ATTACHMENT 1

1.0 INTRODUCTION

The model TN-B1 package holds NRC approval USA/9372/B(U)F-96 and is designed for the transport of unirradiated boiling water reactor (BWR) fuel for use in commercial reactors. A full description of the package is provided in the safety analysis report (SAR), FS1-0014159, Revision 9 [1] and in Section 5(a)(2) of the NRC Certificate of Compliance (CoC) [2]. In support of the development of enhanced accident tolerant fuels (eATF), Framatome plans to ship material test rods which have been inserted into standard rod positions in an otherwise standard ATRIUM 10XM BWR fuel assembly (FA). The modified FA (hereinafter, the ATRIUM 10XM LTR) will be shipped to a domestic commercial power reactor for irradiation. Two test rods, in fixed, specified locations, will be placed in up to four FAs (i.e., a total of eight test rods to be shipped). Up to two modified FAs will be shipped in the TN-B1. The purpose of this Attachment 1 is to demonstrate that a shipment of the ATRIUM 10XM LTR FA in the TN-B1 package meets all applicable requirements of 10 CFR 71 because the ATRIUM 10XM LTR FAs fall within the existing licensing basis.

Of particular note, no change is made to the TN-B1 packaging. It remains unchanged from the current approval under CoC Revision 2. In addition, except for the replacement of two standard fuel rods by two material test rods, no change is made to the ATRIUM 10XM FA.

1.1 Description of the Test Rods

Test rods are full length rods composed of several segments that are connected using threaded joints. Each segment is made from two threaded ends welded to a length of cladding. As shown in Figure 1, the threaded connections are tack welded to ensure the security of the joint. Except for one segment which is perforated (open to coolant – OTC), all segments are enclosed and watertight. The upper and lower ends of the test rods have the same interface to the FA upper and lower tie plates as a standard fuel rod.

The overall diameter and length of a test rod is the same as for a standard fuel rod. The material of the cladding is Zircaloy-2 (Zry2), and its thickness is the same as in a standard fuel rod. All closed sections of cladding have a liner, or thin internal coating, made of a slightly different zirconium alloy. The OTC segment does not feature this coating. Some of the segments (roughly half) feature an external chromium/titanium metallic coating a few microns thick which is intended to improve the accident tolerance of the cladding. The remaining segments are uncoated. All segments except the OTC segment contain Zry2 slugs which provide some

physical mass without significantly affecting the neutronic behavior of the test rods or adding to the eventual post-irradiation activity.

The OTC segment is perforated to allow reactor coolant to circulate around mechanical test specimens made of silicon carbide (SiC). The SiC test specimens include both tensile test and four-point bend test coupons, and are enclosed in cages made of Zry2 within the cladding. The cages maintain the test coupons in their designated position while in the reactor. Not all test rods contain an OTC segment. Closed segments (i.e., non-OTC) are pressurized to 80 ± 7 psi, which is the same pressure as standard fuel rods.

There is no fissile or radioactive material in any of the test rods.

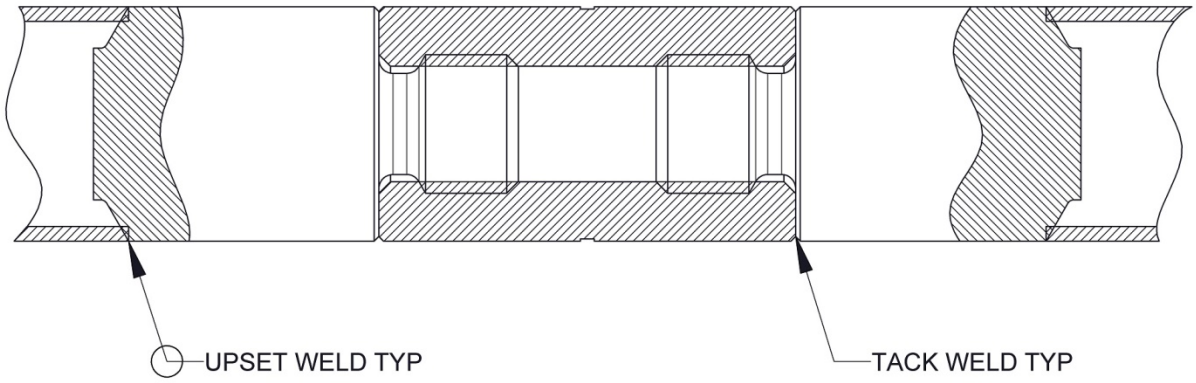

Figure 1 – Test Rod Segment Joint Configuration

1.2 Description of the ATRIUM 10XM LTR FAs

The currently approved ATRIUM 10XM BWR FA (also referred to as the FANP 10x10 FA in the CoC) is the basis for the ATRIUM 10XM LTR FA. The FANP 10x10 FA is a 10x10 array of fuel rods with up to 12 partial length fuel rods (PLFR) and a water channel in the center. As shown in Figure 2, ATRIUM 10XM LTR FAs have up to two test rods located on the periphery of the assembly in locations B10 and L2. Further details of the ATRIUM 10XM LTR FAs relative to the criticality evaluation are provided in Section 2.5 and [3].

