Omaha Public Power District
444 South 16th Street Mall
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LIC-15-0060

10 CFR 50.46

April 30, 2015

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D.C. 20555

Fort Calhoun Station (FCS), Unit 1
Renewed Facility Operating License No. DPR-40
NRC Docket No. 50-285

Subject: Annual Report for 2014 Loss-of-Coolant Accident (LOCA)/ Emergency Core Cooling System (ECCS) Models Pursuant to 10 CFR 50.46

References:
1. EMF-2328(P)(A), Revision 0, "PWR Small Break LOCA Evaluation Model, S-RELAP5 Based," Framatome ANP, Inc., March 2001
2. EMF-2103(P)(A), Revision 0, "Realistic Large Break LOCA Methodology for Pressurized Water Reactors," Framatome ANP, Inc., April 2003.
3. Letter from OPPD (L. P. Cortopassi) to NRC (Document Control Desk) "Small Break Loss-of-Coolant Accident (SBLOCA) / Emergency Core Cooling System (ECCS) Evaluation Model Change/Error - 30-Day Report," dated April 24, 2015 (LIC-15-0059)

In accordance with 10 CFR 50.46(a)(3)(ii), the Omaha Public Power District (OPPD) hereby submits the annual 10 CFR 50.46 summary report for Fort Calhoun Station (FCS), Unit No. 1. The report provides an update of all identified changes or errors in the LOCA/ECCS codes, methods, and applications. References 1 and 2 respectively are the small break (SB) and realistic large break LOCA analysis methodology used by AREVA (formerly Framatome ANP) for the FCS Analyses of Record (AOR).

A design change to the initial fill gas pressure of new UO_2 fuel rods that will be used in the Operating Cycle 28 core is estimated to increase the peak clad temperature (PCT) for the SBLOCA AOR by +31°F. Also, a non-conservatism in AREVA's correlation for vapor absorptivity used in S-RELAP5 was discovered that increased PCT by +23°F in the SBLOCA AOR. These issues are described in Attachment 2 and were reported in Reference 3. Attachment 1 provides the 2014 SBLOCA Margin Summary Sheet for FCS. Due to total errors reported in previous years and the +31°F change and +23°F error noted above, the SBLOCA PCT has changed from the baseline value of 1537°F (Updated Safety Analysis Report (USAR) Section 14.15) to 1800°F. The sum of the absolute values of the changes/errors in the SBLOCA AOR is 471°F.

Two (2) RLBLOCA Analysis 10 CFR 50.46 Model Assessment errors were discovered in 2014. Each of the two (2) errors and the design change discussed above changed the PCT in the RLBLOCA AOR by +0°F. These issues are described in Attachment 4. Attachment 3 provides the 2014 RLBLOCA Margin Summary Sheet for FCS. Due to total errors reported in previous

years, the two 0°F errors discovered in 2014, and the design change, the RLBLOCA PCT has changed from the baseline value of 1636°F (USAR Section 14.15) to 1587°F. The sum of the absolute value of the changes/errors in the RLBLOCA AOR is 91°F.

In summary, the FCS PCT values for the SBLOCA AOR and the RLBLOCA AOR continue to remain significantly less than the 10 CFR 50.46(b)(1) acceptance criterion of 2200°F. OPPD is currently planning to reanalyze the SBLOCA and the RLBLOCA to incorporate the pending AREVA methodology revisions associated with these analyses.

If you should have any questions, please contact Mr. Bill Hansher at (402) 533-6894.

No commitments to the NRC are made in this letter.

Respectfully,

Louis P. Cortopassi
Site Vice President and CNO

LPC/SEC/mle

Attachments:
1. Small Break LOCA Margin Summary Sheet - Annual Report
2. 10 CFR 50.46 Small Break LOCA Model Assessments
3. Realistic Large Break LOCA Margin Summary Sheet - Annual Report
4. 10 CFR 50.46 Realistic Large Break LOCA Model Assessments

c: M. L. Dapas, NRC Regional Administrator, Region IV
C. F. Lyon, NRC Project Manager
S. M. Schneider, NRC Senior Resident Inspector

Small Break LOCA Margin Summary Sheet - Annual Report

Plant Name: Fort Calhoun Station, Unit No. 1
Utility Name: Omaha Public Power District

Evaluation Model: Small Break LOCA			
		Net PCT Effect (ΔPCT)	Absolute PCT Effect
A.	Prior 10 CFR 50.46 Changes or Error Corrections-Previous Years	+209°F	417°F
B.	Prior 10 CFR 50.46 Changes or Error Corrections-This Year	+23°F	23°F
C.	Prior 10 CFR 50.46 Changes or Error Corrections-This Year	+31°F	31°F
Absolute Sum of 10 CFR 50.46 Changes			471°F

The sum of the PCT from the most recent analysis using an acceptable evaluation model and the estimates of the PCT impact for changes and errors identified since that analysis is less than 2200°F.

