DUKE ENERGY.

*Garry D. Miller*
*Sr. Vice President*
*Nuclear Engineering*

***Duke Energy Corporation***
*EC07H/526 South Church Street*
*Charlotte, NC 28202*

*Mailing Address:*
*EC07H/P. O. Box 1006*
*Charlotte, NC 28201-1006*

PROPRIETARY INFORMATION - WITHHOLD UNDER 10 CFR 2.390

December 16, 2013

10 CFR 50.46
RA-13-1007

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

Duke Energy Carolinas, LLC (Duke Energy)
Oconee Nuclear Station, Units 1, 2, and 3
Docket Numbers 50-269, 50-270, and 50-287
Renewed Operating License Nos. DPR-38, DPR-47, and DPR-55

**Subject:** 30-Day Report Pursuant to 10 CFR 50.46, Changes to or Errors in an Evaluation Model

References:

1) Letter, D. C. Culp (Duke Energy) to USNRC, Subject: Oconee Nuclear Station - 30-Day Report Pursuant to 10 CFR 50.46, Changes to or Errors in an Evaluation Model, March 9, 2012. [ADAMS Accession No. ML12073A354]

2) Letter, Michael J. Annacone (Duke Energy) to USNRC, Subject: Oconee Nuclear Station - Report Pursuant to 10 CFR 50.46, Changes to or Errors in an Evaluation Model, July 11, 2013. [ADAMS Accession No. ML13196A248]

10 CFR 50.46 (a)(3)(ii) requires the reporting of changes to or errors in Emergency Core Cooling System (ECCS) evaluation models (EMs), or in the application of such models that affect the temperature calculation. On November 14, 2013, Duke Energy received a letter from AREVA identifying an error which affects the large break loss of coolant accident (LBLOCA) analysis of record for Oconee Units 1, 2, and 3. The error has been characterized by AREVA as an error occurring in a control variable for filtered core flow rates used in the LBLOCA blowdown model for Oconee. This control variable is used for the calculation of the core flow rates that affect heat transfer rates during the first half-second of the LBLOCA transient. The Oconee Small Break LOCA (SBLOCA) analyses are not affected by this error.

Attachment 1 to this letter provides a more detailed description of the LBLOCA EM error. AREVA has corrected the filtered flow control variable error and performed a LBLOCA reanalysis for Oconee. The Oconee LBLOCA reanalysis including the filtered flow error correction also incorporates corrections to two other errors in the LBLOCA evaluation model that were previously reported to the NRC in Reference 1.

The Oconee LBLOCA reanalysis with all three error corrections results in a maximum peak cladding temperature (PCT) of 1852 °F. This new limiting PCT is less than the LBLOCA PCT of 1913 °F most recently reported to the NRC in the Oconee annual 10 CFR 50.46 report for the 2012 calendar year [Reference 2].

Attachment 2 transmitted herewith contains Proprietary Information. Withhold from public disclosure under 10 CFR 2.390. Upon removal of Attachment 2 this letter is decontrolled.



A002
NRR

Since the magnitude of the PCT reduction is greater than 50 °F, the change in PCT is considered to be significant per 10 CFR 50.46 (a)(3)(i). Significant changes in PCT are required to be reported within 30 days per 10 CFR 50.46 (a)(3)(ii).

AREVA considers the Oconee LBLOCA analysis which incorporates all of the error corrections to be a reanalysis that replaces the previous Oconee LBLOCA analysis of record. Therefore, the reanalysis requirement per 10 CFR 50.46(a)(3)(ii) is considered to be satisfied via submission of this 30-day report. Since the PCTs have decreased, the maximum local cladding oxidation and whole core hydrogen generation values are not adversely affected, and remain acceptable. Included in this report is a LOCA PCT summary table for Oconee Units 1, 2, and 3 which reflect the LBLOCA reanalysis results. The information provided in this letter satisfies the 30-day reporting requirements of 10 CFR 50.46 (a)(3)(ii). There are no regulatory commitments contained in this letter.

