ENCLOSURE 2

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO AMENDMENT NO. 332

TO RENEWED FACILITY OPERATING LICENSE NO. DPR-65

DOMINION NUCLEAR CONNECTICUT, INC.

MILLSTONE POWER STATION, UNIT NO. 2

DOCKET NO. 50-336

(Non-Proprietary - Redacted Version)

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Proprietary information pursuant to Title 10 of the *Code of Federal Regulations* Section 2.390 has been redacted from this document.

Redacted information is identified by blank space enclosed within double brackets ([[ ]]).

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

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1.0 INTRODUCTION

By application dated May 25, 2016 (Reference 1), as supplemented by letters dated June 15, 2016 (Reference 2), and October 18, 2016 (Reference 3), Dominion Nuclear Connecticut, Inc. (the licensee) requested changes to the Millstone Power Station, Unit No. 2 (MPS2) Technical Specification (TS) Section 6.9.1.8.b, "Core Operating Limits Report." The proposed change would add the evaluation model in AREVA Topical Report EMF-2103(P), Revision 3, "Realistic Large Break LOCA Methodology for Pressurized Water Reactors" (Reference 4) to the MPS2 TS Section 6.9.1.8.b list of analytical methods to establish core operating limits. The licensee proposed the change as a result of reanalyzing the large break loss-of-coolant accident (LBLOCA) with EMF-2103(P)(A), Revision 3 methodology.

The supplemental letters dated June 15, 2016, and October 18, 2016, provided additional information that clarified the application, did not expand the scope of the application as originally noticed, and did not change the U.S. Nuclear Regulatory Commission (NRC or the Commission) staff's original proposed no significant hazards consideration determination as published in the *Federal Register* (FR) on August 30, 2016 (81 FR 59662).

2.0 REGULATORY EVALUATION

2.1 Background

The current LBLOCA analysis of record (AOR) for MPS2 is based on the NRC-approved EXEM Pressurized Water Reactor (PWR) LBLOCA evaluation model (EM) as modified by EMF-2087(P), "SEM/PWR-98: ECCS Evaluation Model for PWR LBLOCA Applications," as described in the MPS2 Final Safety Analysis Report (FSAR).

With this license amendment request (LAR), the licensee is requesting the use of EMF-2103(P)(A), Revision 3 (Reference 5), as the EM for analyzing the design-basis LBLOCA. The realistic large-break loss-of-coolant accident (RLBLOCA) methodology consists of the COPERNIC fuel rod design code and S-RELAP5 thermal-hydraulic code (which includes the ICECON code for containment response). This LBLOCA analysis was completed by modeling the AREVA Standard CE14 CTP [high thermal performance] fuel product with M5® cladding, which the licensee intends on loading for MPS2 Cycle 25. The licensee did not analyze the fuel product that is currently loaded at MPS2 with the RLBLOCA methodology. Rather, the licensee

intends on maintaining both the current LBLOCA AOR and the RLBLOCA analysis (once the M5® cladding fuel product is loaded) until the current fuel product used at MPS2 is no longer limiting.

The submitted MPS2 RLBLOCA analysis is based on the draft safety evaluation (SE) for the initial submittal of the RLBLOCA methodology (Reference 6); the responses to first and second round request for additional information (RAIs) (Reference 7); the revised pages for EMF-2103(P), Revision 3 (Reference 8); and the draft SE for EMF-2103(P), Revision 3 (Reference 9).

The licensee proposed EMF-2103 implementation prior to AREVA's final submittal of the approved methodology to the NRC. Therefore, during the course of its review, the NRC staff verified that no changes were made to the final, as-approved methodology that would have impacted the results and conclusions of the submitted plant-specific analysis. The NRC staff did not identify any such items. Further, the NRC staff requested that the licensee describe how it satisfied the final limitations outlined in the SE approving EMF-2103P-A, Revision 3, hereafter referred as the "final SE" (Reference 10). The staff evaluation of the licensee's disposition for the limitations is discussed in Section 3.1.1 of this SE.

2.2 Proposed Changes

The licensee has proposed to revise TS 6.9.1.8.b to add the RLBLOCA methodology to the list of analytical methods used to determine the core operating limits for MPS2.

Specifically, the licensee has proposed to add the following reference to TS 6.9.1.8.b:

> 18) EMF-2103(P)(A), "Realistic Large Break LOCA Methodology for Pressurized Water Reactors."

No additional changes to the TSs were requested.

2.3 Applicable Regulatory Requirements and Guidance

The regulatory requirements and guidance that the NRC staff considered in its review of the proposed license amendment include the following:

- *Code of Federal Regulations* (10 CFR) Section 50.36, "Technical specifications," insofar as it requires technical specifications that include limiting conditions for operation (LCOs) that are the lowest functional capability or performance levels of equipment required for safe operation of the facility, which are, in part, established for a process variable, design feature, or operating restriction that is an initial condition of a design-basis accident analysis that either assumes failure of or presents a challenge to the integrity of a fission product barrier.

