October 6, 2016

Mr. Gary Peters, Director
Licensing and Regulatory Affairs
AREVA Inc.
3315 Old Forest Road
Lynchburg, VA 24501

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION RE: AREVA INC. TOPICAL REPORT BAW-10192PA-00, SUPPLEMENT 1, REVISION 0, "BWNT LOCA – BWNT LOSS-OF-COOLANT ACCIDENT EVALUATION MODEL FOR ONCE-THROUGH STEAM GENERATOR PLANTS" (CAC NO. MF7145)

Dear Mr. Peters:

By letter dated November 25, 2015 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML15337A242), AREVA INC. (AREVA) submitted for U.S. Nuclear Regulatory Commission (NRC) staff review and approval Topical Report (TR) BAW-10192PA-00, Supplement 1, Revision 0, "BWNT [Babcock and Wilcox Nuclear Technologies] LOCA [loss-of-coolant accident] – BWNT Loss-of-Coolant Accident Evaluation Model for Once-Through Steam Generator Plants." Upon review of the information provided, the NRC staff has determined that additional information is needed to complete the review. On August 31, 2016, Jerald Holm, AREVA Product Licensing Manager, and I agreed that the NRC staff will receive the response to the enclosed RAI questions by January 23, 2017.

If you have any questions regarding the enclosed request for additional information (RAI) questions, please contact me at 301-415-4053.

Sincerely,

/RA/

Jonathan G. Rowley, Project Manager
Licensing Processes Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Project No. 728

Enclosure:
RAI Questions

October 6, 2016

Mr. Gary Peters, Director
Licensing and Regulatory Affairs
AREVA Inc.
3315 Old Forest Road
Lynchburg, VA 24501

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION RE: AREVA INC. TOPICAL REPORT BAW-10192PA-00, SUPPLEMENT 1, REVISION 0, "BWNT LOCA – BWNT LOSS-OF-COOLANT ACCIDENT EVALUATION MODEL FOR ONCE-THROUGH STEAM GENERATOR PLANTS" (CAC NO. MF7145)

Dear Mr. Peters:

By letter dated November 25, 2015 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML15337A242), AREVA INC. (AREVA) submitted for U.S. Nuclear Regulatory Commission (NRC) staff review and approval Topical Report (TR) BAW-10192PA-00, Supplement 1, Revision 0, "BWNT [Babcock and Wilcox Nuclear Technologies] LOCA [loss-of-coolant accident] – BWNT Loss-of-Coolant Accident Evaluation Model for Once-Through Steam Generator Plants." Upon review of the information provided, the NRC staff has determined that additional information is needed to complete the review. On August 31, 2016, Jerald Holm, AREVA Product Licensing Manager, and I agreed that the NRC staff will receive the response to the enclosed RAI questions by January 23, 2017.

If you have any questions regarding the enclosed request for additional information (RAI) questions, please contact me at 301-415-4053.

Sincerely,

/RA/
Jonathan G. Rowley, Project Manager
Licensing Processes Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Project No. 728

Enclosure:
RAI Questions

DISTRIBUTION:

PUBLIC	RidsNrrDpr	JRowley	KHsueh
RidsNrrDss	BParks	JDean	RidsNrrDprPlpb
RidsNroOd	RidsResOd	RidsNrrDssSnpb	RidsOgcMailCenter
RidsACRS_MailCTR			

ADAMS Accession Nos.: ML16271A259 ***concurrence via e-mail** **NRR-106**

OFFICE	PLPB/PM	PLPB/LA*	SNPB/BC	PLPB/BC	PLPB/PM
NAME	JRowley	DHarrison	JDean	KHsueh	JRowley
DATE	9/27/16	10/6/16	9/14/16	9/21/16	10/6/16

OFFICIAL RECORD COPY

REQUEST FOR ADDITIONAL INFORMATION

RELATED TO TOPICAL REPORT BAW-10192PA00, SUPPLEMENT 1, REVISION 0

"BWNT LOCA – BWNT LOSS-OF-COOLANT ACCIDENT EVALUATION MODEL FOR

ONCE-THROUGH STEAM GENERATOR PLANTS"

AREVA INC.