Attachment 2 includes information that has been classified by AREVA to be proprietary information. Duke Energy requests that Attachment 2 be withheld from public disclosure. An affidavit from AREVA for those documents considered proprietary is also included in Attachment 3. This affidavit sets forth the basis on which the information may be withheld from public disclosure by the NRC pursuant to 10 CFR 2.390. Attachment 4 contains a non-proprietary version of Attachment 2.

Please address any comments or questions regarding this matter to Thomas R. Byrne at (980) 373-3249 (Tom.Byrne@duke-energy.com).

Sincerely,

Garry D. Miller
Sr. Vice President
Nuclear Engineering

Attachment 1: Report of Error Corrections on AREVA Large Break LOCA ECCS Evaluation Model for Application to Oconee Nuclear Station

Attachment 2: Estimation of Transient Impacts to Peak Cladding Temperature due to Fuel Pellet Thermal Conductivity Degradation (AREVA Proprietary Information)

Attachment 3: AREVA Affidavit for Proprietary Information Contained Within Attachment 2

Attachment 4: Estimation of Transient Impacts to Peak Cladding Temperature due to Fuel Pellet Thermal Conductivity Degradation (Non-Proprietary Version)

xc (with attachments):

V. M. McCree, Region II Administrator
U.S. Nuclear Regulatory Commission
Marquis One Tower
245 Peachtree Center Avenue NE, Suite 1200
Atlanta, GA 30303-1257

R. V. Guzman, Acting Project Manager (ONS)
U. S. Nuclear Regulatory Commission
11555 Rockville Pike
Mail Stop 0-8 C2
Rockville, MD 20852-2738

NRC Senior Resident Inspector
Oconee Nuclear Station

bxc (with attachments)

Chris Nolan
Julie Olivier
Lara Nichols
Mark Handrick
Scott Thomas
David Culp
Chris Wasik (ON03RC)
ONS Master File 801.01 – ON02DM

DUKE ENERGY CAROLINAS, LLC

OCONEE NUCLEAR STATION, UNITS 1, 2, AND 3

Attachment 1

Report of Error Corrections on AREVA LBLOCA ECCS Evaluation Model for Application to Oconee Nuclear Station

Table 1: LOCA Peak Cladding Temperature Margin Summary – Oconee Units 1, 2, and 3

By letter dated November 14, 2013 [Reference 1], AREVA notified Duke Energy of an error which affects the Large Break Loss of Coolant Accident (LBLOCA) analysis of record for Oconee Units 1, 2, and 3. AREVA has described the error as occurring in a control variable in the RELAP5/MOD2-B&W blowdown model for Oconee. This control variable is used for the calculation of the core flows using a low pass filter with the variable filter break frequency supplied by the control variable. The low pass filter calculates the flow used for hot channel and hot pin heat transfer calculations. The control variable should start at a break frequency of 30 and then reduce by 0.15 per time step until a frequency of 2 times pi (6.283) is achieved. The error was the result of incorrectly specified variable break frequencies. The initial value of the filter break frequency was set to 6.263 (instead of 30), and the value of 6.263 was unchanged for the entire transient. This error changes the core flow rates used for heat transfer in the hot channel and hot pin when these rods are predicting departure from nucleate boiling and subsequent transition or film boiling heat transfer during the first half-second of the LBLOCA transient. The filtered flow error is contained in the base LBLOCA analysis for Oconee that support core designs of full-core Mk-B-HTP fuel assemblies with gadolinia as an integral burnable absorber [Reference 2]. AREVA has stated that the filtered flow error correction does not apply to the Oconee Small Break LOCA analysis.

