fuel rod shifted to the desired axial position and then substituted into the array at selected locations. Staff evaluated the effect of the applicant's "corner" scenario and confirmed a reduction in reactivity for Groups 1 and 2. Staff opted not to evaluate a rod displacement scenario for VVER fuel.

Staff conducted an evaluation on the presence of polyethylene packing materials, since hydrogenous packing material has a comparatively large moderating effect. Staff modeled the assembly wrap, fuel pin wrap, and collected melt configurations chosen by the applicant under HAC and NCT. The assembly wrap model consisted of a cuboid external to the outermost rows and columns.

The staff modeled the fuel pin wrap as an additional cylinder external to the fuel clad. The staff modeled the collected melt by starting with the axial rod displacement model and replacing water with polyethylene around the fuel pins to a height that corresponded to a fixed mass of polyethylene. Since the staff only conducted a comparative evaluation, staff did not vary the pitch axially and used maximum pitch throughout the length of the assembly.

The staff unflooded NCT model showed a large subcritical margin, even with a mass of polyethylene that exceeded the loading limit. Under HAC, staff's results showed that polyethylene external to the assembly would eventually reduce the amount of interaction between adjacent packages. The staff's results for uniform fuel pin wrap and collected melt within the expanded pitch zone confirmed an increase in reactivity.

Staff repeated the fuel pin wrap and collected melt evaluations for an array of rod pipe packages under HAC. Staff results confirmed the applicant's determination that reactivity increases with an increased amount of polyethylene packing material, and that the most reactive configuration is a partially loaded rod pipe with the space external to the fuel clad modeled as polyethylene in an expanded, regular lattice. The staff's results also confirmed that the most reactive rod-pipe configuration would remain subcritical.

Staff did not confirm the applicant's determination of the baseline case, since the baseline case was subject to further perturbation to ultimately determine maximum reactivity.

Based on the level of agreement between the staff's and applicant's trends and actual k_{eff} values determined from respective evaluations, staff finds reasonable assurance that the results of the applicant's analyses are accurate.

6.5 Single Package Evaluation

6.5.1 Configuration

Per the recommendation of NUREG-1886, the applicant modeled all void areas are flooded, and the package is reflected with 20 cm of full-density water. The applicant first determined the most reactive single package configuration and considered this to be a baseline case. This baseline configuration is used, by the applicant, to represent a bounding model that is carried through the sensitivity studies to demonstrate maximum reactivity.

The applicant summarized the baseline and bounding configurations in Tables 6-22 and 6-25 of the application. Staff finds this approach acceptable since it covers the range of conceivable fuel variations, such as a shift within the package or those due to manufacturing tolerances, to demonstrate a bounding configuration.

6.5.2 Results

The applicant presented maximum reactivity results in Table 6-26 of the application and the results of the sensitivity studies in Tables 6-27 through 6-50 of the application. Staff finds sufficient evidence that the applicant acceptably determined a bounding, most reactive configuration and that a single, flooded package will remain subcritical under NCT.

6.6 Evaluation of Package Arrays under NCT

6.6.1 Configuration

The applicant modeled all inner spaces of the package as void and reflected the package array with 20 cm of full-density water. The applicant repeated the baseline evaluations and sensitivity studies done with the single package evaluation. The baseline and bounding configurations, along with the array size, N, are summarized in Tables 6-51 through 6-54 of the application.

6.6.2 Results

The applicant presented maximum reactivity results in Table 6-55 and the results of the sensitivity studies in Tables 6-56 through 6-70 of the application. Staff finds sufficient evidence that the applicant acceptably determined a bounding, most reactive configuration and that a water-reflected array of voided packages will remain subcritical under NCT.

6.7 Evaluation of Package Arrays under HAC

6.7.1 Configuration

The applicant modeled all inner spaces of the package as flooded with full-density water and reflected by 20 cm of full-density water, per the recommendation of NUREG-1609. The applicant modeled fuel structural materials and packaging components as void.

Staff finds this modeling assumption acceptable since it increases neutron interaction between packages in an array. The baseline and bounding configurations, along with array size, N, are summarized in Tables 6-71 through 6-74 of the application.

6.7.2 Results

The applicant presented maximum reactivity results in Table 6-55 and the results of the sensitivity studies in Tables 6-76 through 6-94 of the application. Staff finds sufficient evidence that the applicant acceptably determined a bounding, most reactive configuration and that an array of flooded packages, reflected by water, will remain subcritical under HAC.

6.8 Benchmark Evaluations

6.8.1 Applicability of Benchmark Experiments

Applicability of benchmark experiments is based on three fundamental parameters. These are materials, geometry, and neutron energy spectrum. The applicant used these criteria outlined in NUREG/CR-6361, “Guide for Validation of Nuclear Criticality Safety Calculational Methodology,” to select benchmark experiments that are as similar as possible to the Traveller.

Both the UO2 and U3Si2 pellets are low-enriched uranium fuel, either bare or clad with zirconium, surrounded by aluminum structure, BORAL absorber, and stainless steel plates. The most reactive cases are moderated, thus having a thermal neutron spectrum.