- Generic Letter (GL) 88-16 (Reference 11), "Removal of Cycle-Specific Parameter Limits form Technical Specifications," insofar as it provides guidance for modifying TSs to remove cycle-specific parameter limits from the TSs to a licensee-controlled core operating limits report (COLR).

- 10 CFR 50.46, "Acceptance criteria for emergency core cooling systems (ECCSs) for light-water nuclear power reactors," insofar as it requires that each boiling or pressurized light-water nuclear power reactor fueled with uranium oxide pellets within cylindrical zircaloy or ZIRLO cladding must be provided with an ECCS that must be designed so that its calculated cooling performance following a postulated loss-of-coolant accident (LOCA) conforms to the criteria set forth in 10 CFR 50.46(b), including peak cladding temperature, maximum cladding oxidation, maximum hydrogen generation, and coolable geometry.

- 10 CFR 50, Appendix A, GDC-35, "Emergency core cooling," insofar as it requires that a system to provide abundant emergency core cooling be provided to transfer heat from the reactor core following any LOCA at a rate so that fuel clad damage that could interfere with continued effective core cooling will be prevented.

Additionally, the NRC staff used Standard Review Plan (SRP) 15.6.5, "Loss-of-Coolant Accidents Resulting from Spectrum of Postulated Piping Breaks Within the Reactor Coolant Pressure Boundary" from NUREG 0800 (Reference 12), as guidance for reviewing the application.

Note that an exemption from 10 CFR 50.46 was approved for MPS2 to allow the use of the M5® alloy for fuel cladding (Reference 13).

3.0 TECHNICAL EVALUATION

The NRC staff used the applicable sections of SRP 15.6.5 of NUREG 0800 as guidance to complete the review. The primary focus of the staff's review was the implementation of, and adherence to, the RLBLOCA methodology. The review, in part, consisted of the following: (1) determining how the licensee addressed the limitations and conditions found in the final SE, (2) reviewing the initial conditions used in the analysis to ensure that they are consistent with the plant's licensing basis, and (3) reviewing the analytical results to ensure that the model is predicting results that are expected for this plant design.

3.1 Implementation of RLBLOCA Methodology

As documented in the NRC staff's SE, the RLBLOCA methodology (Reference 5) is approved for use. This MPS2 analysis is the first plant-specific application of the methodology. The staff reviewed the LAR to ensure that the methodology was implemented appropriately, which involved an examination of the licensee's: (1) adherence to the RLBLOCA methodology limitations (identified in the final SE), (2) development of the MPS2-specific model, (3) execution of the analysis, and (4) review and presentation of the results.

3.1.1 RLBLOCA Methodology Limitation Review

In the LAR, the licensee addressed the limitations provided in the draft SE (Reference 9). Given that the licensee is seeking approval with the finalized version of the RLBLOCA methodology, the staff asked whether the analysis adhered to the finalized limitations found in Section 4.0 in the final SE (found after the cover page of Reference 5).

The licensee addressed the finalized limitations and conditions in RAI-1 of its response in Reference 3 to the NRC staff's RAI dated September 16, 2016 (Reference 14). The licensee addressed each finalized limitation. Each of the limitations and how the licensee satisfied them are summarized below.

Limitation 1: Acceptance Criteria Satisfied by This Evaluation

This limitation states that EMF-2103, Revision 3, 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) only, and the EM is not acceptable for use is determining whether the requirements of 10 CFR 50.46(b) paragraphs (4) or (5) are satisfied.

The NRC staff reviewed the LAR and determined, from the results presented in Attachment 4 of the LAR and discussion in Section 5.1 of Attachment 1 of the LAR, that the licensee is only using the RLBLOCA methodology to show compliance with 10 CFR 50.46(b), paragraphs (1) through (3). Thus, the NRC staff concludes that this limitation is met.

Limitation 2: Plant Design Applicability

The RLBLOCA methodology is applicable to 3-loop and 4-loop Westinghouse-designed plants and Combustion Engineering (CE)-designed plants with cold leg ECCS injection, only.

The NRC staff reviewed the licensing basis for MPS2 and confirmed that MPS2 is a CE-designed plant with cold leg ECCS injection. Thus, the NRC staff concludes that this limitation is met.

Limitation 3: Fuel Cladding

The RLBLOCA methodology is limited to the use of AREVA proprietary M5® fuel cladding.

The NRC staffed reviewed the LAR and confirmed that the analysis with the RLBLOCA methodology was completed using M5® fuel cladding. Additionally, the licensee states that current fuel product, analyzed with the AOR methodology, will continue to remain in the licensing basis, along with the RLBLOCA methodology, and that both analyses will be maintained. Since both AOR analysis and this analysis will be governed by the requirements of 10 CFR 50.46, and 10 CFR 50.46 does not provide a limit to the number of analyses used to demonstrate the criteria, the NRC staff finds this approach acceptable.

