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

SAFETY EVALUATION REPORT
Docket No. 71-9372
Model No. TN-B1
Certificate of Compliance No. 9372
Revision No. 3

SUMMARY

By letter dated January 28, 2022, Framatome Inc. (the applicant), requested an amendment to Certificate of Compliance (CoC) No. 9372, for the Model No. TN-B1 transportation package to (i) include the optional use of synthetic rubber within the inner container and shock isolation system and also make some exterior rubber parts optional, and (ii) allow the option of having either rubber or neoprene for the inner and outer container gaskets.

The applicant demonstrated that material reactions associated with multiple rubber types show that no excessive corrosion will occur and that the changes for the vibration isolation rubber material and inner container cushioning material have no effect onto the package performance.

The applicant also updated the criticality evaluation for: (i) the fuel assembly orientation within the package, (ii) the increased fuel channel side thickness to ≤ 0.320 cm to bound fabrication tolerances, (iii) SCALE code errors for H1-Poly cross section. The applicant considered preferential flooding in the NCT array configuration and revised the criticality safety index (CSI) to 1.50 for the 11x11 fuel assembly.

The U. S. Nuclear Regulatory Commission (NRC) staff reviewed the applicant's request and found that the package meets the requirements of Title 10 of the *Code of Federal Regulations* (10 CFR), Part 71.

EVALUATION

Several modifications were made to the licensing drawings and new drawings were introduced for this amendment request:

> Drawing FS1-0042698, Rev. 1, allows the use of synthetic rubber, in addition to natural rubber, for the inner container support frame (side face, bottom face and fastening pads). All items are rubber pads on the exterior of the outer container; pads were changed to optional in case they become dislodged during transport.
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> Drawing FS1-0042700, Rev. 1, allows the use of rubber, to include the option of natural or synthetic rubber, for the vibro-isolating components; components can now be either round or square (40 x 28 mm).
>
> Drawing FS1-0042703, Rev. 1 adds the option to allow the use of either rubber or neoprene and changes a material from 304 stainless steel to SUS 304.

Drawing FS1-0042705, Rev. 1 replaces the words “shock absorber” with “vibration absorber” for a better consistent definition throughout the application and allows the use of either foam or rubber for vibration control.

Drawing FS1-0042707, Rev. 1 allows for strips of rubber between the foam to aid in supporting the fuel channel: the inner container vibration absorber material allows for either polyethylene foam or rubber.

Drawing FS1-0042708, Rev. 1 allows the use of either rubber or neoprene.

MATERIALS EVALUATION

The applicant stated that the ATRIUM 11 fuel channel side thickness is increased to fully bound the channel’s nominal thickness dimension plus a fabrication allowance. The applicant stated that previous evaluations have shown a slight reactivity increase when the channel thickness is increased.

The applicant stated that the existing vibro-isolating rubber components were restrictively defined as “natural rubber” and to increase the vibration absorption performance of the packaging during normal conditions of transport (NCT), additional materials such as synthetic rubber are considered using a conservative bounding approach. Additionally, the applicant stated that the existing inner container cushioning material, previously labeled as “shock absorber”, does not protect against impact loads intended for NCT or hypothetical accident condition drops, and is now renamed as “vibration absorber”.

In addition, this inner container cushioning material was restrictively defined as “polyethylene foam”, but to increase the vibration absorption performance of the packaging during NCT, additional materials such as synthetic rubber are considered using a conservative bounding approach.

The applicant stated that such additional rubber material selection options are inherently stable products that can be easily monitored, and the package is not exposed to a harsh environment that could accelerate degradation of rubber’s properties. The applicant stated that the rubber and the associated locations are inspected prior to each use.

The applicant mentioned that a plastic sleeve is around the channel fuel assembly and any negative effect from the rubber is anticipated to be first identified by the discoloration of the plastic sleeve. Furthermore, the applicant stated that fuel assemblies are not stored for extended periods of time, i.e., greater than 6 months, within the packaging without being re-packaged. The staff finds this explanation to be acceptable because the additional options for rubber material are very similar in kind for this application and visual inspections can identify any degradation that can then be addressed.

Material Chemical, Galvanic or Other Reactions

The applicant stated that the materials added as an option to replace the existing natural rubber are regularly used as gaskets and seals in the packaging industry and that these types of rubbers are very stable and unreactive in their intended use of the TN-B1 package. The applicant also stated that the inner and outer containers do not form an air-tight seal, thereby allowing venting of any off-gassing material should it occur. The staff finds that the applicant’s justification is acceptable because the package is not exposed to any harsh conditions and is inspected periodically and before each use.

