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10 CFR 50.46

RS-12-087

May 21, 2012

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

Braidwood Station, Unit 1
Facility Operating License No. NPF-72
NRC Docket No. STN 50-456

Byron Station, Unit 1
Facility Operating License No. NPF-37
NRC Docket No. STN 50-454

Subject: ECCS Evaluation Model Error - 10 CFR 50.46 Report

Reference: Letter from David M. Gullott (Exelon Generation Company, LLC) to U.S. NRC, "Annual 10 CFR 50.46 Report of the Emergency Core Cooling System Evaluation Model Changes and Errors," dated April 6, 2012

In the Reference letter, Exelon Generation Company, LLC, (EGC) committed to complete by April 30, 2012, an estimate of the effects of thermal conductivity degradation (TCD) on peak cladding temperature (PCT) in the Westinghouse Electric Company furnished realistic emergency core cooling system large break loss-of-coolant accident evaluation models for Braidwood Station, Unit 1 and Byron Station, Unit 1. On April 19, 2012, the estimated effect of TCD on PCT was determined to be significant.

Pursuant to 10 CFR 50.46, "Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors," paragraph (a)(3)(ii), EGC is submitting this letter to fulfill the 30 day reporting requirement for Braidwood Station, Unit 1 and Byron Station, Unit 1. In accordance with 10 CFR 50.4, "Written communications," paragraph (a), the response is due by May 21, 2012.

Regulatory commitments are contained in Attachment 3 of this letter.

If you have any questions about this letter, please contact me at (630) 657-2823.

Respectfully,

Patrick R. Simpson
Manager - Licensing
Exelon Generation Company, LLC

Attachments:

1. Information Regarding Thermal Conductivity Degradation Estimation
2. 10 CFR 50.46 30 Day Report for Braidwood Station Unit 1 and Byron Station Unit 1
3. Regulatory Commitments

cc: Regional Administrator, U.S. NRC Region III
U.S. NRC Senior Resident Inspector, Braidwood Station
U.S. NRC Senior Resident Inspector, Byron Station

ATTACHMENT 1

Information Regarding Thermal Conductivity Degradation Estimation

The NRC in Reference 1 requested that Exelon Generation Company, LLC, (EGC) respond to the following specific issues associated with the effect of thermal conductivity degradation (TCD) on peak cladding temperature (PCT) in the Westinghouse Electric Company furnished realistic emergency core cooling system evaluation models for Braidwood Station, Unit 2 and Byron Station, Unit 2:

1) An estimation of the effect of the thermal conductivity degradation error on the peak fuel cladding temperature calculation for the emergency core cooling system evaluations at Braidwood Station, Unit No. 2 and Byron Station, Unit No. 2.

2) A description of the methodology and assumptions used to determine the estimates. This description shall include consideration of experimental data relevant to thermal conductivity degradation and specific information regarding any computer code model changes which were necessary to address these data.

Reference 2 provided the requested information for Braidwood Station, Unit 2 and Byron Station, Unit 2. The following sections provide the information for Braidwood Station, Unit 1 and Byron Station, Unit 1.

Response

Reference 3 contains the latest 10 CFR 50.46 annual report submitted to the NRC for Braidwood and Byron Stations and provided the most recent results of the large break loss of coolant accident (LBLOCA) Analysis of Record (AOR). The PCT reported for the LBLOCA was 1913°F for Braidwood Station, Unit 1 and Byron Station, Unit 1.

The 2004 Westinghouse Realistic Large Break LOCA Evaluation Model Using ASTRUM (i.e., Reference 4) is based on the PAD 4.0 fuel performance code (i.e., Reference 5). PAD 4.0 was approved without explicitly considering fuel pellet TCD with burnup. Explicit modeling of fuel pellet TCD in the fuel performance code leads to changes in the fuel rod design parameters beyond beginning of life which are input to the LBLOCA analysis. The effects of explicitly modeling fuel pellet TCD on the Braidwood Station, Unit 1 and Byron Station, Unit 1 LBLOCA analysis have been considered as described in Reference 6.