Limitation 4: Modeling Guidelines

Appendix A to the RLBLOCA methodology contains modeling guidelines. If these guidelines are followed, these plant-specific applications will generally be considered acceptable. Additionally, the LAR should include a statement summarizing the extent to which the guidelines were followed and justify any departures. Additionally, the NRC staff should determine if the absolute adherence to the modeling guidelines would be inappropriate for a specific plant.

The licensee stated in Item 4 in Table 2-1 of the RAI response that the modeling guidelines contained in Appendix A of the RLBLOCA methodology were followed; thus, the NRC staff concluded that this limitation is met. Additionally, the staff reviewed the results provided in the

LAR and the June 15, 2016, supplemental information, and determined that the results were as expected for a plant of this type such that the modeling guidelines contained in Appendix A of the RLBLOCA methodology were adequate for the MPS2 analysis.

Limitation 5: Burnup Limitation

The fuel pellet relocation packing factor in the RLBLOCA methodology was derived from data that extend to the currently licensed fuel burnup limits. A plant-specific justification or revision to the RLBLOCA methodology would be required if the analysis was performed beyond a rod average burnup limit of **[[ ]]**.

The licensee stated in Item 5 in Table 2-1 of the RAI response that the analysis was conducted within the licensed burnup limit of **[[ ]]** for M5® cladding; the NRC staff reviewed Item 5 in Table 2-1 of the RAI response and concluded that this limitation is met.

Limitation 6: Pellet Relocation Packing Factor Data Set

The fuel pellet relocation packing factor in the RLBLOCA methodology is derived from the currently available data set as discussed in Section 3.3.2 of the final SE. Should new data become available to suggest that fuel pellet fragmentation behavior is other than that suggested by the currently available database, it may be necessary to update the model to reflect the new data. A request would be made 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 an update is not needed.

To date, the NRC has not sent a letter to AREVA requesting an update to the model or an assessment. Since this request has not been made, the NRC staff determined that the analysis was completed with the appropriate fuel pellet fragmentation model and this limitation has been met.

Limitation 7: 13-Percent Cathcart-Pawel Equivalent Clad Reacted 1

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 Cathcart-Pawel (C-P) correlation, this limit shall be reduced to 13 percent, inclusive of pre-transient oxidation layer thickness.

The licensee provided the results for maximum local oxidation (MLO) in Table 5 of Attachment 5 of the LAR. These results are below 13 percent. If the oxidation is assumed to occur at very high temperatures (i.e., approximately 2200 degrees Fahrenheit (°F)), a 13 percent C-P equivalent clad reacted (ECR) would equate to 17 percent if calculated using the Baker-Just equation. For oxidation occurring at lower temperatures, the difference in calculated cladding oxidation between these two correlations diminishes. Thus, the NRC staff determined that this limitation is met since the ECR calculated using C-P remained below 13 percent, and the predicted peak cladding temperature (PCT) is less than 2200 °F, which provides reasonable

assurance that the ECR, if calculated using the Baker-Just equation, would remain below 17 percent, in compliance with the acceptance criterion at 10 CFR 50.46(b)(2).

Limitation 8: 13-Percent ECR 2

This limitation is in conjunction with Limitation 7 above, which ensures that the safety analysis retains sufficient margin to the ECR analytical limit. This limitation states that the C-P oxidation results will be considered acceptable, provided that the plant-specific **[[**

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The licensee provided the results in the LAR. The NRC staff reviewed these results and concluded that they meet this limitation such that no additional technical justification or quantitative assessment is necessary.

Limitation 9: Uncertainty Treatment for Plant Parameters

This limitation stipulates the treatment of uncertainty for plant parameters. Additionally, it allows alternative approaches, provided that they are supported with appropriate justification.

The plant parameters used in the analysis are found in Table 2 of Attachment 4 of the LAR. The NRC staff reviewed these plant parameters and found that they adequately cover the range of permissible operation and adhere to the stipulation of this limitation. Thus, the NRC staff determined that this limitation is met.

Limitation 10: **[[** **]]**

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The NRC staff reviewed the **[[**

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Therefore, the NRC determined that this limitation was met.

Limitation 11: Re-Analysis

Any plant submittal to the NRC using the RLBLOCA methodology, 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.

The NRC staff reviewed the licensee's response and determined that this limitation is met **[[**

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3.1.2 Adherence to the RLBLOCA Methodology Modeling Guidelines

Appendix A of the RLBLOCA methodology contains modeling guidance. In order to have adequately completed the analysis, it is necessary for the analysis to either adhere to the Appendix A guidance or to provide an adequate justification for deviation from the guidance. This stipulation is discussed in Limitation 4 in the final SE. The licensee stated in the LAR that the modeling guidance found in Appendix A of the RLBLOCA methodology was followed completely. Additionally, the NRC staff reviewed the results to ensure that strict adherence to the Appendix A guidance was appropriate. The staff determined for this MPS2 RLBLOCA analysis that the licensee's modeling approach was adequate. Thus, the NRC staff concludes that the RLBLOCA methodology was implemented adequately for MPS2.

