U.S. Department
of Transportation

**Pipeline and
Hazardous Materials
Safety Administration**

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Nishka Devaser, Project Manager
Storage and Transportation Licensing Branch
Division of Fuel Management
Office of Nuclear Material Safety and Safeguards (NMSS)
U.S. Nuclear Regulatory Commission
11545 Rockville Pike
Mail Stop TWFN D 439
Rockville, MD 20852-2738

Dear Mr. Devaser:

In accordance with the Memorandum of Understanding between our agencies, on October 1, 2020 I requested that you review the Japanese Certificate of Approval No. J/170/B(U)F-96, Revision 3, for the JRC-90Y-950K package and make a recommendation concerning our revalidation of the package for import and export use (Docket No. 71-3036 and EPID L-2020-DOT-0000). On February 8, 2021, you sent a Request for Additional Information (RAI) regarding this review.

Attached is the response to your RAI letter I have received from our applicant, Daher Nuclear Technologies. Supporting files in electronic form were provided previously to you.

If you have any questions or need any additional safety information, please feel free to contact Michael Conroy of my staff at (202) 366-3597 or via email at Michael.Conroy@dot.gov.

Sincerely,

Richard Boyle

Digitally signed by Richard Boyle
Date: 2021.09.29 07:38:23 -04'00'

Richard W. Boyle,
Radioactive Materials
Division of Sciences and Engineering
Office of Hazardous Materials Safety

Enclosure

Answer for the request of JRF-90Y-950K validation from NRC

Kyoto UniversityAugust 27, 2021

RAI 6.1

Revise the application to specify the thickness, including tolerance, of the rectangular stainless steel pipes that make up the fuel basket.

The staff needs this dimension in order to perform confirmatory criticality calculations for the package design. This dimension does not appear in the general arrangement drawings or description of the packaging in SAR Section C.

This information is needed for the staff to confirm that the package design will meet the criticality safety requirements in paragraph 673 of IAEA SSR-6, “Regulations for the Safe Transport of Radioactive Material.”

Answer

The dimension of one rectangular stainless steel pipe is shown in under figure. The outer dimension is 100 mm square and inner dimension is 94 mm square. Therefore, the thickness is 3 mm.

Fig. 0 Dimensions of rectangular pipeTolerances on all dimensions shall

be

- One place decimal: +/- 0.8
- Two place decimal: +/- 0.2

RAI 6.2

Revise the application to demonstrate that content loads less than the maximum requested will remain subcritical.

SAR Table A.1 states that the number of Kyoto University Critical Assembly (KUCA) fuel elements is 1,200 or less for coupon elements, and 300 or less for flat elements. However, the criticality analysis only demonstrates that the maximum load for each element type is subcritical. Lower numbers of elements may allow for greater spacing between elements with a more optimum degree of moderation, and therefore a higher system keff. Initial staff confirmatory analyses indicate that k-effective (keff) is higher for lower numbers of plates at an optimized pitch. The analysis in the SAR should demonstrate that all allowable content loads, up to the maximum requested, remain subcritical under all conditions.

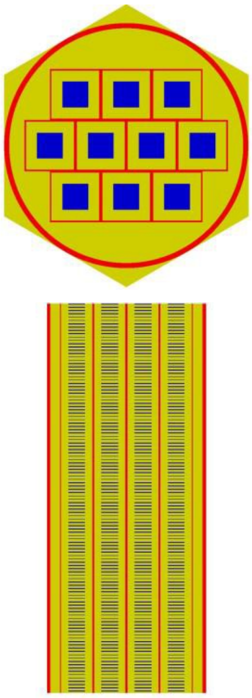
Answer

- Coupon

The question is related the optimum degree of moderation for neutron. Therefore, the effect of gaps and number of elements was numerically investigated by changing these factors.

For the investigations, coupons were set at the center of pipe and the gaps between each coupon were evenly spread (Fig.1). The yellow part of Fig. 1 is water and the boundary is perfect reflection. Then, the gap was changed maximum space case (0.77 mm@1,200 coupons) to narrow space case. Also, the cases of 1,200 coupons and 1,000 coupons were investigated. The results of numerical investigation were shown in Fig. 2. The 1,200 coupons case has higher k-effective than 1,000 coupons case. And theoptimum gap is 0.3 mm. It indicated the greater spacing between coupons do not have more optimum degree of moderation. Therefore, the 1,200 coupons case has maximum k-effective. In the SAR, the coupons were shifted to the center of the basket and gap was set at 0.4 mm (it was investigated such as same way).