Fuel performance data that accounts for fuel pellet TCD (using an unlicensed model) was used as input to the Braidwood Station, Unit 1 and Byron Station, Unit 1 evaluation. The new PAD fuel performance data was generated with a representative model that includes explicit modeling of fuel pellet TCD. Therefore, the evaluations performed consider the fuel pellet TCD effects cited in Reference 7.

Evaluation of Fuel Pellet TCD and Peaking Factor Burndown

Fuel pellet TCD and peaking factor burndown were not explicitly considered in the Braidwood Station, Unit 1 and Byron Station, Unit 1 LBLOCA AOR. EGC estimated the

effect of TCD on the PCT calculation for Braidwood Station, Unit 1 and Byron Station, Unit 1. This change affects the LBLOCA evaluation model using ASTRUM (i.e., Reference 4).

A quantitative evaluation as discussed in Reference 6 was performed to assess the PCT effect of TCD and peaking factor burndown with other considerations of burnup on the Braidwood Station, Unit 1 and Byron Station, Unit 1 LBLOCA analysis and concluded that the estimated PCT impact is +110°F for 10 CFR 50.46 reporting purposes. The peaking factor burndown included in the evaluation is provided below in Tables 1, 2, and 3. EGC and its vendor, Westinghouse Electric Company LLC, utilize processes which ensure that the LOCA analysis input values conservatively bound the as-operated plant values for those parameters. Specifically, these tables are already included in the cycle specific Reload Safety Analysis Checklist limits.

Table 1: FDH Burndown Considered in the Evaluation of TCD

Rod Burnup (MWD/MTU)	FDH[(1)(2)]
0	1.7
33,000	1.7
40,000	1.56
50,000	1.46
60,000	1.41
70,000	1.31

(1) Includes uncertainties.
(2) Hot assembly average power uses same burndown, since it is a function of FDH.

Table 2: Steady State FQ Burndown Considered in the Evaluation of TCD

Rod Burnup (MWD/MTU)	FQ Steady-State
0	2.1
40,000	2.1
50,000	1.95
60,000	1.89
70,000	1.81

Table 3: Transient FQ Burndown Considered in the Evaluation of TCD

Rod Burnup (MWD/MTU)	FQ Transient[(1)]
0	2.6
40,000	2.6
50,000	2.34
60,000	2.29
70,000	2.16

(1) Includes uncertainties.

Evaluation of Analysis Input Changes

To demonstrate compliance with the 10 CFR 50.46(b)(1) acceptance criterion concerning PCT when explicitly considering fuel pellet TCD and peaking factor burndown in the Braidwood Station, Unit 1 and Byron Station, Unit 1 LBLOCA analysis,

analysis input values were revised, yet still bound the as-operated plant values. These input changes are not changes to the approved evaluation model in Reference 4. The updated inputs for Braidwood Station, Unit 1 and Byron Station, Unit 1 include:

- Reduction in the as-analyzed FQ to a value closer to the desired FQ as defined by the ASTRUM evaluation method for several of the most limiting cases used in the evaluation. This reduction removed analysis conservatism associated with using values of FQ in code executions that exceeded target values.
- Increase in the conservatively low assumed containment pressure boundary condition (see Figure 1).