The base LBLOCA analysis for Oconee also contained an emergency core cooling system (ECCS) end of bypass timing error, and the B&W plant ECCS evaluation model [Reference 3] did not include a column weldment model in the reactor vessel upper plenum. To assess these errors, AREVA developed a simplified column weldment model located over the top of the hot channel. When the simplified column weldment model was used, and the ECCS bypass error corrected, AREVA conservatively estimated the net impact on peak cladding temperature (PCT) for the LBLOCA transient to be 0 °F [Reference 4]. The estimated impact on PCT for the ECCS bypass and column weldment errors has been previously reported by Duke Energy to the NRC in accordance with 10 CFR 50.46 via Reference 5.

In response to requests for additional information from the NRC regarding the ECCS bypass error and column weldment error estimates, AREVA's letter to the NRC [Reference 6] stated the correction of the ECCS bypass error and modeling of the column weldments will be incorporated into the LBLOCA model for application in future analyses.

The filtered flow error is an additional change that is applied to Oconee LBLOCA reanalyses that have recently been performed by AREVA to incorporate all error corrections, specifically ECCS bypass, column weldment modeling, and the filtered flow variable [Reference 7]. A description of the detailed column weldment modeling that was developed by AREVA and used for these Oconee LBLOCA reanalyses is provided on page 5 of this attachment.

The impact of all three errors was determined by performing explicit reanalyses of three different LBLOCA scenarios for the $UO_2$ fuel: (1) the previously limiting beginning of life (BOL) case with an axial power shaped peaked at the 2.506-ft core elevation, (2) the new limiting middle of life (MOL) case with an axial power shaped peaked at the 2.506-ft core elevation, and (3) and the limiting unruptured node BOL case with an axial power shaped peaked at the 7.779-ft core elevation. AREVA considers these cases to be

sufficient to capture the limiting PCT when all error corrections are included in the explicit reanalysis. In addition, all gadolinia cases at BOL and MOL were reanalyzed.

In order to separately capture the impact of the filter flow error correction, two sets of cases were required for each axial peaking / time in life scenario. The first set of cases include the combined effects of incorporating the detailed column weldment model and the corrected ECCS bypass error to establish the analyzed PCT versus the estimated net PCT change of 0 °F, as previously reported in Reference 5 where a simplified column weldment model was employed. The first set of cases do not include correction of the erroneous filtered flow model. The second set of cases are the same as the first set of cases, but the filtered flow error is corrected in order to isolate the PCT change applicable only to the filtered flow error.

The reanalyzed cases used the same maximum allowable linear heat rates as the base Oconee LBLOCA analysis, and the reanalyzed cases were used to develop estimated changes to the PCTs for the remaining non-limiting cases at all other core elevations and times in life for $UO_2$ and gadolinia fuel. The PCT results for the reanalyzed $UO_2$ cases are shown in the table below.

| Axial Peaking / Time in Life Case<br><br>Analysis Scenario | 2.506-ft BOL PCT (°F) | 2.506-ft MOL PCT (°F) | 7.779-ft BOL PCT (°F) |
|---|---|---|---|
| Oconee LBLOCA Base Analysis [Ref. 2] | <u>1913.2</u> | 1879.0 | 1905.7 |
| Change No. 1 | | | |
| Reanalysis of limiting cases incorporating correction for ECCS bypass error and use of detailed column weldment [Ref. 7] | 1872.4 | 1831.2 | <u>1878.0</u> |
| ΔPCT from Base Analysis for specific case | -40.8 | -47.8 | -27.7 |
| Change No. 2 | | | |
| Reanalysis of limiting cases incorporating correction for ECCS bypass error and use of detailed column weldment, and filtered flow error correction [Ref. 7] | 1836.9 | <u>1851.9</u> | 1848.0 |
| Separable ΔPCT due to filtered flow error correction for specific case | -35.5 | 20.7 | -30.0 |

Note: Underlined PCT value is the limiting case for each set of analyses

The results of the first set of cases incorporating the ECCS bypass error correction and detailed column weldment modeling show reductions in PCT for all conditions, when compared to the Oconee LBLOCA base analysis. These results confirm the conservative nature of the PCT error estimates reported in Reference 5 for ECCS bypass and simplified column weldment, where no net reduction in PCT was credited.