X-Y



X-Z

Fig. 1 Calculation system for coupon

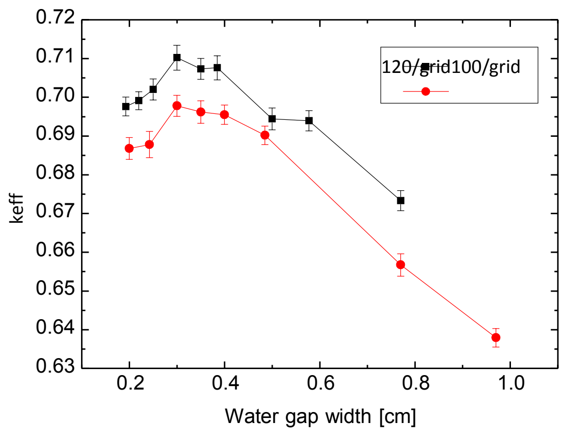


Fig. 2 Results of numerical investigation of coupon

- Flat plate

Flat plates were set at the center of pipe and the gaps between each plate were evenly spread. Then, the gap was changed maximum space case (0.163 mm@300 plates) to narrow space case (Fig. 3). Theyellow part of Fig. 3 is water and the boundary is perfect reflection. Also, the cases of 300, 280, 250 and200 plates were investigated. The results of numerical investigation were shown in Fig. 4. The 280 plates case has slightly higher k-effective than other cases. And the optimum gap is most widely spread case in the pipe. The k-effective of all cases were less than 1.0. In the SAR, the number of flat plate is 300. Thegap was set at 0.163 mm.

X-Y

X-Z

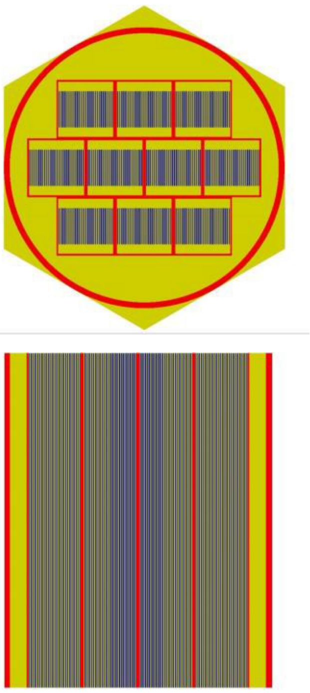


Fig. 3 Calculation system for flat plate

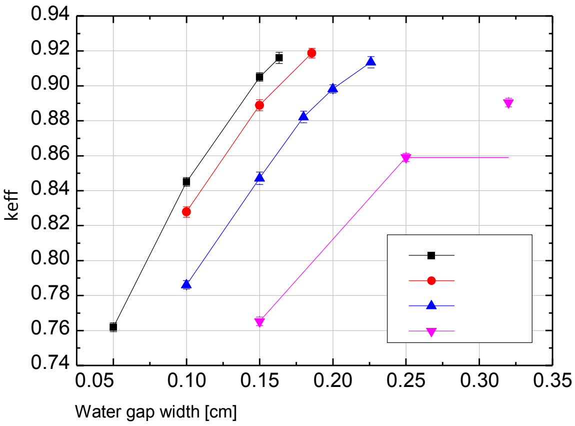


Fig. 4 Results of numerical investigation of flat plate

RAI 6.3

Revise the criticality analysis to consider hydrogen-bearing material other than water that may be present in the package with the fissile material contents.

SAR Section D.3 states that KUCA fuel contents are “wrapped by some buffer such as polyurethane foam,” and that “silicone rubber spacers are used to the upper and lower sides of the fuel plates in orderto absorb possible impact energy during transport, and also to fix the fuel plates.” The criticality analysisin Section E of the SAR only considers water as a possible moderator. The hydrogen-bearing materials discussed in Section D.3 can have a higher hydrogen density than water for a given mass and may be more effective moderators than water. The criticality analysis should be revised to consider the moderating effects of these materials, including consideration of any reconfiguration of the materials under accident conditions (e.g., melting).

Answer

The density of polyurethane foam which is used as buffer is very low (about 0.016 g/cm^3). Therefore, the moderating effect of polyurethane foam is considered to be included in the analysis with water.

The atomic density of hydrogen in silicone rubber is close to that of water and silicone rubber includes carbon. Therefore, calculation was performed by replacing water with silicone rubber. The green part of Fig. 5 and 6 is silicone rubber and the other calculation conditions were same as water case. The resultsof k-effective are shown in Table 1. The k-effectives of water moderator case are higher than silicone rubber case in both coupon and flat plate. It demonstrates the analysis of water moderator includes thatof silicone rubber case.