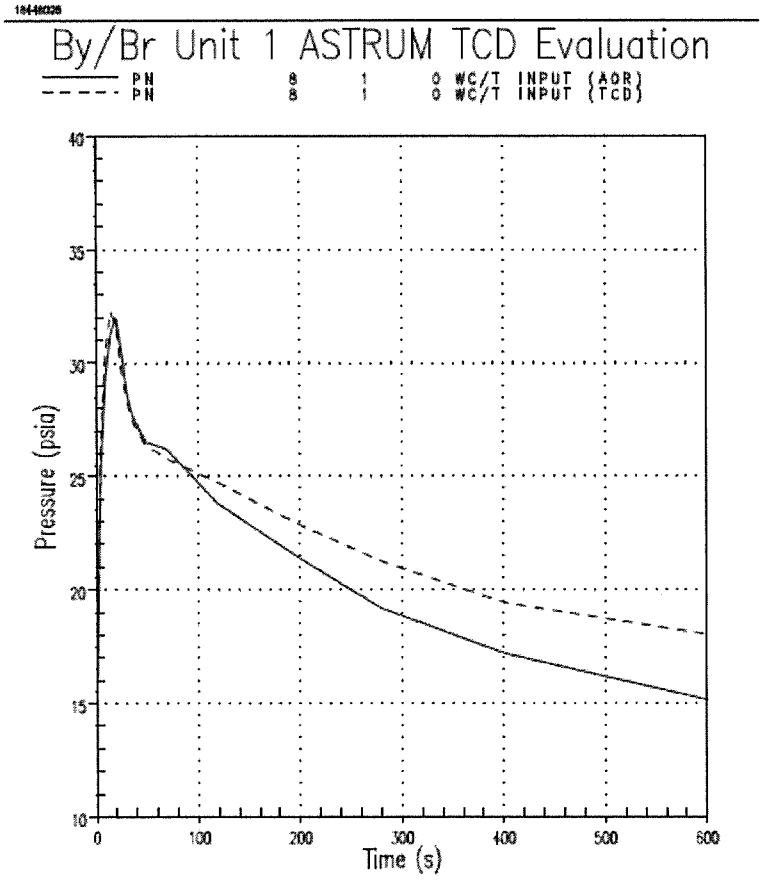

Figure 1: Comparison of AOR assumed containment pressure boundary condition with that of the Analysis Input Changes and TCD evaluations

EGC and its vendor, Westinghouse Electric Company LLC, utilize processes which ensure that the LOCA analysis input values conservatively bound the as-operated plant values for those parameters. This change affects the LBLOCA evaluation model using ASTRUM (i.e., Reference 4).

A quantitative evaluation as discussed in Reference 6 was performed to estimate an overall PCT change due to changes in analysis input parameters. The evaluation

concluded that the estimated PCT impact of these analysis input changes is -66°F for 10 CFR 50.46 reporting purposes.

LBLOCA Description of Evaluation

The evaluation method discussed in Reference 6 was used to determine the estimated effect of fuel pellet TCD and peaking factor burndown. First, the integrated PCT was calculated to demonstrate compliance with the 10 CFR 50.46(b)(1) criterion when the Analysis Input Changes and TCD and burndown were considered. Then, the margin PCT was calculated, including only the Analysis Input Changes.

For the integrated PCT calculation, a total of 25 WCOBRA/TRAC executions were performed. The uncertainty attributes of these executions were taken from among the most limiting cases from the original 124-run ASTRUM analysis. The evaluation considered an adequate range of burnup such that the effects of TCD and related burnup effects were captured. HOTSPOT executions were performed for each WCOBRA/TRAC case to consider the effect of local uncertainties for both IFBA (Integral Fuel Burnable Absorber) and non-IFBA fuel.

For the margin PCT calculation, a total of 12 WCOBRA/TRAC executions were performed. Again, the uncertainty attributes were taken from among the most limiting cases from the original 124-run ASTRUM analysis.

The estimated effect of TCD with burndown was then taken as the difference between the integrated PCT and the margin PCT.

LBLOCA Results

Consistent with Reference 4, the most limiting PCT from each evaluation was taken as the representative PCT. The limiting integrated PCT case, considering all Analysis Input Changes and TCD and burndown, was 1957°F, less than the 2200°F acceptance criterion. Considering only the Analysis Input Changes, the margin PCT was 1847°F.

Given the current AOR PCT of 1913°F, the estimate of effect of the Analysis Input Changes for 10 CFR 50.46 reporting purposes is -66°F. The estimate of effect of TCD and burndown is the difference between the margin PCT and the integrated PCT, or +110°F. These changes are inherently linked and cannot be separated out, so the results of the estimated net PCT change for LBLOCA is +44°F, creating a new limiting PCT value of 1957°F. The updated PCT value remains within the NRC 10 CFR 50.46 acceptance criterion of 2200°F.

Methodology and Assumptions

With respect to a description of the methodology and assumptions used to determine the above estimate, Westinghouse has provided this information directly to the NRC in Reference 6. This description includes consideration of experimental data relevant to TCD and specific information regarding computer code model changes which were necessary to address these data.