Thermal Evaluation

The applicant stated that the thermal properties of the polyethylene cushioning material were conservatively modeled in the thermal evaluation and there is no change to the existing thermal evaluation. The staff finds this to be acceptable because this material is not relied upon for any safety function during a thermal event.

Conclusion

These vibration isolation and shock absorption components reduce vibrational loading of the fuel assemblies during NCT. While the fuel assembles would not fail as a result of NCT vibrational loading, excessive vibrational loading could result in surface abrasion by contact between the fuel cladding and the assembly hardware. Fuel assemblies are inspected after receipt and even minor evidence of abrasion would need to be evaluated and dispositioned prior to use. By using improved vibration isolating materials, the amount of vibration induced abrasion is reduced.

Based on the discussion above, the staff concludes that the selected materials are acceptable.

CRITICALITY EVALUATION

The applicant requested an amendment to the Model No. TN-B1 package with the following changes accounted for in the criticality safety evaluation: 1) Replacing natural rubber in the inner container clamping system and the inner container cushioning material; 2) Increasing ATRIUM 11 fuel channel thickness from 0.254 to 0.320 centimeters (cm); 3) Correction for h1_poly cross section errors in SCALE; 4) Consideration of fuel assembly orientation within the package; and 5) Explicit consideration of preferential flooding in the normal conditions of transport (NCT) array configuration.

The current Certificate of Compliance for the TN-B1 package only allows for natural rubber in the inner container clamping system and cushioning material. The change requested will allow other kinds of materials (e.g., neoprene, synthetic rubber, or polyethylene) to be used in these components of the package. The hydrogen density of these materials can be higher than that of natural rubber, which was evaluated in previous applications, and may result in a higher system k_{eff}.

As presented in the applicant's sensitivity study in Section 6.12.11.6 of the SAR, the applicant modeled the previously evaluated worst case package configuration (package in the hypothetical accident conditions (HAC) array with ATRIUM 11 fuel contents) with varying polyethylene densities to determine the most reactive density. Synthetic rubber has a maximum density of 1.362 grams per cubic centimeter (g/cm^3) and of the additional materials considered in the analysis, polyethylene has the highest hydrogen weight percentage.

The applicant used a combination of this density and weight percentage to bound all synthetic materials or natural rubbers, as demonstrated in Table 6-124 of the SAR. The density of this combination, modeled as polyethene, was varied from 0.08 g/cm^3 to 1.362 g/cm^3 for the top and sides of the liner, and 0.16 g/cm^3 to 2.724 g/cm^3 for the bottom of the liner. The most reactive density was found to be 0.28 g/cm^3 and 0.56 g/cm^3 for the top/sides and bottom of the liner, respectively, resulting in a k_{eff} plus two times the Monte Carlo calculation uncertainty (2σ) of

0.9343. This is below the applicant's previously calculated Upper Subcritical Limit (USL) of 0.94094. The staff finds that the applicant has used the most conservative configuration of package materials to determine the maximum package k_{eff}.

Included in the applicant's model of the worst-case configuration was an ATRIUM 11 fuel assembly channel thickness of 0.320 cm, which is larger than the previously evaluated channel thickness for this fuel type. The applicant had previously determined that the maximum channel thickness results in the highest system k_{eff}. The applicant evaluated the effect of the increased channel thickness for the NCT and HAC single package and array analyses and used the channel thickness resulting in the highest reactivity for determining the maximum k_{eff} for each configuration. The staff finds that the applicant has used the most conservative assembly channel thickness to determine the maximum package k_{eff}.

The applicant also determined a correction factor for an error in the h1_poly cross section in SCALE, identified by Oak Ridge National Laboratory (ORNL) in a SCALE User Notice dated February 26, 2021. The determination of this correction factor is described by the applicant in Section 6.12.11.5 of the SAR for the evaluation of keff of the package with ATRIUM 11 fuel assembly contents. The applicant determined the correction factor by calculating k_{eff} of the package using the cross-section library containing the known h1_poly error and subtracting it from k_{eff} of the package calculated using a corrected cross section library distributed by ORNL. The applicant calculated the final package k_{eff} for each configuration evaluated by adding the correction factor for the h1_poly cross section error to the k_{eff} that the applicant calculated for the previously approved package.

