ATTACHMENT 2

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION FOR LICENSE AMENDMENT REQUEST REGARDING REALISTIC LARGE BREAK LOSS OF COOLANT ACCIDENT ANALYSIS – RAI QUESTIONS 1 THROUGH 3 (NON-PROPRIETARY)

DOMINION NUCLEAR CONNECTICUT, INC.
MILLSTONE POWER STATION UNIT 2

0414-12-F04 (Rev. 001, 03/10/2016)

AREVA

Millstone Unit 2 M5® Upgrade, Realistic Large Break LOCA Analysis RAI Responses

ANP-3316QNP
Revision 0

Licensing Report

October 2016

AREVA Inc.

Nature of Changes

Item	Section(s) or Page(s)	Description and Justification
1	All	Initial Issue

Contents

List of Tables

List of Figures

Nomenclature

Acronym	**Definition**
ASI	Axial Shape Index
COLR	Core Operating Limits Report
ECCS	Emergency Core Cooling System
EM	Evaluation Model
LAR	Licensing Amendment Request
LHGR	Linear Heat Generation Rate
LOCA	Loss of Coolant Accident
NRC	Nuclear Regulatory Commission
NSSS	Nuclear Steam Supply System
PLHGR	Peak Linear Heat Generation Rate
RAI	Request Additional Information
RLBLOCA	Realistic Large Break LOCA
SE	Safety Evaluation

1.0 SUMMARY

This report contains the responses to RAI 1 through RAI 3 as asked by the NRC for the Millstone Unit 2 M5® Upgrade Realistic Large Break LOCA Analysis.

2.0 RAI 1

Question

At the time of submittal of the LAR, the realistic large break loss of coolant accident (RLBLOCA) methodology limitations and conditions were not fully established. Since the application is seeking approval with the final approved version of the methodology, please address in Table 4 of the LAR the limitations and conditions that are now fully established and finalized and approved in the RLBLOCA methodology final safety evaluation.

Response

The final SE limitations have been reviewed. A revised SE limitation evaluation table is provided in Table 2—1.

Table 2—1 Final SE Limitations Evaluation

Limitations (Section 4.0 of the Safety Evaluation in Ref. [1])		Response
1	This EM was specifically reviewed in accordance with statements in EMF-2103, Revision 3. The NRC staff determined that the EM is acceptable for determining whether plant-specific results comply with the acceptance criteria set forth in 10 CFR 50.46(b), paragraphs (1) through (3). AREVA did not request, and the NRC staff did not consider, whether this EM would be considered applicable if used to determine whether the requirements of 10 CFR 50.46(b)(4), regarding coolable geometry, or (b)(5), regarding long-term core cooling, are satisfied. Thus, this approval does not apply to the use of SRELAP5-based methods of evaluating the effects of grid deformation due to seismic or LOCA blowdown loads, or for evaluating the effects of reactor coolant system boric acid transport. Such evaluations would be considered separate methods.	This analysis applies only to the acceptance criteria set forth in 10 CFR 50.46(b), paragraphs (1) through (3).
2	EMF-2103, Revision 3, approval is limited to application for 3-loop and 4-loop Westinghouse-designed nuclear steam supply systems (NSSSs), and to Combustion Engineering-designed NSSSs with cold leg ECCS injection, only. The NRC staff did not consider model applicability to other NSSS designs in its review.	Millstone Unit 2 is a Combustion Engineering-designed NSSS with cold leg ECCS injection.
3	The EM is approved based on models that are specific to AREVA proprietary M5® fuel cladding. The application of the model to other cladding types has not been reviewed.	The analysis supports operation with M5® cladding.
4	Plant-specific applications will generally be considered acceptable if they follow the modeling guidelines contained in Appendix A to EMF 2103, Revision 3. Plant-specific licensing actions referencing EMF 2103, Revision 3, analyses should include a statement summarizing the extent to which the guidelines were followed, and justification for any departures.	The modeling guidelines contained in Appendix A of EMF-2103, Revision 3 were followed completely for the analysis described in this report.