10 CFR 50.46 Reporting

The estimated impact on the Braidwood Station, Unit 1 and Byron Station, Unit 1 LBLOCA evaluation model from fuel TCD represents a significant change in PCT, as defined in 10 CFR 50.46(a)(3)(i). 10 CFR 50.46(a)(3)(ii) requires the licensee to provide a report within 30 days, including a proposed schedule for providing a reanalysis or taking other action as may be needed to show compliance with 10 CFR 50.46. Attachment 2 of this submittal contains the 30 day report required by 10 CFR 50.46(a)(3)(ii) for Braidwood Station, Unit 1 and Byron Station, Unit 1. EGC has evaluated the requirement for reanalysis specified in 10 CFR 50.46(a)(3)(ii) and proposes the following schedule for reanalysis.

By December 15, 2016, EGC will submit to the NRC for review and approval a LBLOCA analysis that applies NRC approved methods that include the effects of fuel TCD for Braidwood Station, Unit 1 and Byron Station, Unit 1. The date for the analysis submittal is contingent on the following milestones which must be completed in order to perform a revised licensing basis LBLOCA analysis with an NRC approved ECCS evaluation model that explicitly accounts for TCD:

1) NRC approval of a fuel performance analysis methodology that includes the effects of TCD. The new methodology for developing inputs to the LBLOCA evaluation model would replace the current licensing basis methodology for Braidwood Station, Unit 1 and Byron Station, Unit 1 that is described in WCAP-15063-P-A, Revision 1 with Errata, "Westinghouse Improved Performance Analysis and Design Model (PAD 4.0)."
2) NRC approval of a LBLOCA evaluation model that includes the effects of TCD and accommodates the rulemaking associated with the proposed 10 CFR 50.46c (Docket ID NRC-2008-0332). The new methodology would replace the current licensing basis methodology, WCAP-16009-P-A, "Realistic Large-Break LOCA Evaluation Methodology Using the Automated Statistical Treatment of Uncertainty Method (ASTRUM)."

Attachment 3 of this submittal contains the regulatory commitment associated with the proposed schedule of reanalysis. This information and that contained in Attachment 2 satisfies the reporting requirements of 10 CFR 50.46(a)(3)(ii).

Conclusions

EGC has reviewed the information provided by Westinghouse and determined that the adjusted LBLOCA PCT values and the manner in which they were derived continue to comply with the requirements of 10 CFR 50.46. EGC concludes, consistent with 10 CFR 50.46(a)(1)(i), there remains a high level of probability that the acceptance criterion of 10 CFR 50.46(b)(1), concerning the fuel PCT, would not be exceeded, when the model is corrected for TCD.

References

1. Letter from Michele G. Evans (U.S. NRC) to Michael J. Pacilio (Exelon Nuclear), "Information Request Pursuant to 50.54(f) Related to the Estimated Effect on Peak Cladding Temperature Resulting from Thermal Conductivity Degradation in the Westinghouse Furnished Realistic Emergency Core Cooling System Evaluation (TAC No. M99899)," dated February 16, 2012

2. Letter from Patrick R. Simpson (Exelon Generation Company, LLC) to U.S. NRC, "Response to Request for Information Regarding Thermal Conductivity Degradation and 10 CFR 50.46 Report," dated March 19, 2012

3. Letter from David M. Gullott (Exelon Generation Company, LLC) to U.S. NRC, "Annual 10 CFR 50.46 Report of the Emergency Core Cooling System Evaluation Model Changes and Errors," dated April 6, 2012

4. WCAP-16009-P-A, "Realistic Large-Break LOCA Evaluation Methodology Using the Automated Statistical Treatment of Uncertainty Method (ASTRUM)," dated January 2005

5. WCAP-15063-P-A Revision 1 with Errata, "Westinghouse Improved Performance Analysis and Design Model (PAD 4.0)," dated July 2000

