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REVISIONS

REVISION	DATE	EXPLANATORY NOTES
4.0	See 1rst page release date	Sections 6, 6.1 and 6.4 – 6.11. Added an example calculation for the bounding ATRIUM 11 fuel design for clarification. Section 7. Added NRC comment to clarify the scope of the section. Section 7, first paragraph, third sentence. Revised sentence to clarify "…failure of the cladding…" Section 7, fifth paragraph, last sentence and Section 8, fourth paragraph, last sentence. Added reference for the statement regarding the "…no failure of the simulated fuel rod…"
3.0	8/29/17	Revised document in support of RAI 2-4 and 3-2 of FCU-17-00006, "NRC Letter of May 15, 2017." Revised text throughout document to clarify the analysis method and that the ATRIUM 11 parameters only will be added to the SAR. The SAR will remain unchanged for the existing fuel designs from Revision 3 of FS1-0014159. Reference to Figures 2-39 through 2-42 were corrected in Section 7. Section 8 and References 21 and 22 were added to address a comment from the June 8, 2017, public meeting with the NRC (ADAMS Accession No. ML17198A317).
2.0	2/16/17	Incorporated additional information to address the NRC RSI (Reference [20]), including minor text changes in Section 2 and 6, added Section 7, added current fuel design data to Table 2, deleted Table 3, deleted Appendix 1 and added References 18 – 20.
1.0	12/8/15	New document

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Name and Title/Discipline	P/LP, R/LR, A	Pages/Sections Prepared/ or Comments
Kevin Elliott Engineer, FDE&M-AR	LP	All
Jim Tolar Engineer, FDE&M-AR	LR	All
Jim Davis Engineer, EHS&L	R	All
Kevin Mon Engineer, FDE&M-AR	R	Sections 7 and 8
Jeff Morris Manager, FDE&M-AR	A	All Delegation to Jason Medina per FD-17-01577-1.0.

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1. INTRODUCTION

The introduction of the ATRIUM™[1] 11 fuel assembly design in reload quantities has necessitated a resubmittal of the TN-B1 shipping container Safety Analysis Report (SAR) (Reference [1]) as this design is outside of the previously evaluated dimensional parameters. The evaluations supporting the new submittal have been split into separate documents. This document specifically addresses the thermal evaluation documented in Section 3 of the SAR. Since the container design and construction are unchanged, the thermal protection characteristics of the container are also unchanged. Therefore, this evaluation is limited to the ATRIUM 11 fuel design, and the results will be incorporated into a revised Section 3 of the SAR.

2. SUMMARY OF RESULTS

The thermal evaluation documented in the current SAR encompasses the TN-B1 container and the fuel assembly. Since the container design and the 8x8 through 10x10 fuel designs are unchanged, the existing thermal evaluation for the container and these non-liner clad fuel designs in Section 3 of the SAR remain applicable. Therefore, only the ATRIUM 11 non-liner clad fuel design was evaluated for the purpose of adding the results as a bounding example to Table 3-5 of the revised SAR.

The thermal evaluation for the AREVA 8x8, 9x9 and 10x10 fuel assembly designs, liner and non-liner clad, was also completed for verification of the methodology for use with the ATRIUM 11 design. The results for the non-liner clad designs (see Table 1) were comparable to the values in Table 3-5 of Reference [1] with the exception of a correction to the maximum allowed cladding inside radius to thickness ratio for the 8x8 fuel design. Fuel designs from other fuel fabricators were not evaluated.

A qualitative evaluation of the influence of the cladding initial stress state, due to Hypothetical Accident Condition (HAC) drop tests, on the capability of the cladding to maintain containment is provided in Section 7. Additionally, a comparison of fuel rod strain between a highway accident and HAC was performed in Section 8.

No other changes to Section 3 of the SAR are recommended.

3. DESIGN DESCRIPTION

This evaluation includes AREVA ATRIUM fuel assembly designs with 9x9, 10x10 and 11x11 lattices for use in boiling water reactors (BWR). All are similar in construction with differing rod and spacer grid quantities and associated dimensional variations. The fuel assemblies consists of a lower tie plate (LTP), an upper tie plate (UTP), fuel rods, spacer grids, a cage assembly and miscellaneous assembly hardware.

A full description of the TN-B1 packaging is provided in Section 1.2 of the SAR.

4. ASSUMPTIONS

No assumptions were made beyond those presented in the Section 3 of the SAR.

