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Carolinas

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U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555-0001

Subject: Duke Energy Carolinas, LLC (Duke)

Catawba Nuclear Station, Units 1 and 2
Docket Numbers 50-413 and 50-414

McGuire Nuclear Station, Units 1 and 2
Docket Numbers 50-369 and 50-370

Oconee Nuclear Station, Units 1, 2, and 3
Docket Numbers 50-269, 50-270, and 50-287

Evaluation Results Confirming Existing Boron Precipitation Analyses of Record Have Sufficient Margin and Remain in Compliance with the Regulations and Plant Design Basis

References:
1. Letter from Duke to NRC, same subject, dated January 8, 2007
2. Letter from Duke to NRC, same subject, dated November 20, 2007

The Reference 1 letter constituted a response to concerns associated with post-LOCA long-term cooling models, specifically those dealing with precluding boron precipitation.

In response to the reference letter, the NRC sent a Request for Additional Information (RAI). The RAI consisted of nine questions. The purpose of this letter is to respond to RAI Questions 2-9. The response to Question 1 was forwarded via the Reference 2 letter.

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NRR

There are no regulatory commitments contained in this letter or its attachment.

If there are any questions concerning this material, please contact L.J. Rudy at (803) 701-3084.

Very truly yours,

James R. Morris

LJR/s

Attachment

xc (with attachment):

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Catawba Document Control File 801.01
McGuire Document Control
Oconee Document Control
Catawba RGC Date File
ELL-EC050

ATTACHMENT

DUKE RESPONSES TO REQUEST FOR ADDITIONAL INFORMATION ON DUKE JUSTIFICATION OF CURRENT OPERATION FOR POST-LOCA BORIC ACID PRECIPITATION ISSUES SUBMITTED ON JANUARY 8, 2007

The NRC staff provided nine questions as part of a Request for Additional Information (RAI) in response to Reference 1. Duke has already submitted a response to RAI question #1 in Reference 2, and submits the following response to RAI questions #2-9.

The NRC has concerns regarding boron precipitation evaluation methods for pressurized water reactors (PWRs), and suspended approval of Westinghouse topical report CENPD-254-P (Post-LOCA Long Term Cooling Model) in Reference 3 due to some non-conservative modeling assumptions. Specifically, Reference 3 described fifteen concerns for Westinghouse to address. The NRC later issued Reference 4 to the Pressurized Water Reactor Owners Group (PWROG), in which the NRC stated it considered the overall framework and general approach of the CENPD-254-P topical report to be valid. While the expectation for Westinghouse to address all of the concerns in Reference 3 remained, the NRC stated in Reference 4 that each licensee would need to address four specific concerns on a plant-specific basis in any future submittals regarding post-LOCA long term cooling. Reference 4 also asked that each licensee perform an evaluation to confirm that sufficient margin exists in their boron precipitation analyses, and demonstrate that they remain in compliance with the regulations and their design bases. The majority of the PWR fleet responded to this request in Reference 5, and Duke issued a separate response in Reference 1 since Duke performs these analyses in-house.

While the CENPD-254-P topical report is not directly applicable to the Duke reactors, Duke does employ similar methods. The Duke methods follow the same overall framework and general approach that the NRC considered valid for CENPD-254-P in Reference 4.

Duke considers only three of the nine questions (#1, #8, and #9) in this RAI to be specific to Duke's response in Reference 1. Duke considers the other six questions (#2, #3, #4, #5, #6, and #7) to be generic to the PWR fleet. These six questions essentially repeat the same concerns originally posed to Westinghouse in Reference 3 when suspending approval of the CENPD-254-P topical report. These concerns were not repeated in Reference 4 as concerns that licensees would need to address in future plant specific submittals. Since the NRC staff considers the overall framework and general approach of CENPD-254-P and similar methods to be valid, Duke considers these six questions to be beyond the scope requested of licensees in Reference 4. Duke is participating in the PWROG's Post LOCA Boric Acid Precipitation Analysis Methodology Project to help address these and other generic concerns.

Duke attendance at the August 2007 PWROG industry meeting (and subsequent verbal discussions) confirmed that a similar RAI was never issued to the PWROG in response to Reference 5. It is important to note that McGuire, Catawba, and Oconee are not unique relative to the rest of the PWR fleet regarding these concerns and the Duke analytical methodology is fundamentally similar to that used by other PWRs. Therefore, the PWROG can represent the entire PWR fleet (including Duke plants) when responding to the entire set of NRC concerns originally issued to Westinghouse in Reference 3. Duke's intentions have always been to provide a response to Reference 4, and then participate in the PWROG project with all other PWR owners to respond to the entire set of the NRC concerns.