(CAC NO. MF7145)

RAI-1

Reference R-1 lacks a detailed description of the analytic process associated with Babcock & Wilcox Nuclear Technologies (BWNT) loss-of-coolant accident (LOCA), and how this process is modified to perform the input adjustments necessary to account for the effects of thermal conductivity degradation (TCD) within BWNT LOCA. Provide a detailed description of the modified large break (LB) LOCA methodology including a figure showing interfaces between the LB LOCA evaluation model (EM) computer codes and the parameters passed from one code to another.

RAI-2

During the audit documented in Reference R-2, the NRC staff reviewed calculation notebooks that provided a detailed discussion of the characteristics of each fuel performance code case that was used to determine the TCD bias function that is applied to the TACO3 (Reference R-3) and GDTACO (Reference R-4) initialization parameters (i.e., initialization parameters that are supplied to RELAP5/MOD2-B&W, Reference R-7). These descriptions are important to justify that the adjustment is based on a sufficient set of cases to provide a bounding representation of cycle operation, as are accompanying power history, or linear heat rate (LHR) limits. The topical report (TR) does not provide any discussion of the cases and the LHR limits shown in Figures 3.1 through 3.6 and Figure 3.8. Provide detailed discussions about them.

RAI-3

The applicability limits provided in Table 3-4 of Reference R-1 are based on calculation files supporting the development of the TR. Compare the basis against the applicability range of the computer codes (COPERNIC2 (Reference R-5), TACO3 and GDTACO) and experimental data used in the development of the TCD bias functions.

RAI-4

The trending illustrated in Figure 3-10 indicates **[**

]. Provide the evidence that **[**

].

Enclosure

RAI-5

During the audit the NRC staff indicated that information sufficient to compare the validating data used in Reference R-1 to current-generation fuel designs in use at Babcock and Wilcox (B&W) nuclear power plants would be necessary. In the response the vendor suggested that such data, regarding the Mark B-HTP fuel design, is available in the current revision of BAW-10179 (Reference R-6). Explain how the data varies for the B&W nuclear power plants.

RAI-6

The TR utilized a comparison between calculated fuel centerline temperature plus TCD bias function and measured fuel centerline temperature to conclude that the TCD bias functions have adequately penalized the TACO3/GDTACO fuel temperature predictions. It is not readily apparent to the NRC staff that such a comparison leads to the conclusion in the TR. Provide the following additional information.

a. Additional justification that applying a bias function based on the **[ ]** for the LOCA initialization.

b. Explanation of the process of transforming the VAFT from TACO3 to RELAP5-BEACH (Reference R-7) heat structure initial temperatures, which includes comparison of the following VAFTs across the core axial elevation for the hot pin: TACO3 best-estimate, TACO3 upper tolerance limit, COPERNIC2 best-estimate, COPERNIC2 upper tolerance limit, TACO3 adjusted additively, and TACO3 with the TCD bias ratio applied.

c. Descriptions and comparisons similar to the ones discussed in Item b, comparing the hot pin adjustment to the hot bundle adjustment.

d. The plots in the presentation during the audit showing the **[ ]** to clarify the application of a **[ ]**. The plots should include more data (purple dots) to compare against the solid gold line as shown on Page 31 of presentation.

RAI-7

Section 3.1.2.1 of Reference R-1 states that the generic TCD bias function is developed with cases **[ ]**. This is inconsistent with the approved LOCA initialization methodology. Provide the explanation of why this is acceptable.

RAI-8

It is necessary to perform a sufficiently complete evaluation of the **[ ]** modeling option employed for LOCA initializations using TACO3 and GDTACO, which were added after NRC staff approval of the TACO3 and GDTACO fuel performance methods.

a. Provide comparisons among TACO3 and GDTACO, TACO3 and GDTACO with **[ ]**, and COPERNIC2 at middle-of-life and end-of-life conditions, as well as experimental data if available, for LOCA-initialized fuel pins. The comparisons should include radial power distribution, VAFTs, cladding inner radii, fuel outer radii, pin pressure, pin gas composition, oxide thickness, and final plenum volume.

b. Clarify the term “[ ]” in the first paragraph on Page 5-4 of Reference R-1. This term seems to mean the “[ ]” based on the LBLOCA analysis methodology discussed in the TR, but the term itself implies that the [ ] of the LOCA initializations.