5	The response to RAI 15 indicates that the fuel pellet relocation packing factor is derived from data that extend to currently licensed fuel burnup limits (i.e., rod average burnup of [ ]). Thus, the approval of this method is limited to fuel burnup below this value. Extension beyond rod average burnup of [ ] would require a revision or supplement to EMF-2103, Revision 3, or plant-specific justification.	The analysis supports operation with M5® cladding, which has a licensed limit of [ ].
6	The response to RAI 15 indicates that the fuel pellet relocation packing factor is derived from currently available data. Should new data become available to suggest that fuel pellet fragmentation behavior is other than that suggested by the currently available database, the NRC may request AREVA to update its model to reflect such new data. Such a request would be tendered by a letter from the NRC to AREVA identifying the newly available data and requesting an update to the model, or an assessment to demonstrate that such an update is not needed.	[ ]
7	The regulatory limit contained in 10 CFR 50.46(b)(2), requiring cladding oxidation not to exceed 17 percent of the initial cladding thickness prior to oxidation, is based on the use of the Baker-Just oxidation correlation. To account for the use of the C-P correlation, this limit shall be reduced to 13 percent, inclusive of pre-transient oxide layer thickness.	The MLO UTL is less than 13% (Ref. [2]: Table 5). [ ]
8	In conjunction with Limitation 8 [*sic*] above, C-P oxidation results will be considered acceptable, provided plant-specific [ ]. If second-cycle fuel is identified in a plant-specific analysis, whose [ ], the NRC staff reviewing the plant-specific analysis may request technical justification or quantitative assessment, demonstrating that [	[ ]

	]	
9	The response to RAI 13 states that all operating ranges used in a plant-specific analysis are supplied for review by the NRC in a table like Table B-8 of EMF-2103, Revision 3. In plant-specific reviews, the uncertainty treatment for plant parameters will be considered acceptable if plant parameters are [ ] , as appropriate. Alternative approaches may be used, provided they are supported with appropriate justification.	[ ]
10	[ ]	[ ]
11	Any plant submittal to the NRC using EMF-2103, Revision 3, which is not based on the first statistical calculation intended to be the analysis of record must state that a re-analysis has been performed and must identify the changes that were made to the evaluation model and/or input in order to obtain the results in the submitted analysis.	[ ]

3.0 RAI 2

Question

a) A strong trend was observed when reviewing the plot of the peak linear heat generation rate (PLHGR) versus the axial shape index (ASI). Please discuss how the PLHGR is used in the development of the axial power shape, why this strong trend exists, and how does this reflect physical plant operation.

b) There are several points that do not fall into the trend observed in Part a (e.g., point with sampled ASI of -0.0071). Please discuss if the plant can physically achieve these points or similar points that do not fall into the observed trend. If such points can physically exist during plant operation, please provide the maximum PLHGR the plant can achieve as a function of ASI over the range used in the analysis and please justify that the analysis results remain conservative.