In summary, Duke understands that the NRC has concerns regarding boron precipitation evaluation methods, and Duke is actively participating in the necessary PWROG projects. The six questions that are generic to the PWR fleet are answered where possible with pertinent information specific to the Duke analyses of record or the McGuire/Catawba confirmatory analysis described in Reference 1.

Please note that the response to question #1 of the RAI was previously submitted to the NRC. For convenience, RAI questions #2-9 are repeated below, and responses to each of the questions follow in *italics*.

2. Since the RCS pressure can remain well above the HPSI run-out flow condition for several hours following all small break LOCAs, so that simultaneous injection cannot flush the core, please describe how boric acid precipitation is prevented for all small breaks. Please describe the procedures to control boric acid for small breaks and identify the operator actions required to preclude precipitation. Please show the key system parameters in addition to the boric acid concentrations versus time covering the range of small breaks which do not readily depressurize to RCS pressures sufficiently low to assure simultaneous injection will flush the core. What RCS pressure must be achieved before flushing can occur for small breaks? Do the current EOPs require the switch to simultaneous injection at 6 hrs/9 hrs regardless of

break size and RCS pressure? Please explain how the full spectrum of break sizes are handled and long term cooling is assured.

Duke is supporting a PWROG project to fully respond to this generic PWR issue. Like most of the PWR fleet, the Duke analyses of record consider large breaks to be limiting with respect to core boron precipitation. Therefore, Duke plants do not have separate procedure actions to control boric acid precipitation for small breaks. The timing associated with switching to hot leg recirculation at 6 hours for McGuire/Catawba, or opening the decay heat drop line at 9 hours for Oconee, is based on large breaks being limiting.

3. Do the large break LOCA precipitation times and, hence, timing to switch to the simultaneous injection include consideration for breaks located on the top of the discharge leg piping? If not, please provide an analysis of breaks in this location since the refilling of the suction legs with ECC will cause the upper plenum pressure to increase and decrease the mixing volume well below the bottom elevation of the hot legs. In this condition, the mixing volume will gradually increase with time. The assumption that the entire volume below the hot legs in the upper plenum provides a constant mixing volume is invalid for breaks on the top of the discharge leg piping.

Duke is supporting a PWROG project to fully respond to this generic PWR issue. Like most of the PWR fleet, the Duke analyses of record use simplifying assumptions in determining a liquid mixing volume and do not target specific break locations (other than it being a cold leg break). Duke obtained acceptable results when evaluating a special case assuming a mixing volume that bounds the collapsed liquid levels observed in the initial reflood phase of the current LBLOCA analyses.

For Oconee, the existence of eight reactor vessel vent valves (RVVVs) that vent steam and water directly from the upper plenum to the upper downcomer (and then to the broken cold leg) makes this a non-issue.

4. What is the sump temperature vs. time following recirculation and how does this impact precipitation? Is the boric acid concentration in the vessel below the precipitation limit based on the minimum sump temperature at the time the switch to simultaneous injection is performed?

Duke is supporting a PWROG project to fully respond to this generic PWR issue. The Duke analyses of record do not address a precipitation limit based on a minimum sump temperature. The entire mixing volume in the Duke analyses of record is assumed to be at saturation since it is in direct contact with the heat source.

5. Can debris from the sump block portions of the core inlet and if so, what is the impact on precipitation timing in the regions where the core boric acid cannot diffuse downward into the lower plenum? Please identify the maximum core inlet blockage that can occur and show local concentrations in the core are below the precipitation limit. With the core inlet blocked, and boric acid and other precipitates in the core, show that the switch to simultaneous injection can flush the core and reduce the concentration to acceptable levels.

Duke is supporting a PWROG project to fully respond to this generic PWR issue. The predominant circulation flow path in the reactor vessel is upward through the core with entrained liquid returning to the core inlet via the barrel-baffle region. This circulation flow path would tend to hold debris that enters the reactor vessel to the core inlet. The boron precipitation analyses of record performed by Duke do not specifically account for debris effects. However, due to not crediting the lower plenum or core barrel baffle regions as part of the mixing volume, debris effects would not appear to significantly impact the Duke analyses.

6. Does the mixing volume consider the maximum content of sump debris that can accumulate in the core? What is the maximum amount (volume) of debris that can accumulate in the core and lower plenum regions during recirculation?

Please see the response to question #5.

7. Vapor exiting the two-phase surface in the core during the long term contains boric acid. What happens to the boric acid in the vapor as it passes through the steam generators to reach the break? Can the boric acid plate out on surfaces in the external loop components and cause flow area reductions during the long term? Please discuss the plate-out effects on the RCS internals and the impact on long term cooling.

Duke is supporting a PWROG project to fully respond to this generic PWR issue. Duke analyses of record determine the time necessary for boron to precipitate in the core region, and were never intended to address plateout effects on other RCS components. Boron carryover and subsequent plateout on RCS components is a non-conservative assumption in core boron precipitation analyses, and Duke analyses of record therefore assume that vapor exiting the two-phase surface in the core contains no boron.