5. COMPLIANCE

In accordance with Section 3.1 of the SAR, the TN-B1 package is designed to provide thermal protection as described in Subpart F of 10 CFR 71 for transport of two BWR fuel assemblies with negligible decay heat. Compliance is demonstrated with 10 CFR 71 subpart F. The TN-B1 protects the fuel through the use of an inner and outer container that restricts the exposure of the fuel to external heat loads. The

[1] ATRIUM is a trademark of AREVA Inc.

insulated inner container further restricts the heat input to the fuel through its insulation. The fuel requires very little thermal protection since similar fuel has been tested to the 800ºC temperature without rupture.

The primary features that affect the thermal performance of the package are: 1) the materials of construction; 2) the inner and outer containers; and 3) the thermal insulation of the inner container. The multi walled construction of the combined outer and inner containers reduces the heat transfer as well as reduces the opportunity for the fire in the accident conditions to impinge directly on the fuel. The thermal insulation also greatly reduces the heat transfer to the fuel from external sources.

Given negligible decay heat, the thermal loads on the package come solely from the environment and solar radiation for Normal Conditions of Transport (NCT), as described in Section 3.4 of the SAR, or a half-hour, 800ºC (1,475°F) fire for Hypothetical Accident Conditions (HAC), as described in Section 3.5 of the SAR. Since the fuel cladding is designed for thermal transients greater than what is found in the NCT and the fuel rod is allowed to expand in the fuel assembly without interference, the fuel cladding stresses are evaluated at the maximum temperature seen during a HAC thermal event.

6. MAXIMUM PRESSURE EVALUATION

Section 3 of the AREVA TN-B1, Docket No. 71-9372, SAR was used to develop the analysis method for the thermal evaluation of the 11x11 fuel rod. This method will be verified to provide results having margin to the fuel design parameters consistent with the results from the previous 8x8, 9x9 and 10x10 fuel designs in the SAR. All designs will be analyzed; however, only the 11x11 fuel design parameters for a non-liner clad fuel rod will be added to Table 3-5 “Maximum Pressure” of the SAR as an example design. The results of the evaluation will be bounding fuel rod fill pressure and diameters and thickness for liner and non-liner cladding given maximum allowed cladding stress at HAC.

The parameters for each design were determined using the initial fuel rod fill pressure, the room temperature and HAC temperature, the maximum allowed cladding stresses, cladding thickness and liner cladding thickness as constants. All other parameters are dependent on these values. If required, the initial fill pressure may be reduced until the cladding diameter and thickness derived bound the current cladding design for each fuel array. The sequence of the parameter calculations is in the following order:

- maximum allowed cladding inside radius to thickness ratio
- minimum design cladding thickness plus margin
- maximum allowed cladding inside diameter base on allowed cladding stress and minimum thickness
- maximum cladding outside diameter based on inside diameter and thickness
- HAC and applied pressures based on fill pressure and temperatures
- cladding stress and stress margin at HAC

Details of these calculations are given in Sections 6.4 through 6.11 with an example calculation for the bounding ATRIUM 11 fuel design non-liner and liner clad.

The results of the evaluation are shown in Table 1, Table 2 and Table 3.

6.1. INITIAL PRESSURE

The maximum initial 11x11 fuel rod pressure of 1.1145 MPa absolute (161.6 psia) was applied for the non-liner clad design consistent with the 9x9 and 10x10 fuel designs in Table 3-5 of the SAR. It is also the pressure that was used in high temperature burst testing of cladding segments in Section 3.5.3.2 of the SAR. For the liner clad fuel designs, the maximum initial fuel rod pressures were determined by an iterative process for each fuel array and cladding type using bounding parameters for the current fuel rod designs to ensure that sufficient margin existed to the allowed HAC stress limit. The resulting value is shown in Table 1.

To verify that the current fuel rod design initial fill pressures are bound, Table 2 & Table 3 compares the calculated bounding values to the current design values. Note that there is currently no non-liner cladding product for the ATRIUM 10XM and 11 fuel assemblies. For these designs, the non-liner cladding is assumed to have the same cladding inside and outside diameters as the liner cladding of the same fuel assembly type. The comparison shows that the bounding initial fuel rod fill pressures are limiting.