Response

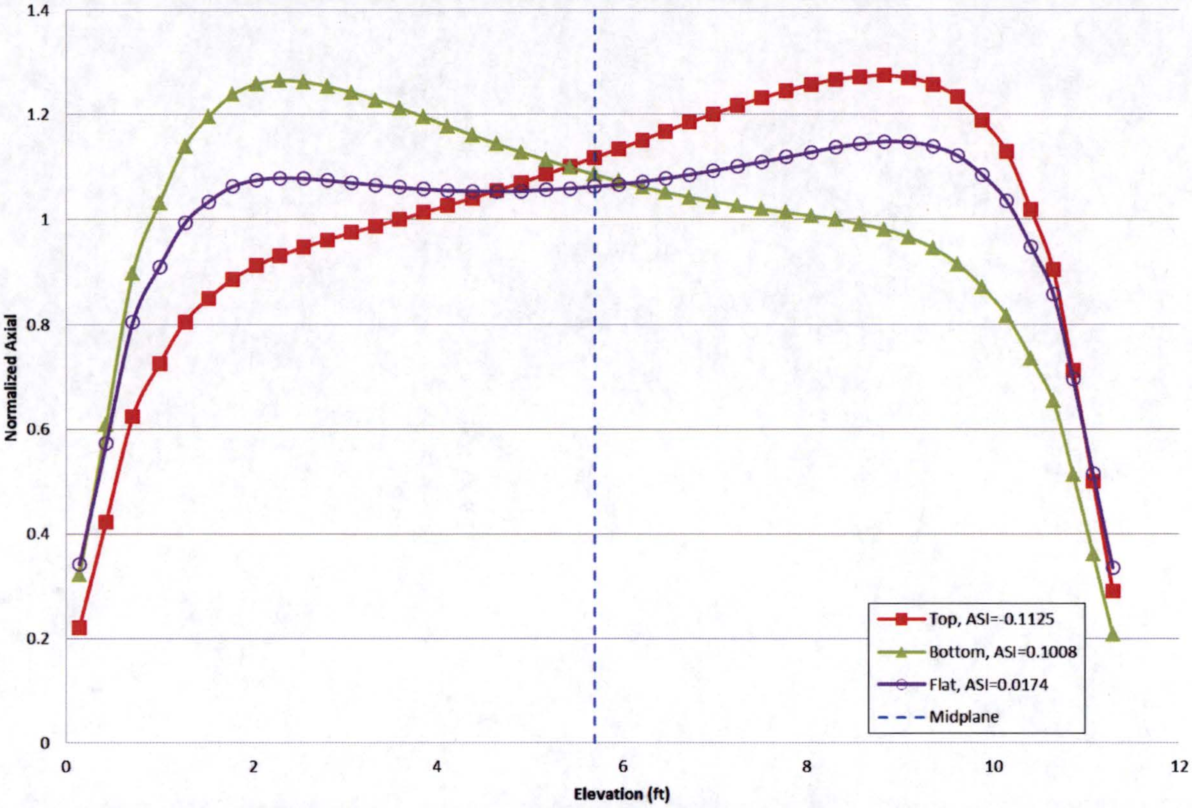
Table A-1 of Reference [2] presents an “LHGR” value and an “ASI” value for each case. The LHGR value is equivalent to the sampled peak linear heat generation rate (PLHGR) and is a measure of the magnitude of power at the peak location. The ASI is the sampled fresh fuel hot rod axial shape index and is a measure of the difference between the power in the bottom half and the top half divided by the sum of the top and bottom halves. A plot of the PLHGR versus the ASI for each case shows the expected V-shape relationship between the two parameters: larger values of PLHGR values are associated with larger absolute ASI values. The V-shape relationship can be best explained using a plot of normalized axial shapes. Figure 3—1 shows an example of a top peaked shaped, a bottom peaked shape, and a relatively flat shape with their corresponding ASI values listed in the plot legend. As the axial shape becomes more skewed, the amount of power in the top or bottom region increases and the absolute value of ASI increases. As can be seen in the Figure 3—1, in order to skew the relative power in a region, the axial peaking increases and, accordingly PLHGR also increases.

However, PLHGR is associated with a single peak location in the rod, whereas ASI is a shape dependent indication of how the power is distributed over the full length of the rod. Because ASI is only a measure of relative power between regions, it is possible for shapes to have a moderate PLHGR and a low absolute ASI, like the case identified in RAI-2b.

During operation, the plant monitors the core power distribution in accordance with the Technical Specifications. It performs this function by continuously verifying that the core ASI and LHGR are maintained within the allowable limits specified in the Core Operating Limits Report (COLR). For the RLBLOCA uncertainty analysis, a set of axial shapes with ASIs supporting the plant's COLR operating barns and Technical Specification limits are generated. The process used in selecting the axial shape from those provided is described in Sections 9.3.1.3 and 9.3.1.4 of Reference [1]. The set of axial shapes is utilized in the sampling process and the selected axial shape is used without modification in the analysis. Accordingly, the relationship between ASI and PLHGR is maintained and that relationship is representative of plant operation.