RAI-9

Apparently, TACO3, GDTACO, and COPERNIC2 do not use common temperature units. While TACO3 and GDTACO use degrees Fahrenheit (°F), COPERNIC2 uses degrees Celsius (°C). Explain clearly the temperature units used in computation, and those used in developing bias functions. Then justify the applying ratios that are based on non-absolute temperature units (i.e., °F and °C have arbitrary zero values, whereas Kelvin (K) and Rankine (R) are the corresponding absolute temperature scales) because the use of different temperature units will result in different values for the VAFT axial adjustment ratio.

RAI-10

Figure 5-18 of Reference R-1 shows the [ ]. However, they are different from those in Figures 3-1, 3-2, and 3-5. The differences are not only in the [ ]. Provide discussion to clarify the differences and explain the significance of distinguishing the figures by [ ].

RAI-11

With regard to the [ ] discussed in Section 4.2.2 of Reference R-1, the following additional information is requested in order to continue its review.

a. Sensitivity studies varying the gas gap multiplier across the range of target values ([ ]), showing the following results: predicted cladding temperature behavior including the peak cladding temperature (PCT), gap conductance, and gap dimension.

b. Consideration, within the sensitivity studies discussed above, for variability in fuel cladding plastic deformation and rupture behavior, and for varying Gadolinia concentrations.

RAI-12

AREVA asserts in the middle of the first paragraph on Page 4-14 of Reference R-1 that “while [ ] can change the heat removal during the first several seconds of the LOCA, it is a minimal effect and the variation is acceptable.” Provide addition clarification to show the effect is minimal and the variation is acceptable.

RAI-13

Provide additional description of the adjustment process, including the as-adjusted fuel rod parameters, analogous to the information provided in Tables 5-7 and 7-5 of Audit Document 32-9245587-000, "LBLOCA Demonstration Analyses for TCD."

RAI-14

AREVA mentioned during the audit that the **[** **]** in the hot rods modeled in the core region. The following additional information is requested to clarify the consequence of monitoring only three nodes.

a. In many cases the PCT occurs downstream from the hot cell (the peak power location). Confirm that the PCT is predicted **[** **]** in the LBLOCA analysis.

b. It appears that the gap multipliers are **[** **]**.

c. Clarify the process of determining and monitoring the gap gas multipliers for the hot bundle and the average bundle.

RAI-15

Uncertainties are added to the VAFTs predicted by TACO3/GDTACO for the hot pin and hot bundle. Provide the following additional information.

a. Detailed discussions of the development and qualification of the uncertainties. In particular, the discussion should highlight the application of uncertainties in the modified LOCA methodology that deviates from the previously approved methodology.

b. Justification for the uncertainty factor of **[** **]**. The uncertainty factor of **[** **]**, determined for the UO_2 hot pin, was based on a statistical analysis of measurements versus TACO3 predictions. However the same uncertainty factor is also applied to temperatures of Gadolinia hot pins (see Equation 6).

RAI-16

A couple of labels in the figures of Reference R-1 are ambiguous and may lead to wrong interpretations. One example is "RELAP w/o TCD" in Figures 4-4 and 4-5. This represents the RELAP5 initial temperature with TCD bias but without considering the burnup-dependent fuel thermal conductivity. Clarify the labels of "RELAP w/o TCD" and "RELAP-TCD" with appropriate discussions.

RAI-17

The last sentence of the second paragraph on Page 4-9 states that the shifts (of the mesh point temperatures) are most obvious at the fuel and clad interface and the outside clad radius. However, there is no clad temperature difference between the predictions of COPERNIC2 and TACO3 as shown in Figure 4-5. Clarify the difference between the discussion and Figure 4-5.

RAI-18

Section 5 of Reference R-1 shows the changes in the PCT predictions with and without TCD adjustments. In all cases a core inlet skewed axial peak at 2.506 feet was taken into account. The second paragraph on Page 5-3 of the TR states, “This core inlet elevation was selected because this is the elevation at which LOCA analyses set the core imbalance limits.” Explain if this elevation is determined from previous LBLOCA analyses and whether this methodology supplement will have any impact on the selection of the elevation for setting the core imbalance limits.