The limiting PCT case from the reanalysis, with all errors corrected, is 1851.9 °F occurring at middle of life. This represents a decrease of 61.3 °F from the previously limiting PCT of 1913.2 °F from the Oconee LBLOCA base analysis. Note that for 10 CFR 50.46 reporting purposes, the previous limiting PCT result had been rounded down to 1913 °F, and the new limiting PCT result will be rounded up to 1852 °F. A summary of the reportable PCT values for Oconee LBLOCA are provided in Table 1, shown on page 7 of this attachment.

Since the PCTs decreased at the allowed LOCA linear heat rate limits for all cases explicitly reanalyzed, the maximum local oxidation did not increase and remained less than 3% and whole core hydrogen generation did not increase and remained less than 0.15%. The PCT, local oxidation, and whole core hydrogen remain well within the 10 CFR 50.46 acceptance criteria for the LBLOCA scenarios. There are no changes to allowed LOCA linear heat rate limits for Oconee, with consideration of the ECCS bypass, detailed column weldment, and filtered flow error corrections. None of these error corrections affect the limiting Small Break LOCA results.

Since the absolute magnitude of the PCT change for the limiting case of the reanalysis is greater than 50 °F due to error corrections, the PCT change is considered to be significant per 10 CFR 50.46(a)(3)(i). Per 10 CFR 50.46(a)(3)(ii), significant changes in PCT must be reported to the NRC within 30 days, and the report shall include a proposed schedule for providing a reanalysis or taking other actions as may be needed to show compliance with 10 CFR 50.46 requirements.

AREVA considers the Oconee LBLOCA analysis documented in Reference 7 which incorporates all of the significant error corrections to be a reanalysis that replaces the previous Oconee LBLOCA analysis of record summarized in Reference 2. Therefore, the reanalysis requirement per 10 CFR 50.46(a)(3)(ii) is considered to be satisfied via submission of this 30-day report.

A separate change in PCT of +2 °F is being carried on the Oconee LBLOCA PCT summary shown in Table 1. This PCT change is based on estimated impacts to LBLOCA analysis results when the effects of fuel pellet thermal conductivity degradation are considered for the LBLOCA transient analyses. The basis for the change in PCT of +2 °F is documented in Reference 8, and is further described in Attachment 2 (AREVA proprietary information) and Attachment 4 (nonproprietary version).

## Description of Detailed Column Weldment Modeling in the BWNT LOCA EM

The original BWNT LOCA EM used a reactor vessel (RV) upper plenum (UP) model that combined the fluid volumes on the inside and outside of the UP guide tube column weldments (GT CW) into a single lumped region with several axially divided control volumes. The core baffle, bypass, hot channel and average channels all connected into this lumped region, so the fluid temperature was the mixed-mean value equal to the hot leg temperature.

The detailed CW UP model separates the upper plenum fluid volume inside the GT CWs from the fluid outside of the GT CWs. The region outside the CWs retains the original UP control volume designations in the new model. The GT CWs are lumped into two separate groupings or channels for the 177 fuel-assembly (FA) plant LBLOCA applications. A single GT CW is modeled over the single hot channel fuel assembly and the remaining CWs are connected to the 176 FAs from the average core channel. Sensitivity studies have shown that the limiting PCTs are produced when the hot channel core exit connects directly to the inlet of a single GT CW without any connection to the upper plenum region outside of the GTs. The modeling of the GT CW is more limiting during the reverse flow period of the blowdown phase of the LBLOCA transient.

Each GT CW channel is modeled with two stacked control volumes that extend from the core exit connection to the top of the GT CW in the RV upper head (UH). The lower UH control volume from the original BWNT LOCA EM is split into two volumes at the top of the GT CW housing to accommodate the junction connections. A junction modeling the holes and slots between the lowermost GT CW volume and the lowermost upper plenum volume is included from both the hot channel and average channel GT CW regions.