3.2 Initial Condition Review

The NRC staff reviewed the licensee's initial conditions used in the RLBLOCA analysis to ensure that they were consistent with the MPS2 licensing basis. Additionally, this best estimate methodology requires that the parameter operating ranges are adequately covered and that the measurement uncertainty and biases are appropriately included. Thus, the NRC staff reviewed the LAR to ensure that the analyzed range was selected consistent with the methodology and was not significantly outside the range of actual plant operation.

The NRC staff reviewed Table 1 and Table 5 in the LAR and compared those values to the licensing basis documents (e.g., FSAR and TSs). The licensee provided the ranges of parameters used in the RLBLOCA in Table 2 of the LAR. The NRC staff asked the licensee if the measurement uncertainty distribution that was identified as "N/A" still included the measurement uncertainty in the analyzed range. The licensee responded in response to RAI-5 that the appropriate uncertainties were included in the ranges analyzed. Based on its review, the NRC staff determined that the initial conditions are consistent with the current licensing basis and plant operation and that adequate ranges were used to model the parameters. A few parameters required more detailed investigation from the NRC staff, which are discussed as follows.

3.2.1 Axial Shape Index

In Table A-1 of Attachment 4 to the LAR, the licensee provided the peak linear heat generation rates (PLHGR) and axial shape indexes (ASI) used for each case in the analysis. Since in the RLBLOCA methodology the ASI is dependent on the sampled PLGHR, the staff reviewed the PLHGR as a function of ASI to ensure that adequate coverage of these parameters was used in the analysis. An adequate range and coverage of the operational parameters supports the fidelity of the statistical results and ensures that the method leads to an analysis that is representative of past, present, and planned facility operation. Two major observations were made when reviewing this plot: (1) there is a strong V-shape trend when viewing PLHGR as a function of ASI and (2) there were values that appeared to be off the strong trend and some areas of reduced coverage for ASI (i.e., values in the range of permissible ASI that were not explicitly analyzed). In RAI-2, the staff asked the licensee why this strong trend exists, how it relates to physical plant operation, and if the points that were off the trend were points that the plant could physically achieve.

In the RAI response, the licensee stated that the V-shape relationship between PLHGR and ASI is expected. The licensee explained that for increasing PLGHR, the axial shape becomes more skewed to the top or bottom of the rod; thus, the amount of power in the top or bottom region of the rod increases, which in turn increases the absolute value of ASI. For low PLGHR, the axial skew is less, and the power in the top and bottom of the rod is more balanced, which in turn leads to lower absolute values of ASI. Additionally, the licensee discussed that the off-trend points are possible when using the RLBLOCA method and are representative of physical plant operation. The NRC staff reviewed this part of the RAI response and the discussion related to the development of the axial power shapes in the RLBLOCA methodology, and agrees, based on the discussion above, that V-shape relationship between PLGHR and ASI is expected. In the RAI response, the licensee discussed the past plant operation and, in particular, discussed how the axial shapes with ASIs supporting the MPS2 COLR are incorporated into the analysis. The NRC staff reviewed this part of the RAI response and the discussion related to the development of the axial power shapes in the RLBLOCA methodology and determined the physical plant operation was incorporated into the analysis, the V-shape relationship between PLGHR and ASI is expected, and that the off-trend points could be expected in the analysis.

In the RAI response, the licensee provided discussion addressing the areas of reduced coverage for ASI. The licensee discussed that the RLBLOCA methodology does not require coverage of all possible combinations of LHGR and ASI for all the time in cycle steps. Additionally, as a result of the technique used in the RLBLOCA methodology, it is expected that some areas will have a reduced coverage of ASI, and the RLBLOCA methodology provides an adequate representation of the fuel conditions for MPS2. The licensee discusses that, generally, high PLHGRs lead to high absolute ASI values, which is conservative, and that even though the results have some reduced coverage of ASI, they still provide a high confidence that the 10 CFR 50.46 criteria are met.

The NRC staff reviewed the response and the applicable sections of the RLBLOCA methodology. Given that the licensee expects that an RLBLOCA analysis may have areas of reduced coverage for ASI, the NRC staff reviewed the ASI coverage to ensure that this parameter does not impact the results or would be conservatively biased to produce consistently more limiting results.