All the sampled case axials in the analysis described in Reference [2] were derived from the axials provided for Millstone Unit 2. While larger PLHGR and, due to the relationship, larger absolute ASI values tend to result in more limiting PCTs, there are many other considerations and sampled inputs that will impact the magnitude of the PCTs. For instance, Figure 3 of Reference [2] shows the strong relationship of the PCT results to the break size input. The RLBLOCA method is a statistically based method and does not strive to make each case the most conservative result. The case-specific LOCA results are representative of the population of possible LOCA events for a given plant. From the set of all the case-specific results, the reported LOCA results are determined in order to provide a high confidence that the 10 CFR 50.46 criteria are met.

Figure 3—1 Example Axial Shapes – Peaking Comparison



4.0 RAI 3

Question

Figure 7 of Attachment 4 of the LAR shows the break flow for the demonstration case. At approximately 60 seconds, there is an increase in break flow on the vessel side that appears to be coincident with the end of safety injection tank (SIT) injection and a decrease in the lower plenum collapsed liquid level in Figure 14. Please explain why the increase in vessel side break flow is observed during this time in order for the staff to confirm that this physical behavior is expected rather than a code numerical abstraction to ensure the analysis results are conservative.

Response

The break flow increase at 60 seconds is driven by a combination of steam binding in the steam generator tubes coincident with downcomer filling, SIT emptying and nitrogen injection into the cold legs.

At about 60 seconds ECCS has filled the downcomer to approximately the cold leg elevation. As the mixture level rises up through the core, steam is generated which entrains liquid up to the entrance of the steam generator tubes. This causes a spike in the upper plenum pressure (Figures 16 and 17 of Reference [2]). As the liquid in the steam generator tubes drops back to the hot leg, the increased upper plenum pressure drives steam flow through the intact loops and out the vessel side break. The SITs empty coincidentally, and nitrogen cover gas combines with the steam flow to entrain liquid from the downcomer, which reached the cold leg nozzle elevation, carrying it to the reactor vessel side of the break. This accounts for the increase in break flow and is similar to the break flow increase that occurs between 40 and 55 seconds.

Therefore, the increase in break flow at 60 seconds is explained by observation of the physical results and is not a numerical anomaly.

5.0 REFERENCES

1. EMF-2103P-A, Revision 3, "Realistic Large Break LOCA Methodology for Pressurized Water Reactors", June 2016
2. AREVA Document, ANP-3316P, Revision 0, "Millstone Unit 2 M5® Upgrade, Realistic Large Break LOCA Analysis Licensing Report", May 2016

ATTACHMENT 3

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION FOR LICENSE AMENDMENT REQUEST REGARDING REALISTIC LARGE BREAK LOSS OF COOLANT ACCIDENT ANALYSIS – RAI QUESTIONS 4 THROUGH 6

**DOMINION NUCLEAR CONNECTICUT, INC.
MILLSTONE POWER STATION UNIT 2**

By letter dated May 25, 2016, Dominion Nuclear Connecticut, Inc. (DNC) submitted a license amendment request (LAR) for Millstone Power Station Unit 2 (MPS2). The proposed amendment would add the AREVA topical report EMF-2103(P)(A), "Realistic Large Break Loss of Coolant Accident (RLBLOCA) Methodology for Pressurized Water Reactors," to TS 6.9.1.8.b, "Core Operating Limits Report," which lists the analytical methods used to determine the core operating limits. In an email dated September 16, 2016, the Nuclear Regulatory Commission (NRC) transmitted a request for additional information (RAI) to DNC related to the LAR. This attachment provides DNC's response to RAI Questions 4 through 6.

RAI – 4

As discussed in the LAR, this analysis does not credit charging flow. It is generally presumed that the reduction of injected flow will provide conservative results. However, there is a competing effect that the additional spilled flow could influence the containment back pressure and potentially impact late reflood peak cladding temperatures (PCTs). Although no credit is given to the injection in the analysis, will the charging system still physically receive an emergency injection signal and provide additional emergency core cooling system (ECCS) flow (both injected and spilled)? If so, please justify that the results (particularly the late reflood case with the highest PCT, Run 181) are still conservative.