The detailed CW modeling requires 4 new CW control volumes for the 177 FA plant and it also requires splitting the lower UH control volume into two volumes. These 5 new volumes added to the original model require additional junctions to model all the flow connections. Additional junctions are needed to split the fuel assembly guide tube and instrument tube core bypass flows between the upper plenum and the two separate CW regions. Junctions were added to model the holes and slots in the CW, the exits into the upper head and their inlet flow from the core. When the detailed column weldment model is used, the upper plenum fluid temperatures differ from the hot and average channel CW fluid temperatures as well as the upper head fluid temperature. While these temperature differences are not critical to the severity of LBLOCA results, they are more representative of the initial conditions in the RV UP and UH region prior to the initiation of the LOCA.

The SBLOCA PCT results are insensitive to the CW orientation over the hot channel because the core exit flows do not reverse for these smaller break sizes. However, it is recognized that the detailed CW modeling should be used to reflect the variable fluid temperatures in the upper plenum and upper head regions prior to the transient that could influence tiny break sizes that do not predict core uncovering. These tiny non-limiting break sizes may evolve differently (still with no core uncovering and cladding heat up) when elevated RV upper head temperatures are used. Therefore, future SBLOCA model analyses will use the detailed CW model as well and it will use the same number of GT CWs as the number of fuel assemblies modeled in the hot channel. The remainder of the GT CWs will be modeled over top of the average channel.

References for Attachment 1


1. AREVA Letter FAB13-00549 to Scott Thomas (Duke Energy), "10 CFR 50.46 LOCA Report of an EM Error Correction (AREVA CR 2013-5610) Related to an Error in the Filtered Flow Calculation of the Filter Break Frequency," November 14, 2013.
2. AREVA NP Document 86-9150446-000, "ONS Full-Core Mark-B-HTP, Gadolinia Fuel, & 24 Month Cycle LOCA Summary Report" , July 22, 2011.
3. AREVA NP Topical Report BAW-10192P-A, Rev. 0, "BWNT LOCA - BWNT Loss-of-Coolant Accident Evaluation Model for Once-Through Steam Generator Plants," June 1998.
4. AREVA Letter FAB12-120 to S. B. Thomas (Duke Energy), "10 CFR 50.46 LOCA Report of Two EM Error Corrections (AREVA CR 2012-165: ECCS Bypass Mathematical Error and AREVA CR 2012-757: Upper Plenum Column Weldment EM Change)," February 23, 2012.
5. Letter, D. C. Culp (Duke Energy) to USNRC, Subject: Oconee Nuclear Station - 30-Day Report Pursuant to 10 CFR 50.46, Changes to or Errors in an Evaluation Model, March 9, 2012. [ADAMS Accession No. ML12073A354]
6. Letter, Pedro Salas, Director, Regulatory Affairs (AREVA NP Inc.) to USNRC, Subject: "Generic RAI Response to a 30-day 10 CFR 50.46 Report of Significant PCT Change", (NRC:12:062), March 28, 2013. [ADAMS Accession No. ML13091A075]
7. AREVA NP Document 32-9208297-001, "Filtered Flow and Detailed CW Model Impact for ONS LBLOCA", November 7, 2013. (AREVA Proprietary)
8. AREVA NP Document 86-9208764-000, "TCD Transient Assessment for B&W Plants Summary Report", October 21, 2013. (AREVA Proprietary)