The NRC staff reviewed the RLBLOCA methodology to understand the relationship between ASI and the peaking factors used in the analysis. The $F_{\Delta H}$ parameter (F_r for CE plants) used in determining the value of ASI is conservative, and the sampling technique used to determine PLHGR, which is also used in determining ASI, is conservative. These conservative peaking factors are used to obtain a power shape rather than explicitly sampling an ASI, and ASI is calculated from that sampled power shape. Thus, ASI is allowed to float with the conservatively sampled PLGHR and conservative $F_{\Delta H}$. If an ASI value were to be forced into a relationship with PLGHR and $F_{\Delta H}$, the problem could be over-constrained and the resulting power shape may be non-physical for MPS2. Additionally, if ASI were explicitly sampled in order to have full coverage over the operating range, one of the peaking factors may have to float in order to obtain a power shape that is an accurate representation for MPS2. This could involve the peaking factors being too low such that they would no longer support the TSs and COLR, or the peaking factors would have to be increased to values that are above what the MPS2 could physically achieve and could be overly conservative for this analysis. In general, the peaking factor inputs to a LOCA analysis have traditionally been assumed to have more influence on the

results than ASI. The MPS2 results are reviewed to confirm **[[**
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The NRC staff reviewed the analysis results to ensure **[[**
]] Since different result types can be impacted differently by LOCA phenomena, the results are reviewed by type: blowdown, early reflood, and late reflood results. The impact of the **[[** **]]** are discussed for each result type as follows.

<u>Blowdown Results</u>

Blowdown results, in part, are dependent on the blowdown stagnation location and PLHGR. A plot of PCT versus PLGHR, Figure 3-2 in the RAI response, generally shows that the PCT increases with increasing PLHGR. The results also show that the range of PCTs at a given PLGHR is less than approximately 200 °F, which is much narrower than that of the early reflood and late reflood cases. From review of the PCT elevation for the blowdown cases, it is observed that the majority of results occur at higher core locations, no results are in the mid-core elevations, and the remainder of the results occur in bottom core locations. **[[**

]] These results indicate that the blowdown results are not highly dependent on ASI, but rather, they are more dependent on PLHGR and the blowdown stagnation point, which appears to be consistently high in the core. This can be further demonstrated by the example provided by the licensee for the case identified in NRC RAI-2. **[[**

]], the NRC staff concludes that the results are adequate with respect to PLHGR and ASI modeling for MPS2.

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Late Reflood Results

Given the nature of how a late reflood case quenches (i.e., bottom of the core to the top of the core), the PCT tends to occur in the upper regions of the core. This effect can be observed in a plot of the PCT versus PCT elevation for the late reflood cases. Additionally, from review of a plot of PCT elevation versus ASI, it can be observed that for all cases with a negative ASI (i.e., more power in the top half of the rod), the PCT elevation is consistently in the higher core elevations. For cases with a positive ASI (i.e., more power in the bottom half of the rod), it can be observed that the majority of PCTs still occur in the top half of the core. These results are consistent with what would be expected of the quench progression of a late reflood case. [[

]], the NRC staff concludes that the results are conservative with respect to PLHGR and ASI modeling for MPS2.

Early Reflood Results

The early reflood cases are more strongly influenced by break size, compared to both the blowdown and late reflood results. At smaller break sizes, the early reflood results behave like the late reflood results, and at higher break sizes, the early reflood results behave like blowdown results. Many of the early reflood results occur at break sizes in between the majority of late reflood and blowdown results and have PCTs that are between the relatively high blowdown PCTs and relatively low late reflood PCTs. For early reflood results that are similar to

the blowdown results, the impact of the PLGHR and ASI modeling will have similar impacts on the results as the blowdown results previously discussed. The same justification can be made for the early reflood results that are similar to the late reflood results. Thus, because the early reflood results will have impacts similar to the blowdown and late reflood cases, the NRC staff concludes that the results are adequate with respect to PLHGR and ASI modeling for MPS2.

3.2.2 Emergency Core Cooling System Flow Modeling

Items K and I in Table 1 of the LAR provide the low pressure safety injection (LPSI) flow and high pressure safety injection (HPSI) flow, respectively, used in the MPS2 analysis. The NRC staff compared the LPSI and HPSI flow used in the RLBLOCA analysis to the values in the AOR provided in Table 14.6.5.1-3 of the FSAR. The NRC staff identified that there were differences between the values and asked the licensee to justify the differences. In the response to RAI-6, the licensee discussed that the ECCS flow delivery values bound the minimum flow rates supported by the MPS2 inservice test program, and the difference can be attributed to rounding and a recalculation of the LPSI flow rates after the LBLOCA AOR was performed. Given that the recalculation of the ECCS flows are still conservative[1] relative to plant operation, the NRC staff finds the changes acceptable.

In the LAR, the licensee noted that charging flow was not credited in the RLBLOCA analysis. The NRC staff asked the licensee if this was conservative because while it is generally presumed that the reduction of injected flow will provide conservative results, there is a competing effect in that the additional spilled flow resulting from charging pump operation could influence containment backpressure and potentially impact the PCTs associated with the late reflood cases. In response to this RAI, the licensee stated the charging pump will deliver ECCS flow even with an assumed single failure, but notes that the additional spilled flow will have a negligible impact on the containment backpressure since the additional ECCS spillage would be negligible (i.e., approximately 0.5 percent). The NRC staff reviewed the response, and since the impact on ECCS spillage is very small, determined that the RLBLOCA analysis conservatively modeled the ECCS flows.