6. Letter from J. A. Gresham (Westinghouse) to U.S. NRC, "Westinghouse Input Supporting Licensee Response to NRC 10 CFR 50.54(f) Letter Regarding Nuclear Fuel Thermal Conductivity Degradation," dated March 7, 2012

7. NRC Information Notice 2011-21, "Realistic Emergency Core Cooling System Evaluation Model Effects Resulting From Nuclear Fuel Thermal Conductivity Degradation," dated December 13, 2011

ATTACHMENT 2

10 CFR 50.46 30 Day Report

for

Braidwood Station Unit 1 and Byron Station Unit 1

Peak Cladding Temperature Rack-Up Sheet

PLANT NAME:	Braidwood Station Unit 1
ECCS EVALUATION MODEL:	Large Break Loss of Coolant Accident (LBLOCA)
REPORT REVISION DATE:	05/21/12
CURRENT OPERATING CYCLE:	17

ANALYSIS OF RECORD

Evaluation Model:	ASTRUM (2004)	
Calculation:	Westinghouse WCAP-16841-P, November 2007	
Fuel:	VANTAGE+ 17 x 17	
Limiting Fuel Type:	VANTAGE+ 17 x 17	
Limiting Single Failure:	Loss of one train of ECCS flow	
Limiting Break Size and Location:	Guillotine break in the Cold Leg	
Reference PCT		PCT = 1913.0°F

MARGIN ALLOCATION

A. PRIOR LOSS OF COOLANT ACCIDENT (LOCA) MODEL ASSESSMENTS

10 CFR 50.46 report dated March 15, 2011 (see Note 1)	ΔPCT = 0°F
10 CFR 50.46 report dated April 6, 2011 (see Note 2)	ΔPCT = 0°F
10 CFR 50.46 report dated April 6, 2012 (see Note 3)	ΔPCT = 0°F

NET PCT **PCT = 1913.0°F**

B. CURRENT LOCA MODEL ASSESSMENTS

Analysis Input Changes with Respect to Plant Operation (see Note 4)	ΔPCT = -66°F
Evaluation of Pellet Thermal Conductivity Degradation and Peaking Factor Burndown (see Note 4)	ΔPCT = +110°F
Total PCT change from current assessments	$\sum$ ΔPCT = +44°F
Cumulative PCT change from current assessments	$\sum \lvert$ ΔPCT $\rvert$ = 176°F

NET PCT **PCT = 1957.0°F**

Peak Cladding Temperature Rack-Up Sheet

PLANT NAME: Byron Station Unit 1
ECCS EVALUATION MODEL: Large Break Loss of Coolant Accident (LBLOCA)
REPORT REVISION DATE: 05/21/12
CURRENT OPERATING CYCLE: 18

ANALYSIS OF RECORD

Evaluation Model:	ASTRUM (2004)
Calculation:	Westinghouse WCAP-16841-P, November 2007
Fuel:	VANTAGE+ 17 x 17
Limiting Fuel Type:	VANTAGE+ 17 x 17
Limiting Single Failure:	Loss of one train of ECCS flow
Limiting Break Size and Location:	Guillotine break in the Cold Leg
Reference PCT	PCT = 1913.0°F

MARGIN ALLOCATION

A. PRIOR LOSS OF COOLANT ACCIDENT (LOCA) MODEL ASSESSMENTS

10 CFR 50.46 report dated March 15, 2011 (see Note 1)	ΔPCT = 0°F
10 CFR 50.46 report dated April 6, 2011 (see Note 2)	ΔPCT = 0°F
10 CFR 50.46 report dated April 6, 2012 (see Note 3)	ΔPCT = 0°F

NET PCT **PCT = 1913.0°F**

B. CURRENT LOCA MODEL ASSESSMENTS

Analysis Input Changes with Respect to Plant Operation (see Note 4)	ΔPCT = -66°F
Evaluation of Pellet Thermal Conductivity Degradation and Peaking Factor Burndown (see Note 4)	ΔPCT = +110°F
Total PCT change from current assessments	$\sum$ ΔPCT = +44°F
Cumulative PCT change from current assessments	$\sum \lvert$ ΔPCT $\rvert$ = 176°F

NET PCT **PCT = 1957.0°F**

Assessment Notes

1. Prior LOCA Model Assessment

   The 30 day 10 CFR 50.46 report in Reference 1 reported a new large break BELOCA (ASTRUM) analysis to support operations for Braidwood and Byron Stations Units 1 and 2. The same report assessed the impact from several errors, issues, and code enhancements. Each of these errors/issues/code enhancements had a 0°F PCT impact with a net 0°F PCT impact.