8. Please describe the basis for the mixing volume void fraction of 50% assumed for the Catawba and McGuire plants during the long term. Is the mixing volume void fraction based on a drift flux model at six hours? Please note that void fraction at the core exit can approach 80% with a similar void value in the upper plenum. Please justify and explain how this void fraction was computed.

Duke analyses of record for McGuire and Catawba assume a 30% long term void fraction, which is taken directly from the Reference 6 methodology. Recognizing that this value corresponds to a 24 hour switchover time per Reference 6, the confirmatory analysis summarized in Reference 1 assumed a more representative long term void fraction of 50% for a 6 hour switchover time. Assuming minimum safeguards, the RELAP5 computer code was used to evaluate an overall core void fraction 6 hours following the initiation of a double-ended cold leg pump discharge break from hot full power conditions. The core power level was held constant to facilitate a steady state core void fraction to be determined. The ECCS injection flow rates used were representative of those expected prior to the alignment of hot leg recirculation and the ECCS injection temperature was selected from long-term containment response calculations. Sensitivity cases were performed on decay heat, ECCS temperature, containment pressure, and the core axial power shape. As expected, these sensitivity cases demonstrated that decay heat and the core axial power shape location had the greatest effect on the overall void fraction results. Using the 1979 ANS decay heat standard at six hours with a bottom peaked axial power shape yielded a core average void fraction of 50%.

9. Please describe the tests used to validate the two-phase level swell and boric acid precipitation models.

Duke did not perform any tests to validate the two-phase level swell for McGuire/Catawba analyses of record. The void fraction selection for the McGuire/Catawba analyses of record and confirmatory analyses is explained in the previous response.

The 50% core average void fraction used in the McGuire/Catawba confirmatory analyses was justified using the RELAP5 computer code. The RELAP5 family of codes have been used extensively by code developers for both pre-test and post-test prediction of the Semiscale and LOFT experiments. RELAP5 validation of MOD2 was also the primary impetus of the International Code Assessment Program (ICAP) which led to the creation of RELAP5/MOD3. Since these efforts to validate the RELAP5 code are generally well recognized, a summary of these activities is not provided in this response.

The Oconee analyses of record employ the BFLOW code to calculate long-term liquid and steam mass flow rates following a LBLOCA. The Yeh-Hochreiter algebraic slip model is used to calculate the axial void fractions. The BFLOW code methodology is described in Section 2.2 of Reference 7, with Section 2.2.3 of Reference 7 specifically explaining the validation of the BFLOW code and Oconee model. This section also states that the Yeh-Hochreiter model compares favorably with the experimental data in Appendix C of Reference 8, which contains comparisons between correlations and data for low pressure and low flow situations (where BFLOW use would be most applicable).

References

1. Letter from J. R. Morris (Duke) to the USNRC dated January 8, 2007. Evaluation Results Confirming Existing Boron Precipitation Analyses of Record Have Sufficient Margin and Remain in Compliance with Regulations and Plant Design Basis.

2. Letter from J. R. Morris (Duke) to the USNRC dated November 20, 2007. Evaluation Results Confirming Existing Boron Precipitation Analyses of Record Have Sufficient Margin and Remain in Compliance with Regulations and Plant Design Basis.

3. Letter from Robert A. Gramm (NRC) to James A. Gresham (Westinghouse) dated August 1, 2005. Suspension of NRC Approval for Use of Westinghouse Topical Report CENPD-254-P, "Post-LOCA Long-Term Cooling Model," Due to Discovery of

Non-Conservative Modeling Assumptions During Calculations Audit.

4. Letter from Daniel S. Collins (NRC) to Gordon Bischoff (WOG) dated November 23, 2005. Suspension of NRC Approval for Use of Westinghouse Topical Report CENPD-254-P, "Post-LOCA Long-Term Cooling Model," Due to Discovery of Non-Conservative Modeling Assumptions During Calculations Audit (TAC No. MB1365).

5. Letter from Frederick P. Schiffley, III (PWROG) to Daniel S. Collins (NRC) dated June 19, 2006. Suspension of NRC Approval for Use of Westinghouse Topical Report CENPD-254-P, Post LOCA Long Term Cooling Model, Due to Discovery of Non-Conservative Modeling Assumptions During Calculation Audit, PA-ASC-0290.

6. Letter from C. L. Caso (Westinghouse) to T. N. Novak (NRC), File CLC-NS-309. Long Term Core Cooling - Boron Considerations. April 1, 1975.

7. DPC-NE-3003-PA, Revision 1. Mass and Energy Release and Containment Response Methodology. Duke Power Company, September 2004.

8. NSAC-107. An Assessment of Eight Void Fraction Models for Vertical Flows. Electric Power Research Institute, December 1986.