3.2.3 Fuel Pellet Thermal Conductivity Degradation

The NRC issued Information Notice 2009-23, "Nuclear Fuel Thermal Conductivity Degradation" (Reference 15), which describes an issue concerning the ability of legacy thermal-mechanical fuel modeling codes to predict the exposure-dependent degradation of fuel thermal conductivity accurately. A safety concern with thermal conductivity degradation (TCD) in a LOCA would be that fuel temperatures modeled incorrectly could affect the initial stored energy, causing the ECCS evaluation model to predict erroneously low PCTs. However, the thermal-mechanical fuel rod design code used in this RLBLOCA analysis is COPERNIC. COPERNIC has been NRC-approved and accounts for TCD as a function of burnup. Thus, the NRC staff determined that TCD has been appropriately accounted for in the RLBLOCA analysis for MPS2.

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[1] The licensee used a bounding, low ECCS flowrate. Lower ECCS flow tends to correlate with higher PCTs and, as such, low ECCS flowrate is conservative.

3.3 Results Review

The licensee provided figures of the results from the RLBLOCA analysis for MPS2 in Figures 1 through 19 of the LAR. Additionally, the licensee provided Table A-1, which contains the sampled input values for all cases analyzed. The NRC staff reviewed these figures and the table to ensure that the RLBLOCA results were within the expectations for a plant of this type.

Scatter Plot Review

Figures 1 through 5 are scatter plots of all the cases simulated in the analysis. Figure 1 and Table 2 of the LAR provide information related to the uncertainty treatment for the plant-specific parameters used in the analysis. The NRC staff reviewed the figure and the table and confirmed that the uncertainty treatment of the plant-specific parameters is consistent with the RLBLOCA methodology, including Limitation 9 of the methodology. Therefore, the NRC staff concludes that the uncertainty treatment for these parameters is acceptable.

Figure 2 is a plot of the PCT results versus the time of PCT for each case. The NRC staff reviewed this plot and determined that the results are consistent with the expected results for a CE plant. The typical CE plant design leads to PCT results that tend to be most limiting during the blowdown and early reflood portion of the transient. The results presented in Figure 2 are consistent with this expectation. Additionally, these results show the same general trend as the CE example case found in Appendix B.4 of the RLBLOCA Topical Report (Reference 5). Since these results generally show the trend that would be expected for a CE plant, the NRC staff finds that results are within the expectation for a plant of this type.

Figure 3 is a plot of the PCT results versus the one-sided break area. The results show that the break area has a strong influence on the PCT results, which is noted by the licensee in various places in the LAR and in the RAI responses. These results are consistent with the expectation of a CE plant design, and in particular, the abundance of coolant provided by a relatively high ECCS capacity tends to quench the fuel rods relatively early in the LBLOCA transient such that the majority of limiting results occur during the blowdown and early reflood portion of the transient. Cases that are late reflood tend to have smaller break sizes with slower depressurization rates. These cases did not quench during blowdown or early reflood. Due to the capacity of the ECCS, which for this plant design tends to reflood the core relatively quickly compared to other plant designs, the PCTs tend to be lower, as there is a limited amount of time for them to heat up to limiting temperatures. Additionally, these results show the same general trend as the CE example case found in Appendix B.4 of the RLBLOCA methodology. Since these results generally show the trend that would be expected for a CE plant, the NRC staff determined that the results are acceptable.

Figures 4 and 5 are plots of MLO versus PCT and core-wide oxidation (CWO) versus PCT, respectively. Both these plots show, at about 1200 °F, the amount of oxidation (both local and core-wide) increases with PCT. Due to the strong correlation between cladding temperature and cladding oxide layer growth that arise with the exothermic nature of the zirconium-steam reaction, these trends are expected. These results for MLO and CWO additionally are consistent with the general trend found for the CE example case in Appendix B.4 of the RLBLOCA topical report. Since these results both reflect generally expected zirconium oxidation behavior and generally show the trend that would be expected for a CE plant, the NRC staff determined that results shown in these plots are acceptable.

Demonstration Case Review

Figures 6 through 19 contain the results for the key parameters for the PCT upper tolerance limit case. The NRC staff reviewed these key parameters to ensure they were within the expectation of a plant of this type. During the review of Figure 7, the NRC staff asked the licensee why there was a break flow increase at approximately 60 seconds, which occurred coincident with the end of safety injection tank injection, to ensure that this was a physical result, as opposed to a code numerical anomaly. The licensee responded (RAI-3) and stated this was not a numerical anomaly and explained the physical response as being 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. The NRC staff reviewed the response and determined that the plant model responded as expected to ensure the analysis results are conservative. Additionally, the NRC staff reviewed the remainder of the figures in the LAR and concluded that the results for the key parameters presented were within the expectations of the plant results for MPS2.