ATRIUM 11 example calculation (bounding):

non-liner clad initial pressure (P) = 1.1145 MPa (same pressure as 9x9 and 10x10 arrays)

liner clad initial pressure (P) = 0.851 MPa (determined by iterative process, targeting ≥0 margin at HAC and cladding dimensions greater than the current supplied design)

6.2. FILL TEMPERATURE

The fuel rod fill temperature of 20°C is defined by the methodology specified in Table 3-5 of Reference [1].

6.3. HAC TEMPERATURE

The HAC fill temperature of 648°C is defined by the methodology specified in Section 3.5.3.1 of Reference [1].

6.4. MAXIMUM ALLOWED CLADDING INSIDE RADIUS TO THICKNESS RATIO

The maximum allowed cladding inside radius to thickness ratio is determined at room temperature given the maximum allowed cladding stress and initial fuel rod fill pressure. All fuel designs shipped in the TN-B1 container shall be limited in design by a maximum allowed cladding stress of 10.18653 MPa at room temperature. This is determined by the product of the initial pressure (Section 6.1) and maximum allowed cladding inside radius to minimum cladding thickness ratio (Table 3-5 note of Reference [1]). The radius to thickness ratio is calculated for each fuel array and cladding type using the following equation:

Maximum r/t = 10.18653 MPa / initial pressure

ATRIUM 11 example calculation (bounding):

non-liner clad max. r/t = 10.18653 MPa / 1.1145 MPa = 9.14 — Section 6.1

liner clad max. r/t = 10.18653 MPa / 0.851 MPa = 11.97 — Section 6.1

The results of the calculation, shown in Table 1, are rounded down to two decimal places.

Applying this method to determine the radius to thickness ratio for the 8x8 results in a value of 16.75 (10.18653 / 0.608) rather than the 20.20 shown the SAR Table 3-5. The thickness of the cladding liner is also subtracted as specified in Section 3.5.3.2 of Reference [1]. Table 1 was updated to show this correction. All other values were verified to be correct.

6.5. MINIMUM ALLOWABLE CLADDING THICKNESS

The minimum allowable cladding thickness is based on the current design drawing values minus the maximum liner thickness and a margin of 0.02 mm to conservatively bound potential future designs. The equation is as follows:

Min. thickness = minimum design cladding thickness – maximum liner thickness – bounding margin

[redacted]

The primary units are metric and are rounded up to three decimal places. Values in inches are obtained by dividing the values in millimeters by 25.4.

The values for the current designs and the results of the calculation for the bounding values are shown in Table 2 & Table 3. The values for the bounding design for non-liner cladding for each array were populated into Table 1.

6.6. MAXIMUM ALLOWABLE CLADDING INSIDE DIAMETER

The maximum allowable cladding inside diameter is based on the previously calculated cladding inside radius to minimum cladding thickness ratio (Section 6.4) and the minimum allowed cladding thickness (Section 6.5). The calculated bounding values should be greater than the current design values. If not, reduce the bounding design initial fill pressure (Section 6.1) and recalculate Section 6.4. The equation is as follows:

Maximum clad I.D. = 2 * maximum r/t * minimum allowed cladding thickness

[redacted]

The primary units are metric and are rounded down to two decimal places. Values in inches are obtained by dividing the values in millimeters by 25.4.

The values for the current designs and the results of the calculation for the bounding values are shown in Table 2 & Table 3. The values for the bounding design for non-liner cladding for each array were populated into Table 1.

6.7. MAXIMUM ALLOWABLE CLADDING OUTSIDE DIAMETER

The maximum allowable cladding outside diameter is based on the previously calculated maximum allowable cladding inside diameter (Section 6.6) and minimum allowed cladding thickness (Section 6.5). The resulting outside diameter is directly related to the r/t value (Section 6.4) and, therefore, the design is bound by the allowable stress limit. The calculated bounding values should be greater than the current design values. If not, reduce the bounding design initial fill pressure (Section 6.1) and recalculate Sections 6.4 and 6.6. The equation is as follows:

O.D. = maximum allowed cladding I.D. + 2 * minimum allowed cladding thickness

[redacted]

The primary units are metric and are rounded down to two decimal places. Values in inches are obtained by dividing the values in millimeters by 25.4.

The values for the current designs and the results of the calculation for the bounding values are shown in Table 2 & Table 3. The values for the bounding design for non-liner cladding for each array were populated into Table 1.