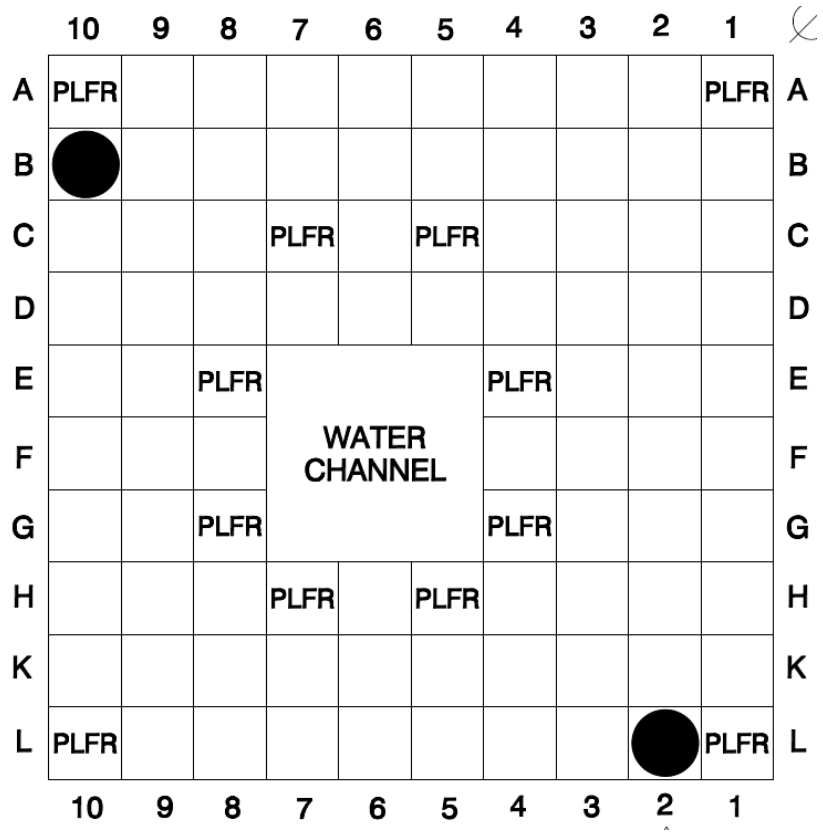

Figure 2 – Locations of the Test Rods

2.0 SAFETY EVALUATION

The following considerations demonstrate the safety of the proposed transport of the ATRIUM 10XM LTR FAs in the TN-B1, and will follow the format guideline of Regulatory Guide 7.9.

2.1 Structural Evaluation

The maximum weight of a test rod is 4.1 lb., which includes the sealed test rods. The SiC OTC test rod minimum weight is slightly less at 3.3 lb. The maximum weight of a standard fuel rod is 6.4 lb. The difference in weight ranges from 2.3 lb. to 3.1 lb for each test rod, or a weight reduction of 4.6 lb. to 6.2 lb. for the ATRIUM 10XM LTR FA compared to a standard FA. This difference is negligible compared to the weight of a standard FA, and is not of concern. Since the test rods do not contain fissile or radioactive material, their structural behavior is not of concern, and no change to the structural evaluation of the TN-B1 is required.

2.2 Thermal Evaluation

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 will be negligible, and no change to the thermal evaluation of the TN-B1 is required.

2.3 Containment

Because the test rods do not contain fissile material, they do not have a containment function, and no change to the containment evaluation of the TN-B1 is required.

2.4 Shielding

Because the test rods do not contain any radioactive material, there is no effect on any shielding effectiveness of the FA or of the packaging, and no change to the shielding evaluation of the TN-B1 is required.

2.5 Criticality

The ATRIUM 10XM LTR FAs are bounded by the existing TN-B1 criticality analysis, with the exception of the new contents introduced in the test rods (Zircaloy-2 slugs and silicon carbide test samples). No prior analysis has been performed on the effect of the new contents. To demonstrate that the new contents do not compromise the criticality safety of the TN-B1 package, a condensed criticality analysis is performed based on the worst-case FANP 10x10 FA criticality parameters as determined in the existing TN-B1 criticality analysis.