**Table 1: LOCA Peak Cladding Temperature Margin Summary – Oconee Units 1, 2, & 3**

| LBLOCA | PCT(°F) | Comments |
|---|---|---|
| Evaluation model: RELAP5/MOD2-B&W | | |
| New analysis of record PCT incorporating error corrections for ECCS bypass, detailed column weldment, and filtered flow | 1852 | Reference F |
| Prior 10 CFR 50.46 Changes or Error Corrections (ΔPCT)<br>1. None | | |
| Current 10 CFR 50.46 Changes or Error Corrections (ΔPCT)<br>1. Transient fuel pellet thermal conductivity degradation (considered a change in the application of the evaluation model) | +2 | Reference G |
| Final licensing basis PCT | 1854 | |
| **SBLOCA Full Power -100% FP** | **PCT(°F)** | **Comments** |
| Evaluation model: RELAP5/MOD2-B&W | | |
| Analysis of record PCT | 1598 | References A, B, C<br>(2 HPI Case) 0.15 $ft^2$ break |
| Prior 10 CFR 50.46 Changes or Error Corrections (ΔPCT)<br>1. Upper Plenum Column Weldment Modeling | 0 | References D, E |
| Current 10 CFR 50.46 Changes or Error Corrections (ΔPCT)<br>1. None | 0 | |
| Final licensing basis PCT | 1598 | |
| **SBLOCA Reduced Power – 50% FP** [1] | **PCT(°F)** | **Comments** |
| Analysis of record PCT | N/A | Will be reported under a separate License Amendment Request (LAR)<br>(References A, B, C) |
| Prior 10 CFR 50.46 Changes or Error Corrections (ΔPCT) | N/A | |
| Current 10 CFR 50.46 Changes or Error Corrections (ΔPCT) | N/A | |
| Errors (ΔPCT) | N/A | |
| Final licensing basis PCT | N/A | Operation Not Justified [2] |

Notes

1. Partial power SBLOCA analysis with one HPI pump out of service, supports 30 day LCO for TS 3.5.2 Condition B. Also supports TS 3.5.2 Condition C1 and C2.
2. Pending review and approval of separate LAR. Refer to Reference A for additional details.

References for Table 1


A) Letter, R. M. Glover (Duke Energy) to USNRC, "30-Day Report Pursuant to 10 CFR 50.46, Changes to or Errors in an Evaluation Model", December 8, 2011. [ADAMS ML11347A193]

B) Letter, B. C. Waldrep (Duke Energy) to USNRC, "Report Pursuant to 10 CFR 50.46, Changes to or Errors in an Evaluation Model", July 5, 2012. [ADAMS ML121910319]

C) Letter, B. C. Waldrep (Duke Energy) to USNRC, "30-Day Report Pursuant to 10 CFR 50.46, Changes to or Errors in an Evaluation Model", December 20, 2012.

D) Letter, G. J. St.Clair (AREVA) to S. B. Thomas (Duke Energy), "10 CFR 50.46 LOCA Report of Two EM Error Corrections (AREVA CR 2012-165: ECCS Bypass Mathematical Error and AREVA CR 2012-757: Upper Plenum Column Weldment EM Change)", Dated February 23, 2012, AREVA Letter FAB12-120.

E) Letter, D. C. Culp (Duke Energy) to USNRC, "30-Day Report Pursuant to 10 CFR 50.46, Changes to or Errors in an Evaluation Model", March 9, 2012. [ADAMS ML12073A354]

F) AREVA Letter FAB13-00549 to Scott Thomas (Duke Energy), "10 CFR 50.46 LOCA Report of an EM Error Correction (AREVA CR 2013-5610) Related to an Error in the Filtered Flow Calculation of the Filter Break Frequency," November 14, 2013.

G) AREVA NP Document 86-9208764-000, "TCD Transient Assessment for B&W Plants Summary Report", October 21, 2013. (AREVA Proprietary)

**Attachment 3**

**AREVA Affidavit for Proprietary Information Contained Within Attachment 2**

**3 pages to follow for Attachment 3**

# AFFIDAVIT

STATE OF WASHINGTON )
) ss.
COUNTY OF BENTON )

1. My name is Alan B. Meginnis. I am Manager, Product Licensing, for AREVA NP Inc. and as such I am authorized to execute this Affidavit.

2. I am familiar with the criteria applied by AREVA NP to determine whether certain AREVA NP information is proprietary. I am familiar with the policies established by AREVA NP to ensure the proper application of these criteria.