Summary of Key Input and Output Parameters

The licensee provided a table for all the cases containing the results and the sampled parameters used in the analysis. The NRC staff reviewed this table to ensure that the sampled inputs influenced the results as would be expected. In doing so, the staff reviewed the results by result type, which was determined by PCT time. The result types are blowdown, early reflood, and late reflood. By completing the review in this manner, the NRC staff was able to focus on the sampled parameters that impact the results for each result type, since each result type is not influenced by the sampled parameters in the same fashion. The staff reviewed the results in the table and compared it to the description of the results discussed by the licensee in the LAR. Additionally, the NRC staff reviewed the results with respect to the Phenomena Identification Ranking Table (PIRT). Using the PIRT, the NRC staff was able to focus on what phenomena was most important for each of the result types. Using this information, the staff was able to focus in on the sampled parameters that impacted the phenomena. From the review of how the sampled parameters influenced the results, with focus on the sampled parameters that have the most influence on the phenomena that impact a result type, the NRC staff concluded that the results behaved as expected and were consistent with the licensee's description of the results. Thus, the NRC staff concludes that the licensee has adequately used the RLBLOCA methodology to analyze MPS2.

Compliance with 10 CFR 50.46(b) Criteria

The licensee provided a summary of the analysis results in Table 5 of the LAR. The NRC staff reviewed the LAR to ensure that the appropriate number of cases were executed to meet the desired tolerance results. The NRC staff also reviewed Table 5 to ensure that the appropriate results were presented such that they represented at least 95 percent coverage of the population for all three figures of merit, with 95 percent confidence. From the review of the results presented in the table, the LAR, and the RAI responses, the NRC staff determined that the appropriate number of cases was executed, and the results were presented such that PCT

MLO and CWO 10 CFR 50.46 criteria were met, with a probability higher than 95 percent with 95 percent confidence. The summary of analysis results is presented in Table 1 below.

Table 1: Summary of MPS2 RLBLOCA Analysis Results

Parameter	**RLBLOCA Analysis Results**	**10 CFR 50.46(b) Limit**
Peak Cladding Temperature	1615 °F	2200 °F
Maximum Local Oxidation	2.01% (includes pre-transient oxidation)	17.0% (Note 1)
Maximum Total Core-Wide Oxidation	0.025%	1.0%

Note (1): Per Limitation 7 in the final SE, the regulatory limit contained in 10 CFR 50.46(b)(2), requiring cladding oxidation not to exceed 17% 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 in the RLBLOCA methodology, this limit shall be reduced to 13%, inclusive of pre-transient oxidation layer thickness. The MPS2 result is below 13%. The NRC staff determined that this limitation is met, since the ECR calculated using C-P remained below 13%, which provides reasonable assurance that the ECR, if calculated using the Baker-Just equation at oxidation temperatures not exceeding 2200 °F, would remain below 17% percent, in compliance with the acceptance criterion at 10 CFR 50.46(b)(2).

3.4 Applicable Regulatory Requirement Compliance

The licensee has proposed to revise TS 6.9.1.8.bto add the RLBLOCA methodology (Reference 5). TS 6.9.1.8.b contains the methodologies used to establish the parameters found in the COLR. The COLR is a licensee-controlled document that contains various cycle-specific parameters that are relocated from the LCOs in the TSs and are established using NRC-approved methodologies. The licensee has appropriately used GL 88-16 guidance by including this methodology in TS 6.9.1.8.b. Per 10 CFR 50.36, the licensee is required to include LCOs in the TSs to ensure safe operation. The licensee has used the RLBLOCA methodology to establish TSs 3.1.3.6, 3.2.1, and 3.2.3 in the COLR, and the staff has determined that this is acceptable. Therefore, the LCO requirement in 10 CFR 50.36 is met.

The MPS2 LBLOCA calculated results demonstrate that the ECCS is designed to meet the 10 CFR 50.46 acceptance criteria, and additionally, demonstrate that the ECCS is designed to meet 10 CFR 50, Appendix A, GDC-35. The NRC staff determined that the analysis was correctly implemented using an NRC-approved RLBLOCA methodology.

3.5 NRC Staff Conclusion

The NRC staff evaluated the licensee's proposed changes to TS 6.9.1.8.b to support reanalyzing the LBLOCA. Based on the considerations discussed in this SE, the NRC staff concludes that the proposed changes to TS 6.9.1.8.b are acceptable.

4.0 STATE CONSULTATION

In accordance with the Commission's regulations, the Connecticut State official was notified on December 8, 2016, of the proposed issuance of the amendment. The State official responded with no comments.

5.0 ENVIRONMENTAL CONSIDERATION

The amendment changes a requirement with respect to installation or use of a facility component located within the restricted area as defined in 10 CFR Part 20. The NRC staff has determined that no significant change in the types, or significant increase in the amounts, of any effluents that may be released offsite, and that there is no significant increase in individual or cumulative occupational radiation exposure. The Commission has previously issued a proposed finding that the amendment involves no significant hazards consideration, and there has been no public comment on such finding (81 FR 59662). Accordingly, the amendment meets the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment need be prepared in connection with the issuance of the amendment.