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10 CFR 50.46 Small Break LOCA Model Assessments

Change to the Vapor Absorptivity Correlation Effect on SBLOCA Analysis

The issue was discovered while preparing an update of the BWR LOCA Appendix K methodology using S-RELAP5. The Thermal Hydraulic Test Facility (THTF) level swell assessment for BWRs was reviewed for rod wall temperatures and determined to be non-conservative relative to the data. This observation was unexpected since other assessments showed good or conservative agreement. In AREVA CR 2012-8371, it was determined that the correlation for vapor absorptivity used in S-RELAP5 was being applied outside of its intended range of applicability. The equation used for the absorption coefficient of vapor has the form:

$$a_g = 1.814 \times 10^{-4} \times P \left(\frac{555.56}{T_g}\right)^2 \left[1 - 0.0054 \left(\frac{555.56}{T_g}\right)^2\right] \alpha_g$$

Where Tg is the vapor phase temperature in K, and P is pressure in Pa and is truncated at 1.03×10^6 Pa (150 psi). The pressure term must be truncated in order to obtain the correct emissivity values for an optically thick steam. The dependency on P and Tg in the absorption coefficient of vapor, and the constant are from the FLECHT SEASET report, which is based on pressure at 10 atm. A simplified pressure relation from Siegel and Howell indicated that the truncation at 150 psi is conservative. There is no lower pressure limit on the vapor absorptivity correlation as the correlation is developed for optically thin gases, which already applies at low pressures.

In order to assess the impact on the current analysis of record for SBLOCA, a developmental version of S-RELAP5 was prepared by AREVA containing the correction to the vapor absorptivity coefficient pressure range. The limiting case and multiple break sizes around the limiting case were rerun with the developmental code version of S-RELAP5. Results determined that limiting the vapor absorptivity correlation to within its intended pressure range allows S-RELAP5 to predict wall temperatures for THTF within the uncertainty bands or above the uncertainty bands, which remains conservative.

The estimated PCT impact of the pressure limit on the vapor absorptivity correlation on the Fort Calhoun SBLOCA AOR is +23°F, resulting in a PCT of 1769°F.

Change to the Initial Fill Gas Pressurization Effect on SBLOCA Analysis

The fuel reload campaign for Cycle 28 is implementing a change in the fuel rod fill gas initial pressurization. The change is intended to provide more margin in the reload analysis for internal rod pressure. The initial fill gas pressure of the UO_2 fuel rods is being changed from 390 psia to 330 psia. Due to this design change, an evaluation of the existing LOCA AOR is required.

For the SBLOCA analysis, the reduction in fuel rod internal pressure affects the swell and rupture model. The SBLOCA transient is a slow progressing transient with PCT occurring later in the event when compared to the RLBLOCA event. A change in the fuel rod internal pressure affects the timing of rupture of the cladding which could result

in a change in the PCT time leading to a change in PCT and calculated oxidation. Therefore, a sensitivity study was performed by AREVA to evaluate the impact on SBLOCA AOR. The limiting case and multiple break sizes around the limiting case were rerun with the reduced internal pressure.

The estimated PCT impact of the change to the initial fill gas pressurization on the Fort Calhoun SBLOCA AOR is +31°F, resulting in a PCT of 1800°F.

Realistic Large Break LOCA Margin Summary Sheet - Annual Report

Plant Name: Fort Calhoun Station, Unit No. 1
Utility Name: Omaha Public Power District

Evaluation Model: Large Break LOCA			
		Net PCT Effect (ΔPCT)	Absolute PCT Effect
A.	Prior 10 CFR 50.46 Changes or Error Corrections-Previous Years	-49°F	91°F
B.	Prior 10 CFR 50.46 Changes or Error Corrections-This Year	0°F	0°F
C.	Prior 10 CFR 50.46 Changes or Error Corrections-This Year	0°F	0°F
D.	Prior 10 CFR 50.46 Changes or Error Corrections-This Year	0°F	0°F
Absolute Sum of 10 CFR 50.46 Changes			91°F

The sum of the PCT from the most recent analysis using an acceptable evaluation model and the estimates of the PCT impact for changes and errors identified since that analysis is less than 2200°F.