6.8. PRESSURE AT HAC

The pressure at HAC is based on the previously calculated initial pressure (Section 6.1), the HAC temperature (Section 6.3) and the fill temperature (Section 6.2) as follows (see Sections 3.5.3.1 and 3.5.3.2 of Reference [1]):

Pressure @ HAC = max initial absolute pressure * max absolute temperature / ambient absolute temperature

ATRIUM 11 example calculation (bounding):

non-liner rod pressure @ HAC =1.1145 MPa * (648°C + 273°C) / (20°C + 273°C) Sections 6.1, 6.2, 6.3
= 3.50 MPa (absolute)

liner rod pressure @ HAC = 0.851 MPa * (648°C + 273°C) / (20°C + 273°C) Sections 6.1, 6.2, 6.3
= 2.67 MPa (absolute)

The values for the current designs and the results of the calculation for the bounding values are shown in Table 2 & Table 3. The values for the bounding design for non-liner cladding for each array were populated into Table 1.

6.9. APPLIED PRESSURE AT HAC

The applied pressure at HAC is the pressure at HAC (Section 6.8) at gauge pressure. The equation is as follows:

Applied Pressure @ HAC = Pressure @ HAC – 1 atmosphere

ATRIUM 11 example calculation (bounding):

non-liner rod applied pressure at HAC = 3.50 MPa - 0.101325 MPa Section 6.8
= 3.40 MPa (gage)

liner rod applied pressure at HAC = 2.67 MPa - 0.101325 MPa Section 6.8
= 2.57 MPa (gage)

The values for the current designs and the results of the calculation for the bounding values are shown in Table 2 & Table 3. The values for bounding design for non-liner cladding for each array were populated into Table 1.

6.10. CLADDING STRESS

The cladding stress is based on the previously calculated applied pressure at HAC (Section 6.9), cladding inside radius (Section 6.6) and minimum cladding thickness (Section 6.5). The calculated bounding values should target a value equal to or slightly less than the allowed cladding stress limit of 31.1 MPa (Section 3.5.3.2 of Reference [1]). If not, reduce the bounding design initial fill pressure (Section 6.1) and recalculate Sections 6.4, 6.6, 6.7, 6.8 and 6.9. The equation is as follows (see Table 3-5 of Reference [1] for method):

Cladding stress = Applied Pressure @ HAC * max allowed inside diameter / min thickness / 2

ATRIUM 11 example calculation (bounding):

non-liner clad stress = 3.40 MPa * 9.14mm / 0.50mm / 2 Sections 6.5, 6.6 & 6.9
= 31.1 MPa

liner clad stress = 2.57 MPa * 8.97mm / 0.375mm / 2 Sections 6.5, 6.6 & 6.9
= 30.8 MPa

The values for the current designs and the results of the calculation for the bounding values are shown in Table 2 & Table 3. The values for the bounding design for non-liner cladding for each array were populated into Table 1.

6.11. MARGIN

The margin to the maximum allowed cladding stress at HAC (31.1 MPa, Section 3.5.3.2 of Reference [1]) is calculated as follows (see Table 3-5 of Reference [1] for method):

Margin = maximum allowed cladding stress at HAC / cladding stress – 1

<u>ATRIUM 11 example calculation (bounding)</u>:

non-liner clad stress = 31.1 MPa / 31.1 MPa -1 Section 6.10
= 0

liner clad stress = 31.1 MPa / 30.8 MPa -1 Section 6.10
= 0.010

The values for the current designs and the results of the calculation for the bounding values are shown in Table 2 & Table 3. The values for the bounding design for non-liner cladding for each array were populated into Table 1.

6.12. CONCLUSION

The values for the 8x8 through 10x10 fuel designs in Table 1 are sufficiently similar to the values shown in Table 3-5 of Reference [1] for verification of the thermal analysis method. Therefore, the 11x11 parameters in Table 1 may be added to Table 3-5 of Reference [1].

7. INFLUENCE OF INITIAL STRESS STATE

NRC RSI Observation, 3.0 Thermal, 3-1 (Reference [20]).

Demonstrate that the integrity of the cladding's containment boundary of the modified fuel assemblies is bounded by the previous hypothetical accident condition drop tests and the subsequent hypothetical accident thermal condition.