The worst-case SAR model is modified to account for the ATRIUM 10XM LTR FAs test rod and PLFR layout. To bound the material composition of the test rods, the test rods are modeled as either solid Zircaloy-2 or solid silicon carbide. To bound any possible failure of the test rods, additional modeling is performed with test rods converted to either water or void. Due to the narrow scope of the modifications, only the most-limiting SAR configuration (HAC array) is analyzed.

No new benchmarking is performed. The worst-case SAR model is rerun in SCALE 6.2.1 along with all new runs. Since the set of models analyzed have similar neutronic properties, any bias or data uncertainties are similarly reflected in all calculated k_{eff} values. A significant decrease in k_{eff} for the ATRIUM 10XM LTR FAs relative to the licensing basis FANP 10x10 FA is sufficient to demonstrate the ATRIUM 10XM LTR FAs will remain subcritical during transport.

As would be expected, the test rod contents have a significant negative effect on package reactivity. Treating the test rods as water or void has a similarly negative effect on reactivity. It is concluded that the ATRIUM 10XM LTR FAs are significantly less reactive than the existing licensing basis FANP 10x10 FA. The ATRIUM 10XM LTR FAs can be shipped using the

existing criticality requirements and restrictions (e.g. CSI) applied to the FANP 10x10 FA without a decrease in criticality safety.

Case	k_{eff}	σ	k_{eff} + 2σ	Δk
Worst-Case FANP 10x10 (SCALE 4.4)[1]	0.9368	0.0008	0.9384	-
Worst-Case FANP 10x10 (SCALE 6.2.1)	0.93781	0.00022	0.93825	-
LTR FA, Test Rods as solid Zircaloy-2	0.91587	0.00022	0.91631	-0.02194
LTR FA, Test Rods as solid Silicon Carbide	0.91600	0.00028	0.91656	-0.02169
LTR FA, Test Rod Locations as Water	0.91609	0.00028	0.91665	-0.02160
LTR FA, Test Rod Locations as Void	0.91666	0.00025	0.91716	-0.02109

Note 1: Case results taken from SAR Table 6-17, *TN-B1 Array HAC Worst Case Parameter Fuel Designs*

2.6 Package Operations

Because the test rods fit into standard locations within a standard FA, there is no change to the FA configuration relative to package operations. Thus, there is no effect on package operating procedures or instructions. The ATRIUM 10XM LTR FA containing the test rods shall be handled, and the TN-B1 package shall be operated in the same manner as for the case of a standard FA.

2.7 Acceptance Tests and Maintenance Program

Because there is no change to the packaging for the subject transport, there is no effect on the acceptance tests or to the maintenance program for the TN-B1 packaging.

3.0 CONCLUSIONS

Based on the foregoing demonstrations, the ATRIUM 10XM LTR FA containing up to two test rods in specified locations as described in Section 1.0 of this Attachment 1 can be safely transported in the TN-B1 package. A shipment of up to two ATRIUM 10XM LTR FAs, or a combination of one ATRIUM 10XM LTR FA and one standard ATRIUM 10XM FA meets all of the applicable requirements of 10 CFR 71.

4.0 CONDITIONS

Because the structural, thermal, shielding, and operational functions of the TN-B1 package are unimpaired by the presence of the test rods, and because the k-eff of the ATRIUM 10XM LTR FA is reduced by the presence of the test rods, there are no governing conditions for transport that differ from those already specified by the current CoC, namely:

- CSI=2.1

- Fuel assemblies to contain commercial grade uranium and meet Type A radioactive material contents
- Fuel assemblies shall be shipped channeled
- TN-B1 packages transporting ATRIUM 10XM LTR FAs shall comingle only with other TN-B1 packages transporting fresh fuel assemblies currently approved in USA/9372/B(U)F-96
- The ATRIUM 10XM LTR FAs shipped in the TN-B1 shall be configured as described in this Attachment 1.

The requested shipping window for these ATRIUM 10XM LTR FAs is between February 8, 2021 and April 30, 2021.

5.0 REFERENCES

1. FS1-0014159, *Framatome TN-B1 Docket 71-9372 Safety Analysis Report*, Revision 9.
2. Certificate of Compliance USA/9372/B(U)F-96, Revision 2.
3. CALC-3023422-000, *TN-B1 Letter Authorization Criticality Analysis*, Orano Federal Services LLC.