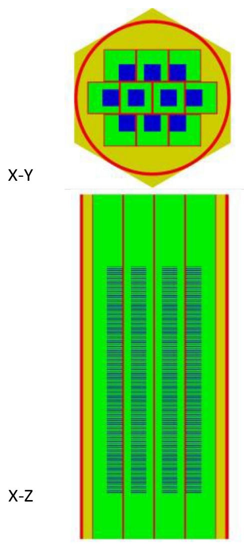


Fig. 5 Calculation system for coupon surrounded by silicone rubber

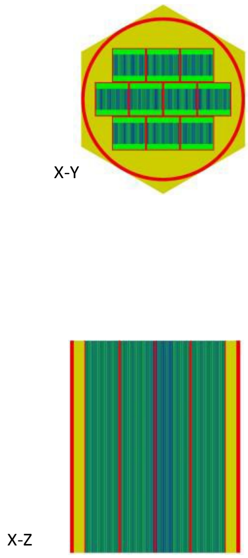


Fig. 6 Calculation system for flat plate surrounded by silicone rubber

Table 1 Results of k-effective

Fuel type	moderator	Keff	error	Keff+3σ
Coupon	Water	0.8080	0.0026	0.8158
	Silicone rubber	0.7894	0.004	0.8014
Flat plate	Water	0.9055	0.003	0.9145
	Silicone rubber	0.8834	0.0034	0.8936

Answer for the request of JRF-90Y-950K validation from NRC

Kyoto UniversitySeptember 24, 2021

<u>RAI 6.4</u>

Revise the application to provide a validation of the calculational method used to determine system keff consistent with the recommendations in IAEA SSG-26, "Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material."

Although Section E.5 of the SAR provides some analyses performed as part of a "benchmarktest," there are several omissions and needed corrections in the evaluation based on the available guidance in IAEA SSG-26 Appendix VI, "Criticality Safety Assessments," specificallyparagraphs VI.22 through VI.39:

1. *The benchmark test in the SAR was performed using a different code and cross section library than used to establish criticality safety in the SAR (KENO V.a and the 137 group MGCL cross section library are used in the benchmark test in Section E.5 of the SAR, while SCALE 5.1/KENO VI and the 238 group ENDF/B-V cross section library are used in the criticality safety assessment). The same computational method must be used consistently between the validation cases and the safety analysis cases to confirm that the bias and bias uncertainty determined in the validation are applicable to the safety evaluation being performed.*
2. *The applicant did not determine a bias and bias uncertainty based on the results of benchmark evaluations, per the recommendation of paragraph VI.23(a) of IAEA SSG-26. Note that the keff values for evaluated critical experiments from Table E.9 show that the code and cross section library used in the benchmark evaluation underpredict keff, on average, by greater than 1%. The calculated bias and bias uncertainty should be added to the calculated system keff to demonstrate that total system keff is less than 0.95, per the recommendations of IAEA SSG-26, paragraph VI.35.*
3. *The applicant did not establish a range of applicability for the benchmark analysis, including any calculated bias and bias uncertainty, based on the range of parameter variation (e.g., enrichment, hydrogen to fissile ratio (H/X), energy of the average lethargy causing fission (EALF)) in the selected experiments and did not show the analysis for the package with KUCA fuel is within the ranges of applicability for these parameters.*
4. *The applicant did not demonstrate that the selected critical experiments have parameters (e.g., materials, geometry) that are characteristic of the package design. Note that some critical experiment parameters differ significantly from the package design (e.g., enrichment for the JAEA TCA criticality experiment (2.6 weight percent 235U) and the ORNL International benchmark test (>93 weight percent 235U) versus 19.95 weight percent for the KUCA fuel per*

the certificate).

5. *The applicant did not evaluate the benchmark results to determine trends that may exist against parameters important in the validation process (e.g., enrichment, H/X, EALF).*

<u>Answer</u>

For the Criticality analysis, KENO-VI Monte Carlo module together with the 238-energy group ENDF/B-V neutron cross section library of the SCALE code system was used for the calculation of keff.

For the verification of the 238 energy group cross-section library based on the Monte Carlo calculation module KENO-VI and ENDF/B-V in SCALE used in the analysis, the comparative study with the experimental results was carried out based on "Validation and Comparison of KENO Va and KENO-VI" from Oak Ridge National Laboratory in the United States [1].

From the benchmark analysis results, the bias between the test model and this analysis method was calculated for the uranium-based benchmark analysis results. In the calculation of the bias, the positive bias that overestimates the effective neutron magnification was conservatively set to zero, and only the negative bias that underestimates the effective neutron magnification was considered. The most underestimated value for effective magnification was 0.974 ± 0.003.

On the other hand, for the verification of ES-3100 package by SCALE 5.0 with 238-group ENDF/B-V cross-section library, the minimum bias given for LEU systems was given as -0.0260 [2].

In this analysis method and benchmark, we decided to consider the negative bias effect of 0.030 because there was an underestimation of up to -0.029 in the analysis of the uranium series. Therefore, regarding the criticality criterion by this analysis method, 0.920 is used as the criterion by subtracting the margin of the bias from the effective neutron magnification of 0.950, which is the criterion for the subcriticality.

<u>Reference</u>

[1] P.B. Fox and L.M. Petrie “Validation and Comparison of KENO V.a and KENO-VI”, ORNL/TM-2001/110, Oak Ridge National Laboratory (2002)

[2] Consolidated Nuclear Security, LLC “Safety Analysis Report For Packaging,Y-12 National Security Complex, Model ES-3100 Package with Bulk HEU Contents”, SP-PKG-801940-A001,Rev.2 (2017)