2. Prior LOCA Model Assessment

   The 10 CFR 50.46 report in Reference 2 reported no changes, corrections, or enhancements for the LBLOCA model.

3. Prior LOCA Model Assessment

   The 10 CFR 50.46 report in Reference 3 reported general code maintenance. This maintenance had a 0°F PCT impact to the LBLOCA model.

4. Current LOCA Model Assessment

   Two changes were performed, affecting the Unit 1 Byron and Braidwood Stations LBLOCA analysis. The first is an error in the evaluation model concerning the modeling of thermal conductivity degradation (TCD) and associated peaking factor burndown. The second is an analysis input change consisting of a reduction in conservatism in analyzed FQ values, and an increase in the assumed containment pressure boundary condition.

   As a result, Westinghouse estimated the effect of the TCD with burndown to be +110°F and estimated the effect of the analysis input changes to be -66°F. These two assessments are coupled together via their evaluations of burnup effects which include TCD, peaking factor burndown and analysis input changes. Therefore, the combined affect of these two changes results in a net change in the reported LBLOCA PCT of +44°F.

References

1. Letter from Jeffrey L. Hansen (Exelon Generation Company, LLC) to U.S. NRC, "ECCS Evaluation Model Error – 10 CFR 50.46 Reports," dated March 15, 2011

2. Letter from Jeffrey L. Hansen (Exelon Generation Company, LLC) to U.S. NRC, "Annual 10 CFR 50.46 Report of the Emergency Core Cooling System Evaluation Model Changes and Errors," dated April 6, 2011

3. Letter from David M. Gullott (Exelon Generation Company, LLC) to U.S. NRC, "Annual 10 CFR 50.46 Report of the Emergency Core Cooling System Evaluation Model Changes and Errors," dated April 6, 2012

ATTACHMENT 3

Regulatory Commitments

The following list identifies those actions committed to by Exelon Generation Company, LLC, (EGC) in this submittal. Any other actions discussed in the submittal represent intended or planned actions by EGC, are described only for information, and are not regulatory commitments.

COMMITMENT	COMMITTED DATE OR "OUTAGE"	COMMITMENT TYPE	
		ONE-TIME ACTION (YES/NO)	PROGRAM-MATIC (YES/NO)
EGC will submit to the NRC for review and approval a LBLOCA analysis that applies NRC approved methods that include the effects of fuel TCD for Braidwood Station, Unit 1 and Byron Station, Unit 1. The date for the analysis submittal is contingent on the following milestones which must be completed in order to perform a revised licensing basis LBLOCA analysis with an NRC approved ECCS evaluation model that explicitly accounts for TCD: 1) NRC approval of a fuel performance analysis methodology that includes the effects of TCD. The new methodology for developing inputs to the LBLOCA evaluation model would replace the current licensing basis methodology for Braidwood Station, Unit 1 and Byron Station, Unit 1 that is described in WCAP-15063-P-A, Revision 1 with Errata, "Westinghouse Improved Performance Analysis and	December 15, 2016	Yes	No

COMMITMENT	COMMITTED DATE OR "OUTAGE"	COMMITMENT TYPE	
		ONE-TIME ACTION (YES/NO)	PROGRAM-MATIC (YES/NO)
Design Model (PAD 4.0)." 2) NRC approval of a LBLOCA evaluation model that includes the effects of TCD and accommodates the rulemaking associated with the proposed 10 CFR 50.46c (Docket ID NRC-2008-0332). The new methodology would replace the current licensing basis methodology, WCAP-16009-P-A, "Realistic Large-Break LOCA Evaluation Methodology Using the Automated Statistical Treatment of Uncertainty Method (ASTRUM)."			