For the analyses described above, the applicant modeled the package in HAC array using the same configuration and materials as for the previously approved package, with the exception of higher hydrogen density in the inner container, increased channel thickness, varied assembly orientation, and varying internal water moderation (NCT). While the previous evaluation for the package resulted in a criticality safety index (CSI) of 1.0, the applicant modeled a smaller array size for this evaluation, consistent with a criticality safety index of 1.5. All of the applicant's analyses for this array size result in k_{eff} values less than the USL of 0.94094.

For calculation of the correction factors for higher hydrogen density materials in the inner container, increased channel thickness, and h1_poly cross section errors, the applicant used the SCALE 6.2.2 code, with the KENO V.a three-dimensional Monte Carlo criticality code and the continuous energy, 252-group, or 56-group ENDF/B-VII.1 cross section libraries. The previous application for this package with ATRIUM 11 fuel assembly contents used SCALE 6.1.3 with the 238-group ENDF/B-VII cross section library. The applicant did not perform additional benchmarking analyses for the SCALE 6.2.2 code with ENDF/B-VII.1 cross section data since this code and cross section library were only used to find differences in k_{eff} from previously evaluated configurations in order to determine the k_{eff} correction factors. The staff finds this acceptable for this amendment request, since there are unlikely to be significant differences in code bias and bias uncertainty for this system between the two SCALE code versions used, and because of the margin between the maximum calculated k_{eff} with the correction factor (0.93419) and the calculated USL (0.94049).

The applicant revised the criticality analysis for ATRIUM 11 fuel assembly contents in the TN-B1 package to consider fuel assembly orientation within the inner container, as shown in Figure 6-85 of the SAR. Changing the orientation of adjacent fuel assemblies changes the relative locations of the credited gadolinium oxide (Gd_2O_3) content within fuel rods, which can influence the maximum calculated system k_{eff}. The applicant evaluated varying assembly orientations in the NCT and HAC single package and array analyses and used the assembly orientation resulting in the highest reactivity for determining the maximum k_{eff} for each configuration. The staff finds that the applicant has used the most conservative assembly orientation to determine the maximum package k_{eff}.

The applicant also revised the criticality analysis for ATRIUM 11 fuel assembly contents in the TN-B1 package to consider the possibility of preferential flooding of the package in the NCT array configuration, as discussed in Section 6.12.11.3 of the SAR. The applicant performed a moderator density study where the inner container and outer container water densities were separately varied between 0% and 100%.

The applicant's results showed that the maximum package k_{eff} was achieved with full water density in the inner packaging and void in the outer packaging, and the applicant used this configuration to determine the maximum system k_{eff} for the NCT array. The staff finds that the applicant has used the most conservative preferential flooding condition to determine the maximum package k_{eff} in the NCT array configuration.

The staff finds that the criticality analyses provided in the applicant's amendment request provide reasonable assurance that the TN-B1 package containing ATRIUM 11 fuel assembly contents, with inner packaging materials changes, increased ATRIUM 11 fuel assembly channel thickness, correction for cross section errors, assembly rotation, preferential NCT flooding, and a reduced CSI of 1.5 as described above, meet the criticality safety requirements of 10 CFR Part 71.

CONDITIONS

The following changes have been made to the CoC:

Item No. 3.b. has been updated to reflect the latest revision number and date of the application.

Condition No. 5(a)(2) has been edited to allow the use of either foam polyethylene or rubber for the cushioning material.

Condition No. 5(a)(3) has been revised to add the new licensing drawings FS1-0042698, Rev. 1; FS1-0042700, Rev. 1; FS1-0042703, Rev. 1; FS1-0042705, Rev. 1; FS1-0042707, Rev. 1 and FS1-0042708, Rev. 1

Condition No. 5(b)(1), Table 4 (Fuel Parameters) has been updated with the new fuel channel side thickness of 0.320 cm for the 11x11 ATRIUM fuel.

Condition No. 5(c) adds a CSI of 1.50 for the 11x11 fuel assembly.

Condition No. 11 authorizes the use of the previous revision of the certificate for approximately one year.

The expiration date of the certificate is not changed.

The references section has been updated to include the January 2022, application.

CONCLUSION

Based on the statements contained in the application, and the conditions listed above, the staff concludes that the changes indicated do not affect the ability of the package to meet the requirements of 10 CFR Part 71.

Issued with Certificate of Compliance No. 9372, Revision No. 3.

Certificate of Compliance No. 9372, Revision No. 3, for the TN-B1 package DATE August 10, 2022

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