3. I am familiar with the AREVA NP information contained in Attachment 2 of the document titled "30-Day Report Pursuant to 10 CFR 50.46, Changes to or Errors in an Evaluation Model," dated December 2013 and referred to herein as "Document." Information contained in this Document has been classified by AREVA NP as proprietary in accordance with the policies established by AREVA NP for the control and protection of proprietary and confidential information.

4. This Document contains information of a proprietary and confidential nature and is of the type customarily held in confidence by AREVA NP and not made available to the public. Based on my experience, I am aware that other companies regard information of the kind contained in this Document as proprietary and confidential.

5. This Document has been made available to the U.S. Nuclear Regulatory Commission in confidence with the request that the information contained in this Document be withheld from public disclosure. The request for withholding of proprietary information is made in accordance with 10 CFR 2.390. The information for which withholding from disclosure is

requested qualifies under 10 CFR 2.390(a)(4) "Trade secrets and commercial or financial information."

6. The following criteria are customarily applied by AREVA NP to determine whether information should be classified as proprietary:

(a) The information reveals details of AREVA NP's research and development plans and programs or their results.

(b) Use of the information by a competitor would permit the competitor to significantly reduce its expenditures, in time or resources, to design, produce, or market a similar product or service.

(c) The information includes test data or analytical techniques concerning a process, methodology, or component, the application of which results in a competitive advantage for AREVA NP.

(d) The information reveals certain distinguishing aspects of a process, methodology, or component, the exclusive use of which provides a competitive advantage for AREVA NP in product optimization or marketability.

(e) The information is vital to a competitive advantage held by AREVA NP, would be helpful to competitors to AREVA NP, and would likely cause substantial harm to the competitive position of AREVA NP.

The information in the Document is considered proprietary for the reasons set forth in paragraphs 6(b), 6(d) and 6(e) above.

7. In accordance with AREVA NP's policies governing the protection and control of information, proprietary information contained in this Document have been made available, on a limited basis, to others outside AREVA NP only as required and under suitable agreement providing for nondisclosure and limited use of the information.

8. AREVA NP policy requires that proprietary information be kept in a secured file or area and distributed on a need-to-know basis.

9. The foregoing statements are true and correct to the best of my knowledge, information, and belief.

SUBSCRIBED before me this 6th day of December, 2013.


Susan K. McCoy
NOTARY PUBLIC, STATE OF WASHINGTON
MY COMMISSION EXPIRES: 1/14/2016

**Attachment 4**

**Estimation of Transient Impacts to Peak Cladding Temperature due to Fuel Pellet Thermal Conductivity Degradation**
**(Non-Proprietary version)**

As a separate impact on PCT not discussed in AREVA's letter to Duke Energy concerning the filtered flow error [Reference 1], the estimated effect of considering fuel pellet thermal conductivity degradation (TCD) during the Large Break LOCA transient is being reported under 10 CFR 50.46 at this time.

AREVA has previously indicated that the conservatisms inherent within the LOCA initialization methods using the TACO3 and GDTACO fuel performance computer codes were adequate to establish steady-state fuel temperatures, accounting for fuel pellet thermal conductivity degradation effects with increasing burnup. Duke Energy understands that the issue of fuel pellet thermal conductivity degradation and corresponding impacts to LOCA analyses for B&W plants was discussed in meetings between AREVA and the NRC conducted in June of 2012, based on a review of References 2 and 3.

Duke Energy has participated in a Pressurized Water Reactor Owners Group (PWROG) project applicable to B&W plants to investigate the representative effects of fuel pellet thermal conductivity degradation during the transient portion of the Large Break LOCA at middle-of-life burnups. The TCD sensitivity study was performed by AREVA using the Oconee Nuclear Station RELAP5/MOD2-B&W model. In addition to the effects of TCD, the Oconee LBLOCA plant model was updated with a detailed column weldment model and corrected errors in both the ECCS bypass and filtered flow models. The TCD sensitivity study is documented within Reference 4.