SAR Section 2.7.4 stated that the maximum hypothetical accident condition testing temperature for an earlier-designed fuel assembly was 921 K (1198°F) and that the fuel rod pressure due to accident conditions does not exceed 508 psig (522.7 psia). The SAR also stated that the fuel rods have a rupture pressure of approximately 520 psi. It was not evident that deformed fuel rods (of the modified fuel assemblies), after the hypothetical accident condition 30 ft drop(end drop, side drop, etc.) and puncture tests, would maintain containment integrity at high temperatures and pressures (e.g., 1198°F and 508 psig). For example, the maximum strain of the deformed cladding after the ambient temperature drop tests was not compared to the maximum strain of the modified fuel assembly's deformed cladding (post-drop test condition) that is also pressurized and at a high temperature due to the hypothetical accident thermal condition.

AREVA's response:

Certification testing of the TN-B1 package is summarized in Section 2.12.1 of the SAR (Reference [1]). Two tests were performed on CTU 1, a 9-meter (30-foot) slap-down on the lid and a 1-meter (40-inch) oblique puncture test on the lid. A 9-meter (30-foot) end drop was performed on CTU 2. The testing resulted in plastic deformation of the fuel rods and a very low leak rate of Helium, but the results met the containment requirements of 10 CFR 71.51 (Section 4.4 of the SAR [1]). Illustrations of fuel rod deformations in CTU 2 tests are shown in Figures 2-39 through 2-42 in the SAR (Reference [1]). While there is plastic deformation to the fuel rods, the magnitude of these deformations are not large as can be seen from the relatively small angles of fuel rod deflections. Such deformations are expected to be limited due to the presence of the fuel pellets within the fuel rods. The deformations observed during the drop tests are consistent with those calculated in the ATRIUM 11 Fuel Assembly Shipping Container Drop Analyses (Reference [18]).

The qualitative result of such deformations is to impart cold-work into the cladding material thereby increasing its yield stress (which would be beneficial in that the cladding would be more resistant to further deformation) and decreasing its ductility (the cladding would be less able to sustain further large deformations without failure). Section 3.5.3.1 of the SAR (Reference [1]) indicates that the peak fuel rod temperature (conservatively assumed to be the same as the peak package inner wall temperature) reaches a maximum of 1198°F (648°C, 921 K) at the end of the fire or 1,800 sec (30 min) after the start of the fire (see SAR [1] Figure 3-3). This peak temperature is somewhat similar to a recrystallization/stress relief temperature (e.g., Reference [19]) that might be used during cladding manufacture, perhaps for a longer exposure time. The impact of such a thermal cycle to the deformed cladding material would be to partially relieve residual stresses resulting from the HAC drop event. At elevated temperatures, the yield stress of the cladding material decreases (plastic deformation is easier) and its ductility increases (failure of containment is less likely).

From a theoretical point of view, the deformation of the fuel rods during the drop event is mainly a slight bending in the axial plane. Therefore, after the drop event, a permanent bending axial strain is present along the fuel rods. It is possible that some of the bending is still elastic and an associated distribution of residual axial stresses across the thickness of the cladding exists; however, as described above, these residual axial stresses will be quickly relaxed during the heat up period.

More importantly, the axial bending deformation has a negligible impact on the deformation mode during the heat up. The loading during the heating period is due to increased internal gas pressure, which acts primarily in the radial direction and causes a principal hoop stress. The prior drop event does not create significant stresses and strains in the radial and circumferential directions of the transverse cross-section, which is the loading plane for the heating period. Therefore, the mechanical deformation during the heating period can be considered independent of the prior small axial bending during the drop event. This is the basis for the analysis in SAR (Reference [1]) Section 3.5, where results of the closed tube pressure ballooning tests have been used to assess the avoidance of clad rupture due to internal gas pressure.

Overall, failure of the deformed cladding during the thermal cycle considered is not expected. This expectation is supported by the GNF-J certification tests discussed in SAR (Reference [1]) Section 2.12.2 which are summarized in Table 2-13 of the same document. As with the certification testing of the TN-B1 package, no failure of the cladding occurred during these tests either. It should be noted that the testing of CTU 2J included a NCT free drop test from 1.2 m, followed by a 9 m HAC free drop, followed by a 1 m HAC puncture drop, followed by an HAC thermal test. This resulted in no failure of the simulated fuel rod cladding (containment boundary) (Section 2.12.2.3.2 of the SAR [1]).

