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

SAFETY EVALUATION REPORT
Docket No. 71-9372
Model No. TN-B1 Package
Authorization for Limited Shipments

BACKGROUND

On June 15, 2020, Framatome (the applicant) submitted a request for authorization to ship Framatome Boiling Water Reactor (BWR) ATRIUM 10XM (FANP 10X10) fresh fuel assemblies, equipped with inert test rods, to support the development of Enhanced Accident Tolerant Fuels (eATF).

The FANP 10x10 fuel assembly (FA) is a 10x10 array of fuel rods with up to 12 partial length fuel rods (PLFR) and a water channel in the center. The ATRIUM 10XM LTR FAs will have up to two test rods located on the periphery of the assembly, in locations B10 and L2.

The Model No. TN-B1 packaging design is not changed, from its current approval, and up to two modified FAs can be shipped in the Model No. TN-B1 package. Framatome is planning for one shipment of four modified FAs.

EVALUATION

The applicant requested an amendment to the Model No. TN-B1 package to transport fresh accident tolerant fuel (ATF) lead test assemblies (LTAs). These ATF LTAs consist of modified FANP 10x10 BWR fuel assemblies (FA), currently approved in the Certificate of Compliance (CoC) as described in Table 3 of the certificate. The requested modification to these assemblies consists of replacing two full-length fuel rods on the periphery of the assembly with inert (i.e., containing no fissile material) test rods. Test rods consist of several inert rod segments connected via threaded joints, with each segment containing one of several different test configurations, including: Zircaloy 2 cladding with chromium/titanium coatings and containing Zircaloy 2 slugs, and perforated cladding containing silicon carbide test articles. The locations of the test rods within the 10x10 fuel assembly lattice are shown in Figure 2 of Attachment 1 to the Framatome letter dated June 15, 2020.

The overall diameter and length of a test rod is the same as for a standard fuel rod. The maximum weight of a test rod is 4.1 lb. while the maximum weight of a standard fuel rod is 6.4 lb. Such a difference is negligible compared to the weight of a standard FA, and their structural behavior is not of any concern; thus, the structural evaluation of the Model No. TN-B1 is still applicable.

Because there are only up to two test rods in each ATRIUM 10XM LTR FA, their effect on the thermal behavior of the FA or on the TN-B1 package is negligible: thus, the thermal evaluation of the TN-B1 package is unchanged.

The test rods do not contain fissile material, and have no containment function: thus, there is no change to the containment evaluation of the TN-B1 package.

The shielding evaluation of the package is still applicable since the test rods do not contain any radioactive material: thus, there is no effect on the shielding effectiveness of the FA or of the packaging.

The applicant evaluated the criticality safety of the ATF LTAs in Orano Federal Services Calculation CALC-3023422, Rev. 0, “TN-B1 Letter Authorization Criticality Analysis.” The applicant modified the most reactive hypothetical accident conditions (HAC) array analysis for the FANP 10x10 fuel assembly to include several representative test rod configurations. The modified configuration was for fuel enriched up to 5.0 weight percent U^{235} with 12 gadolinium oxide (Gd_2O_3) rods required. The applicant did not model the normal conditions of transport (NCT) single package or array of packages, or the HAC single package. The HAC array evaluation for the previously approved fuel contents bounded the other configurations, and the current evaluation to evaluate the difference in k_{eff} due to the addition of test rod configurations will still bound the NCT single package, NCT array, and HAC single package configurations. The staff agrees that changes in system k_{eff} for the HAC array bound the changes for the NCT array, the NCT single package, and the HAC single package, as this configuration was the most reactive, and should therefore be the most sensitive to replacement of the fuel rods with test rods.

The only change from the previously approved most reactive configuration, except for the addition of the test rods, was that the applicant modeled the actual partial length rod configuration for the LTAs (as shown in Figure 2 of Attachment 1 to the Framatome letter dated June 15, 2020), and the applicant moved one Gd_2O_3 rod slightly so that it would not coincide with a partial-length rod location. The staff agrees with the applicant’s conclusion that these are minor changes to the configuration of the FANP 10x10 fuel assembly, and that this revised configuration will be bounded by the previously evaluated most reactive configuration of this fuel assembly.

The applicant modeled the test rods as solid Zircaloy 2 or solid silicon carbide, and included additional configurations with the test rods removed and replaced with water or void, to simulate potential fuel reconfiguration. The staff agrees that the configurations modeled by the applicant are a conservative representation of the test rod configuration for intact and potentially reconfigured fuel rods under NCT and HAC, when the fuel assembly contents are limited to the configuration of test rods and partial-length rods shown in Figure 2 of Attachment 1 to the Framatome letter dated June 15, 2020.