The values for the degraded fuel pellet thermal conductivity were calculated using the same method as used by the GALILEO fuel rod performance code, where the fuel pellet thermal conductivity is calculated based on degradation with burnup and radiation damage and is then corrected to account for fuel porosity. [

]

[

]

[

]

The maximum cladding temperature reached in the TCD sensitivity study transient resulted in an increase of 1.9 °F compared to the transient without degraded fuel pellet thermal conductivity. [

]

Therefore, it is determined that a degraded thermal conductivity used in a RELAP5 transient analysis has only a minimal impact upon the change in maximum cladding temperature during a LBLOCA analyses.

It is AREVA's conclusion that the change in cladding temperature from TCD during the transient is insignificant, and therefore the results of the study validates use of the non-degraded fuel thermal conductivity in the ECCS evaluation model and LOCA analyses for B&W plants. AREVA concluded that the results from this TCD investigation confirm that no changes are needed in the method for transient analyses and the results of this sensitivity study should not be used to replace any licensing applications.

Duke Energy does not consider use of degraded fuel pellet thermal conductivity within the RELAP5/MOD2-B&W model to be a change in the approved ECCS evaluation model as described in Reference 5, or a change to the approved RELAP5/MOD2-B&W plant model as described in Reference 6. Section 4.3.3.4 of BAW-10192-NP says that "the thermal and mechanical properties of the fuel and clad are based on current nuclear industry materials data." The reader is then directed to BAW-10164 for additional details. Section 2.3.2 of BAW-10164NP, Rev. 6 states "thermal conductivity of the fuel rod materials, except the thermal conductivity of the gas gap, must be supplied by the user." Appendix E of BAW-10164NP, Rev. 6 states that the thermal conductivity values "may be selected by the user for use in the heat structure heat conduction calculations." The default $UO_2$ thermal conductivities vs. temperature are then listed, if the user selects the default option. The approved topical reports do not require the LOCA analyst to use the default (non-degraded) $UO_2$ thermal conductivities within RELAP5/MOD2-B&W. Therefore, Duke Energy considers the use of degraded fuel pellet thermal conductivity within the RELAP5/MOD2-B&W transient model to be a change in the application of a previously approved ECCS evaluation model.

Duke Energy will carry the transient TCD assessment of +2 °F on the Oconee 10 CFR 50.46 PCT summary table until such time as AREVA fuel performance codes that explicitly model TCD (e.g. GALILEO) are approved by the NRC and ultimately incorporated into the Oconee LBLOCA analyses of record.

References for Attachment 2


1. AREVA Letter FAB13-00549 to Scott Thomas (Duke Energy), "10 CFR 50.46 LOCA Report of an EM Error Correction (AREVA CR 2013-5610) Related to an Error in the Filtered Flow Calculation of the Filter Break Frequency," November 14, 2013.
2. AREVA Letter NRC:12:023 to USNRC , "Response to NRC letter Regarding Nuclear Fuel Thermal Conductivity Degradation Evaluation of Light Water Reactors Using AREVA Codes and Methods," April 27, 2012. [ADAMS Accession No. ML121220377]
3. AREVA Summary of June 2012 Fuel Performance Meeting with NRC: Thermal Conductivity Degradation Letter (PWR) – NRC Concerns, June 27, 2012. [ADAMS Accession No. ML12205A127]
4. AREVA NP Document 86-9208764-000, "TCD Transient Assessment for B&W Plants Summary Report", October 21, 2013. (AREVA Proprietary)
5. AREVA NP Topical Report BAW-10192P-A, Rev. 0, "BWNT LOCA - BWNT Loss-of-Coolant Accident Evaluation Model for Once-Through Steam Generator Plants," June 1998.
6. AREVA NP Topical Report BAW-10164P-A, Rev. 6, "RELAP5/MOD2-B&W - An Advanced Computer Program for Light Water Reactor LOCA and Non-LOCA Transient Analysis."