RAI-19

Supplement the information presented in Tables 5-1 through 5-4 of Reference R-1 by including the peak rod burnup and the TACO3/GDTACO best-estimate initial peak VAFT as determined using the **[ ]** LOCA initialization.

RAI-20

In Section 3.2.2 of Reference R-1 a comparison of temperatures between calculated and measured data from high burnup test rods is used to validate the generic TCD bias functions. Equation 7 shown on Page 3-12 of Reference R-1 **[ ]**. There is no technical basis provided in the TR to justify the equality shown in the equation. However it can be inferred from Equation 3 and the discussion in the first paragraph on Page 4-5 of Reference R-1 that if the **[ ]** is removed from the right hand side of Equation 7 the resulting temperature then represents a best-estimate prediction of centerline temperature that accounts for TCD. That is,

[ ]

Using the above formulation as the predicted centerline temperature, quantify the temperature difference (the predicted minus measured centerline temperature) that bounds 95 percent of the data with a 95 percent confidence level. That is, find the value of X, such that,

[ ]

RAI-21

The TCD effect raises the fuel pellet temperatures leading to variations in thermal expansion of the fuel pellet (as compared to no TCD effect) and affects the fuel pellet radius and the clad inner radius. The LOCA EM applies RELAP5 calculated radial displacement factors for the fuel pellet and the clad to set the fuel radius and the clad inside radius for the gap size calculation throughout the transient (see discussion on Page 4-7 of Reference R-1). The following information is requested to assist in the review of the application of the displacement factors in the context of accounting for the effect of TCD in a LOCA analysis.

a. The discussion of the radial displacement factor is in Reference R-1, Section 4.2 – LOCA Transient EM Method Changes. Identify and clarify changes in the calculation and application of the radial displacement factors that are different from the approved LOCA EM.

b. Explain if there is any impact on the determination and application of the TCD bias factor due to the application of the radial displacement factors in the LOCA initialization.

c. Is there any difference in the calculation of the radial displacement factor and its axial variation for all the different fuel in the core (hot pins, hot bundle and average bundle)?

d. How does the application of the radial displacement factors affect the determination of the gap gas multipliers?

   Provide justification for using constant radial displacement factors throughout the LOCA transient.

REFERENCES

R-1. AREVA, Inc., "BWNT LOCA: BWNT Loss-of-Coolant Accident Evaluation Model for Once-Through Steam Generator Plants," BAW-10192PA-00, Supplement 1P/NP, Revision 0, Project No. 728, November 25, 2015, Agencywide Document Access and Management System (ADAMS) Package No. ML15337A257.

R-2. U.S. NRC, "AREVA Inc. – Babcock and Wilcox Nuclear Technologies Loss-of-Coolant Accident Evaluation Model for Once-Through Steam Generator Plants – Supplement 1P to BAW-10192PA – Nuclear Performance and Code Review Branch Audit Report (TAC No. MF7145)," Project No. 728, May 31, 2016, ADAMS Accession No. ML16147A031 (Proprietary document; no publicly available copy located).

R-3. Babcock and Wilcox Nuclear Technologies, "TACO3 – Fuel Pin Thermal Analysis Code," BAW-10182P-A, October 1989 (Document not found in ADAMS).

R-4. Babcock and Wilcox Nuclear Technologies, "GDTACO – Urania Gadolinia Fuel Pin Thermal Analysis Code," BAW-10184P-A, February 1995, ADAMS Accession No. ML15028A446 (Proprietary report; no non-proprietary version available).

R-5. Framatome ANP, Inc., "COPERNIC Fuel Rod Design Computer Code," BAW-10231(P/NP)(A), Project No. 728, September 30, 2004, ADAMS Package No. ML042930233.

R-6. AREVA NP, Inc., "Safety Criteria and Methodology for Acceptable Cycle Reload Analyses," BAW-10179(P/NP)(A), Revision 8, Project No. 694, August 6, 2010, ADAMS Package No. ML102210442.

R-7. AREVA NP, Inc., "RELAP5/MOD2-B&W: An Advanced Computer Program for Light Water Reactor LOCA and Non-LOCA Transient Analysis," BAW-10164P-A, Revision 6, June 2007, ADAMS Accession No. ML091410456 (Proprietary report; no publicly available copy located).