10 CFR 50.46 Realistic Large Break LOCA Model Assessments

Change to the Vapor Absorptivity Correlation Effect on RLBLOCA Analysis

The issue was discovered while preparing an update of the BWR LOCA Appendix K methodology using S-RELAP5, where the THTF level swell assessment for BWRs was reviewed for rod wall temperatures and determined to be non-conservative relative to the data. This observation was unexpected since other assessments showed good or conservative agreement. In AREVA CR 2012-8371, it was determined upon further investigation that the correlation for vapor absorptivity used in S-RELAP5 was being applied outside of its intended range of applicability. The equation used for the absorption coefficient of vapor has the form:

$$a_g = 1.814 \times 10^{-4} \times P \left(\frac{555.56}{T_g}\right)^2 \left[1 - 0.0054 \left(\frac{555.56}{T_g}\right)^2\right] \alpha_g$$

Where Tg is the vapor phase temperature in K, and P is pressure in Pa and is truncated at 1.03×10^6 Pa (150 psi). The pressure term must be truncated in order to obtain the correct emissivity values for an optically thick steam. The dependency on P and Tg in the absorption coefficient of vapor, and the constant are from the FLECHT SEASET report, which is based on pressure at 10 atm. A simplified pressure relation from Siegel and Howell indicated that the truncation at 150 psi is conservative. There is no lower pressure limit on the vapor absorptivity correlation as the correlation is developed for optically thin gases, which already applies at low pressures.

For RLBLOCA, single phase steam only exists for a very limited time just before the beginning of reflood. During the majority of the blowdown phase and during the entire reflood phase, which are the important RLBLOCA phases, the core is in a dispersed flow regime. The S-RELAP5 methodology uses the FLECHT-SEASET reflood tests to determine the heat transfer bias & uncertainty under these conditions. In addition, the transient progression is very quick and the system depressurizes in the first few seconds after the break opening. Due to the fast depressurization, the amount of time that the correlation for vapor absorptivity used in RLBLOCA is applied outside of the range of applicability is limited and therefore the results predicted in the AOR remain valid.

The estimated PCT impact of the pressure limit on the vapor absorptivity correlation on the Fort Calhoun RLBLOCA AOR is 0°F, resulting in a PCT of 1587°F.

Non-Physical Axial Shapes Generated by the Modal Decomposition Effect on RLBLOCA Analysis

The issue was discovered during an evaluation by AREVA on the modal decomposition method which led to a detailed examination of the actual axial shapes that were produced by the modal decomposition procedure. The examination revealed that the modal decomposition procedure creates axial shapes that exhibit super-imposed oscillations leading to non-physical, artificial local peaks and valleys in the shape. When such shapes are generated and used in the LOCA analyses they tend to shift the PCT location toward higher elevations, as well as generate higher or lower PCT values than would normally occur.

In the AREVA RLBLOCA methodology, axial shapes are generated in a 24-node format. Two bounding axial shapes are determined and then a 24-node shape is created by interpolating between the two bounding shapes. This 24-node axial must then be mapped to the number of heat structure nodes and elevation points used by S-RELAP5, which is between 40 to 52 nodes. This is done currently using a process called modal decomposition.

The evaluation for the set of cases and axial shapes applied to Fort Calhoun RLBLOCA AOR shows that the axial shapes mapped using modal decomposition provide a good fit relative to the pre-mapped axial shapes. Therefore, it is concluded that the RLBLOCA AOR remains valid.

The estimated PCT impact of the axial shapes generated using the modal decomposition method on the Fort Calhoun RLBLOCA AOR is 0°F, resulting in a PCT of 1587°F.

Change to the Initial Fill Gas Pressurization Effect on RLBLOCA Analysis

The fuel reload campaign for Cycle 28 is implementing a change in the fuel rod fill gas initial pressurization. The change is intended to provide more margin in the reload analysis for internal rod pressure. The initial fill gas pressure of the UO_2 fuel rods is being changed from 390 psia to 330 psia. Due to this design change, an evaluation of the existing LOCA AOR is required.

Per the AREVA RLBLOCA methodology applied to the Fort Calhoun AOR, the swell and rupture model is not incorporated on plant specific applications as it is considered a benefit in the PCT calculation. In addition, the relocation phenomenon is not evaluated for Fort Calhoun as the AOR PCT results are below 1850°F and the phenomenon is not significant below this threshold. Consequently, in the AOR, the PCT is not driven by the rupture node or rupture time and changes in the initial rod pressure do not have an effect on the PCT estimate.

Therefore, it is concluded that the RLBLOCA AOR remains valid and the estimated impact of the Cycle 28 design change on the Fort Calhoun RLBLOCA analysis calculated PCT is 0°F, resulting in a PCT of 1587°F.