8. COMPARISON OF HIGHWAY ACCIDENT TO HAC

During the public meeting with the NRC on June 8, 2017 (memo to Anthony Hsia, ADAMS Accession No. ML17198A317, July 12, 2017), the reviewer of RAI 3-2 requested the following:

> "Justify the sentence in the RAI response that mentions that the fuel rod associated with NUREG/CR-5892 "… incurred plastic deformation in excess of the RAJ-II 9 m drop CTU-2 assembly," by quantifying the amount of plastic deformation in both units."

AREVA's response:

The damage to the fuel assemblies in the fuel shipment accident (Reference [21]) was primarily the result of exposure of the shipping containers to high temperatures due to the fire that started from the collision. Some containers at the front of the trailer experienced extreme temperature conditions above HAC and also fell from the trailer bed. No attempt was made to extinguish the fire. The fuel assemblies were not significantly damaged due to the fall from the trailer bed, and the fuel assemblies appeared to have only deformed to accommodate the shape of the metal inner containers warped by exposure to the fire for approximately two hours. The plastic deformation of the fuel assembly was measured to be over 1 inch (25.4 mm) from straight, and some fuel rods expanded from the increased internal rod pressure over a length of about 20 inches (508 mm). Also, some cracks were observed. Analyses indicate that temperatures in excess of 1500°F (815°C) are required for this type of damage. This result is consistent with thermal testing performed on rodlets pressurized to ten atmospheres in an oven test (Section 3.5.3.2 of Reference [1]). Some rods heated to 850°C for one hour experienced ruptures whereas rods heated to 800°C did not.

In comparison, the certification test assembly, GNF-A CTU-2, was subjected to a 9 m end drop test which is the orientation resulting in the most severe damage (Section 2.7.1.1 of Reference [1]). The damage, isolated to the lower end of the test assembly, was measured to be 48.82 mm maximum radially over an axial length of 1.6 m (Page 30 of Reference [22]). The HAC thermal testing performed on a GNF-J CTU-2J resulted in no failure of the simulated fuel rod cladding (containment boundary) (Table 2-13 and Section 2.12.3.2 of Reference [1]).

Therefore comparing the plastic deformation between the highway accident and the certification testing, the fuel assembly bow were equivalent, but the highway accident resulted in more plastic deformation due to the fuel rod swelling as shown be the cladding cracks.

Table 1: Maximum Pressure

Parameter	Units	8 x 8 Fuel	9 x 9 Fuel	10 X 10 Fuel	11 X 11 Fuel
Initial Pressure, Max	MPa absolute	0.6079	1.1145	1.1145	1.1145
Fill temperature	°C	20	20	20	20
Temperature during HAC	°C	648	648	648	648
Outside Diameter	mm	12.50	11.73	10.56	10.14
Maximum	inches	0.492	0.462	0.416	0.399
Minimum Allowable	mm	0.680	0.579	0.521	0.500
Cladding Thickness	inches	0.0268	0.0228	0.0205	0.0197
Cladding Inside	mm	11.14	10.58	9.52	9.14
Diameter Maximum	inches	0.439	0.417	0.375	0.360
Pressure @ HAC	MPa absolute	1.91	3.50	3.50	3.50
	psia	277	508	508	508
Applied Pressure @	MPa	1.81	3.40	3.40	3.40
HAC	psig	262	493	493	493
Stress Pr/t	MPa	14.8	31.1	31.1	31.1
	psi	2150	4508	4508	4510
Margin, (allowed stress / actual stress) – 1	None	1.098	0.001	0.001	0.000
Max Allowed Cladding Inside Radius / Thickness	None	16.75	9.14	9.14	9.14

Note: The cladding thickness and diameters bound current fuel designs and are for example purposes only. However, all fuel to be shipped must have a maximum pre-pressure times the maximum Inside Radius/Thickness product of 9.14 x 1.1145 MPa = 10.18653 MPa absolute or less. The thickness of the liner in liner cladding shall be excluded when determining radius and thickness. Thus, all products must meet the maximum product of allowed pressure multiplied by Inside Radius/Thickness of 10.18653 MPa.

Table 2: Bounding vs. Current Fuel Design Thermal Evaluation, Non-Liner

[redacted]

[2] AREVA currently does not have non-liner cladding product for ATRIUM 10XM and 11 fuel designs. Cladding ID and OD are derived from liner cladding drawings.

Table 3: Bounding vs. Current Fuel Design Thermal Evaluation, Liner

[redacted]