The applicant selected a group of benchmarks from the International Handbook of Evaluated Criticality Safety Benchmark Experiments Handbook. The selected cases are low enriched uranium in arrays of solid rods with a thermal spectrum. Staff finds the applicants benchmark experiments acceptable since it meets the material and neutron spectrum criteria in NUREG/CR-6361.

6.8.2 Bias Determination

The applicant evaluated four parameters for trending and determined a correlation coefficient for each. These trending parameters are Energy of the Average Lethargy causing Fission (EALF), Fuel Enrichment, WtF Volume ratio, H/U ratio.

The applicant selected the trending parameter with the largest correlation, EALF in this case, and used it to generate the USL with USLSTATS code. Staff finds the applicants approach acceptable since this method has been well-tested and is generally accepted.

The applicant provided a summary table of criticality evaluation for the three contents groups and rod pipes in Section 6.1.2.1 of the SAR. The summary table of Upper Subcritical Limits (USL) is reproduced below for reference.

Summary Table of Upper Subcritical Limits			
Contents	**Limiting EALF (eV)**	**Bias and Uncertainty (β - $\Delta\beta$)**	**USL (1 - Δk_m + β - $\Delta\beta$)**
Groups 1 and 2 (single)	0.294665	-0.01098	0.93902
Group 1 (array)	0.195762	-0.00907	0.94093
Group 2 (array)	0.270923	-0.01052	0.93948
Group 3 (Single and array)	0.335131	-0.01176	0.93824
Rod Pipe UO_2 Fuel Rods (Single and Array)	0.254252	-0.01020	0.93980
Rod Pipe U_3Si_2 Fuel Rods (Single and Array)	0.310042	-0.01127	0.93873

6.9 Evaluation Findings

Based on the information provided by the applicant and verified by the staff's own confirmatory analyses, the staff concludes that the package model Traveller meets the criticality requirements of 10 CFR Part 71, and the applicable design and acceptance criteria have been satisfied.

The evaluation of the criticality safety design provides reasonable assurance that the Traveller system will remain subcritical under Normal Conditions of Transport and Hypothetical Accident Conditions as prescribed in 10 CFR 71.71 and 71.73.

7.0 Operating Procedures

Chapter includes now additional details to represent the current usage of the packages and the activities that are applicable to all sites that use the packages.

The operating procedures have been updated to include a discussion on the definitions of unirradiated content and a provision which describes the Type A quantity of U-238 to be shipped in the package. The procedures in general contain only editorial changes to clarify already approved procedures

8.0 Acceptance Tests and Maintenance Program

The maintenance and acceptance procedures have been updated to include the use of an additional Lord Sandwhich Shock Mount Part Number. The applicant indicated the nominal thermal characteristics for the 6 pcf, 10 pcf and 20 pcf nominal density polyurethane pours, with a minimum of three specimens per qualification.

The thermal test is not required for acceptance of the Traveller package, and is also not necessary for assurance of continued performance per NCT and HAC thermal analyses.

CONDITIONS

The following changes have been made to the certificate:

Condition No. 3(b), “Title and Identification of Report or Application,” has been updated to reference the latest consolidated application.

Condition No. 5.(a)(2): Package weights and dimensions were adjusted due to corrections in the conversion factors.

Condition No. 5(b), “Contents (Type and Form of Material),” has been completely updated per the new criticality safety methodology. It includes descriptions of “PWR Group 1 Fuel Assembly,” “PWR Group 2 Fuel Assembly,” “PWR Group 3 Fuel Assembly (VVER),” “Loose Uranium Dioxide Fuel Rods,” and “Loose Uranium Silicide Fuel Rods.” The full contents specifications can be found in chapter 6 of the application. The polyethylene packing material limits have been also reduced for fuel assembly contents.

Condition No. 5(c), “Criticality Safety Index,” has been updated to include the criticality safety index (CSI) of 0.7 for the loose uranium silicide fuel rods content. CSIs have been increased for all contents types.

Condition No. 9 has been updated to authorize use of Revision Nos. 7, 8, and 9 of the Certificate of Compliance until June 30, 2018. Revision No. 7 is the basis for DOT CAC Rev. 5, the Competent Authority approval for the majority of international validations. Revision Nos. 8 and 9 are the basis for DOT CAC Rev. 7, the Competent Authority approval for required international validations of the Traveller VVER design. Those extended expiration dates allow the applicant to align all international validations to a new single certificate, and are providing Competent Authorities one year for review and approval for new validations.

The references section has been updated to include this amendment request.

CONCLUSION

Based on the statements and representations contained in the application and the conditions listed above, the staff concludes that the design has been adequately described and evaluated, and the Model Nos. Traveller STD, Traveller XL, and Traveller VVER packages meet the requirements of 10 CFR Part 71 and the guidance on format and content in NUREG-1886 for joint approval in the U.S. and Canada.

Issued with Certificate of Compliance No. 9297, Revision No. 10 on June 28, 2017.

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