DNC Response

The MPS2 charging pumps are positive displacement pumps that deliver a nominal 44 gpm per charging pump or a maximum of 49 gpm per charging pump. MPS2 has three charging pumps in total, one pump for each ECCS train and one pump maintained in pull-to-lock such that it will not automatically start on a safety injection signal. Following a LOCA with a single failure of an ECCS train, one charging pump will deliver flow into two reactor coolant system (RCS) cold legs on a safety injection signal.

Due to the difference in system resistances, the charging flow to the intact RCS cold leg is 21 gpm (43%) while the charging flow to the broken RCS cold leg is 28 gpm (57%) when the RCS cold leg pressures are equal. Assuming an RCS pressure of 35 psia (an expected RCS pressure during the late reflood period), the ECCS flow to the intact legs (high pressure safety injection (HPSI) and low pressure safety injection (LPSI)) is 1644 gpm and the ECCS flow (HPSI and LPSI) to the broken leg is 1417 gpm (See Table 1 of Attachment 4 of the LAR).

In this scenario, one charging pump would increase the ECCS spilled flow by less than 2% and the ECCS injected flow by 1.2%. The RLBLOCA analysis assumes a total containment spray of 3800 gpm. The additional ECCS spillage to the containment from the charging system is a 0.5% increase over the combined ECCS

spillage and containment spray assumed in the RLBLOCA analysis. The 0.5% increase is negligible. Therefore, the analysis results presented in the LAR remain valid.

RAI – 5

Table 2 of Attachment 4 of the LAR notes that the Measurement Uncertainty Distribution is not applicable (N/A) for some parameters. To ensure that the analysis is conservative, please confirm that although measurement uncertainty distribution is N/A for these parameters, the measurement uncertainty is still included in the analyzed range.

DNC Response

Table 2 of Attachment 4 of the LAR notes that the measurement uncertainty distribution is not applicable for the following parameters: safety injection tank (SIT) volume, SIT pressure, containment/SIT temperature, containment volume, initial flowrate, and initial operating temperature. The measurement uncertainty is included in the sampled ranges of these parameters listed in the table, with the exception of the containment volume, which is not measured. The containment volume ranges from a minimum value corresponding to the net free volume of containment to a maximum value corresponding to the gross volume of containment. Thus, the appropriate uncertainties were included in the analyzed ranges.

RAI – 6

Table 1, Item K and I in Attachment 4 of the LAR provides the Low Pressure Safety Injection (LPSI) flow and High Pressure Safety Injection (HPSI) flow, respectively, used in the RLBLOCA analysis. Table 14.6.5.1-3 of the MPS2 Final Safety Analysis Report contains the HPSI and LPSI flow used in the analysis of record (AOR). The RLBLOCA values and the AOR values in these tables appear to differ from one another. Please explain why there is this difference between the AOR and the RLBLOCA analysis and please confirm that the flows used in both analyses remain conservative relative to plant operation.

DNC Response

The current LBLOCA AOR and RLBLOCA analysis use minimum ECCS flow delivery values that bound the minimum flow rates supported by the current MPS2 In-Service Test (IST) program.

The RLBLOCA analysis uses the same values for the HPSI flow rates, expressed in gallons per minute, as the current LBLOCA AOR except that the flow rate to each

RCS loop are rounded down to the nearest integer value. The minimum LPSI flow rates, used in both the RLBLOCA analysis and LBLOCA AOR, also bound the values supported by the current MPS2 IST program. The differences in LPSI flow rates between the RLBLOCA analysis and the current LBLOCA AOR are due to a recalculation of the LPSI flow rates after the LBLOCA AOR was performed. Both HPSI and LPSI flow rates used in the RLBLOCA LAR and the current AOR remain conservative relative to plant operation.

ATTACHMENT 4

AREVA APPLICATION FOR WITHHOLDING AND AFFIDAVIT

DOMINION NUCLEAR CONNECTICUT, INC.
MILLSTONE POWER STATION UNIT 2