6.0 CONCLUSION

The Commission has concluded, based on the considerations discussed above, that: (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner; (2) there is reasonable assurance that such activities will be conducted in compliance with the Commission's regulations; and (3) the issuance of the amendment will not be inimical to the common defense and security or to the health and safety of the public.

7.0 REFERENCES

1. Sartain, Mark D., letter to U.S. Nuclear Regulatory Commission, "Dominion Nuclear Connecticut, Inc. Millstone Power Station Unit 2, Proposed License Amendment Request – Realistic Large Break Loss of Coolant Accident Analysis," dated May 25, 2016 (ADAMS Accession No. ML16153A026).

2. Sartain, Mark D., letter to U.S. Nuclear Regulatory Commission, "Dominion Nuclear Connecticut, Inc. Millstone Power Station Unit 2, Proposed License Amendment Request – Realistic Large Break Loss of Coolant Accident Analysis," dated June 15, 2016 (ADAMS Accession No. ML16175A608).

3. Sartain, Mark D., Supplemental letter to U.S. Nuclear Regulatory Commission, "Dominion Nuclear Connecticut, Inc. Millstone Power Station Unit 2, Response to Request for Additional Information for Proposed License Amendment Request Regarding Realistic Large Break Loss of Coolant Accident Reanalysis (CAC No. MF7761)," dated October 18, 2016 (ADAMS Accession Nos. ML16294A269 (letter) and ML16294A270 (RAI response)).

4. AREVA NP Inc., EMF-2103(P), Revision 3, "Realistic Large Break LOCA Methodology for Pressurized Water Reactors, Topical Report," September 2013 (ADAMS Package Accession No. ML13283A220).

5. AREVA Inc., EMF-2103P-A, Revision 3, "Realistic Large Break LOCA Methodology for Pressurized Water Reactors," dated June 17, 2016 (ADAMS Package Accession No. ML16286A579).

6. Salas, Pedro, AREVA NP Inc. letter to U.S. Nuclear Regulatory Commission, "Request for Review and Approval of EMF-2103(P), Revision 3, "Realistic Large Break LOCA Methodology for Pressurized Water Reactors," dated September 13, 2013 (ADAMS Package Accession No. ML13283A224).

7. Peters, Gary, AREVA Inc., letter to U.S. Nuclear Regulatory Commission, "Response to First and Second Request for Additional Information Regarding EMF-2103(P), Revision 3, 'PWR Realistic Large Break LOCA Methodology for Pressurized Water Reactors'," dated February 16, 2016 (ADAMS Package Accession No. ML16054A205).

8. Peters, Gary, AREVA NP, Inc., letter to U.S. Nuclear Regulatory Commission, "Revised Pages for EMF-2103(P), Revision 3, 'PWR Realistic Large Break LOCA Methodology for Pressurized Water Reactors'," dated February 19, 2016 (ADAMS Accession No. ML16057A029).

9. Hsueh, Kevin, U.S. Nuclear Regulatory Commission, letter to AREVA Inc., "Draft Safety Evaluation for AREVA NP Inc. Topical Report EMF-2103(P), Revision 3, 'Realistic Large Break LOCA Methodology for Pressurized Water Reactors (TAC No. MF2904)'," dated April 14, 2016 (ADAMS Accession No. ML16098A366).

10. Hsueh, Kevin, U.S. Nuclear Regulatory Commission, letter to AREVA Inc., "Final Safety Evaluation for AREVA NP Inc. Topical Report EMF-2103(P), Revision 3, 'Realistic Large Break LOCA Methodology for Pressurized Water Reactors (TAC No. MF2904)'," dated June 17, 2016 (ADAMS Accession No. ML16139A656).

11. NRC Generic Letter 88-16, "Removal of Cycle-Specific Parameter Limits form Technical Specifications," dated October 4, 1988 (ADAMS Accession No. ML031130447).

12. NUREG-0800, Standard Review Plan, Section 15.6.5, "Loss-of-Coolant Accidents Resulting from Spectrum of Postulate Piping Breaks Within the Reactor Coolant Pressure Boundary," March 2007 (ADAMS Accession No. ML070550016).

13. Guzman, Richard V., letter to Dominion Nuclear Connecticut, Inc. "Millstone Power Station, Unit No. 2 – Exemption from 10 CFR 50.46 and Appendix K to Allow Use of M5™ Alloy for Fuel Cladding (TAC No. MF3917)," dated May 12, 2015 (ADAMS Accession No. ML15093A497).

14. E-mail from Guzman, Richard V. to Craft, Wanda, "Millstone Unit 2 – Request for Additional Information – License Amendment Request Realistic Large Break Loss of Coolant Accident Analysis," dated September 16, 2016 (ADAMS Accession No. ML16260A006).

15. Information Notice 2009-23, "Nuclear Fuel Thermal Conductivity Degradation," dated October 8, 2009 (ADAMS Accession No. ML091550527).

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