The results of the applicant’s criticality evaluations of HAC arrays of the TN-B1 package with the various assumed test rod configurations are shown in Table 6-1 of CALC-3023422. These results show that modeling the test rods as solid Zircaloy 2 or solid silicon carbide, or modeling the test rod locations as water or void (in addition to the minor changes regarding partial-length rod and Gd_2O_3 rod locations discussed in the previous paragraph), all result in more than a 2% reduction in the calculated k_{eff}. These results demonstrate that the addition of test rods in the FANP 10x10 fuel assembly lattice, in the locations shown in Figure 2 of Attachment 1 to the Framatome letter dated June 15, 2020, will reduce system k_{eff}, and that the Criticality Safety Index (CSI) for the 10x10 fuel assembly contents described in Certificate of Compliance 71-9372 condition 5(b)(1) still applies for these LTAs in the TN-B1 package.

For the previously approved criticality evaluation of the TN-B1 package, the applicant used the CSAS25 sequence of the SCALE 4.4a code system, with the 44-group ENDF/B-V cross section library and the KENO V.a three-dimensional Monte Carlo code. For the analysis of the FANP 10x10 LTAs with ATF test rods, the applicant used the CSAS25 sequence of the SCALE 6.2.1 code system, with the 238-group ENDF/B-VII cross section library and the KENO V.a three-dimensional Monte Carlo code.

The applicant did not perform a separate benchmarking analysis of the SCALE 6.2.1 code and 238-group ENDF/B-VII cross section library for use with the TN-B1 package loaded with LTAs, to determine a separate code bias and bias uncertainty. The applicant stated that no new benchmarking analysis was needed, since the ATF test assembly has very similar neutronic properties to the licensed worst-case FANP 10x10 fuel assembly, and any biases or bias uncertainties are similarly reflected in the k_{eff} values for both cases. The applicant reran the most reactive HAC array analysis using the SCALE 6.2.1 code and 238-group ENDF/B-VII cross section library so that the comparison to the LTA configuration would use consistent code and cross section data.

The staff agrees with the applicant's conclusions regarding a separate benchmarking analysis for the SCALE 6.2.1 code and 238-group ENDF/B-VII cross section library for use with the TN-B1 package loaded with LTAs for the following reasons:

1) the code is only used to determine direction of changes in system reactivity, and is not used to evaluate the final most reactive system, which remains the same as in the previously evaluated SAR,

2) the results are consistent with the expected behavior of the system with the proposed changes; and

3) the staff's own confirmatory analyses with a different version of SCALE show similar results.

The staff performed a confirmatory analysis of the TN-B1 package with the proposed LTA fuel contents using the SCALE 6.2.3 Monte Carlo radiation transport code, with the CSAS6 criticality sequence and the ENDF/B-VII.1 continuous-energy neutron cross section library. Using modeling assumptions similar to the applicant's, the staff's independent evaluation resulted in k_{eff} values that were similar to, or bounded by, the applicant's results.

Based on the discussion above, the staff found the applicant's proposed package contents for this letter authorization request, consisting of FANP 10x10 BWR fuel assemblies with the configuration of test rods and partial length rods shown in Figure 2 of Attachment 1 to the Framatome letter dated June 15, 2020, would not affect the ability of the Model No. TN-B1 package to meet 10 CFR Part 71 requirements.

CONDITIONS

(1) This Authorization is for a maximum of 1 shipment of all 8 test rods (4 fuel assemblies) in one transport.

(2) The ATRIUM 10XM LTR FAs include up to two test rods located on the periphery of the assembly, in locations B10 and L2. FAs contain commercial grade uranium, meet Type A contents, and shall be shipped channeled.

(3) TN-B1 packages transporting ATRIUM 10XM LTR FAs shall commingle only with other TN-B1 packages transporting fresh fuel assemblies currently approved in the CoC No. 9372.

(4) All other conditions of CoC No. 9372 shall remain the same.

(5) This authorization shall expire on October 31, 2021.

CONCLUSIONS

Based on the statements and representations in the application dated June 15, 2020, the staff agrees that the use by Framatome of the Model No. TN-B1 package meets the requirements of 10 CFR Part 71, subject to the conditions listed above.

Issued on October 9, 2020.