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RS-14-118

10 CFR 50.46

April 7, 2014

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

Braidwood Station, Units 1 and 2
Facility Operating License Nos. NPF-72 and NPF-77
NRC Docket Nos. STN 50-456 and 50-457

Byron Station, Units 1 and 2
Facility Operating License Nos. NPF-37 and NPF-66
NRC Docket Nos. STN 50-454 and 50-455

Subject: Annual 10 CFR 50.46 Report of Emergency Core Cooling System Evaluation Model Changes and Errors

References:
1) Letter from D. M. Gullott (Exelon Generation Company, LLC) to U.S. NRC, "Annual 10 CFR 50.46 Report of Emergency Core Cooling System Evaluation Model Changes and Errors," dated April 5, 2013

2) Letter from D.M. Gullott (Exelon Generation Company, LLC) to U.S. NRC, "ECCS Evaluation Model Error – 10 CFR 50.46 30-Day Report," dated February 27, 2014

In accordance with 10 CFR 50.46, "Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors," paragraph (a)(3)(ii), Exelon Generation Company, LLC, (EGC) is submitting the attached information to fulfill the annual reporting requirements for Braidwood and Byron Stations, Units 1 and 2.

The attachments describe the changes in accumulated peak cladding temperature (PCT) since the previous annual report submitted in Reference 1 and the 30-day report submitted in Reference 2. The Reference 2 letter provided the estimated impact of changes and errors in the ASTRUM Large Break Loss of Coolant Accident (LBLOCA) analysis for Braidwood Station, Unit 1 and Byron Station, Unit 1. The cumulative PCT for Unit 1 was 66° F whereas the cumulative PCT impact for Unit 2 was 46° F; therefore, Braidwood Station, Unit 2 and Byron Station, Unit 2, were not addressed in the Reference 2 letter and is reported herein. Also not addressed in the Reference 2 letter was the Small Break Loss of Coolant Accident (SBLOCA) analysis which is not affected by the ASTRUM LBLOCA methodology.

Attachment 1 provides PCT information for the limiting loss-of-coolant accident (LOCA) evaluation for the Braidwood and Byron Stations. Attachment 2 contains the assessment notes, which provide the detailed description for each change reported.

There are no regulatory commitments contained in this submittal. Should you have any questions concerning this letter, please contact Jessica Krejcie at (630) 657-2816.

Respectfully,

David M. Gullott
Manager – Licensing
Exelon Generation Company, LLC

Attachments:
1) Braidwood and Byron Stations, Units 1 and 2 – 10 CFR 50.46 Report
2) Braidwood and Byron Stations, Units 1 and 2 – 10 CFR 50.46 Report Assessment Notes

cc: NRC Regional Administrator, Region III
NRC Senior Resident Inspector, Braidwood Station
NRC Senior Resident Inspector, Byron Station
NRR Project Manager, Braidwood and Byron Stations
Illinois Emergency Management Agency – Division of Nuclear Safety

Attachment 1
Byron and Braidwood Units 1 and 2
10 CFR 50.46 Report

PLANT NAME: Braidwood Station Unit 1
ECCS EVALUATION MODEL: Small Break Loss of Coolant Accident (SBLOCA)
REPORT REVISION DATE: 04/07/14
CURRENT OPERATING CYCLE: 18

ANALYSIS OF RECORD (AOR)

Evaluation Model: NOTRUMP
Calculation: Westinghouse CN-LIS-00-208, December 2000
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: 2-inch Break in the Bottom of the Cold Leg
Reference Peak Cladding Temperature (PCT) PCT = 1624.0°F

MARGIN ALLOCATION

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

10 CFR 50.46 report dated June 11, 2001 (Note 1)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 18, 2002 (Note 2)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 14, 2003 (Note 3)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 14, 2004 (Note 4)	ΔPCT = 35 °F
10 CFR 50.46 report dated April 14, 2005 (Note 5)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 14, 2006 (Note 6)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 13, 2007 (Note 7)	ΔPCT = 0 °F
10 CFR 50.46 report dated June 22, 2007 (Note 9)	ΔPCT = 0 °F
10 CFR 50.46 report dated November 19, 2007 (Note 10)	ΔPCT = 90 °F
10 CFR 50.46 report dated April 11, 2008 (Note 11)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 9, 2009 (Note 12)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 8, 2010 (Note 13)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 6, 2011 (Note 15)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 6, 2012 (Note 17)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 5, 2013 (Note 19)	ΔPCT = 0 °F

NET PCT **PCT = 1749.0°F**

B. CURRENT LOCA MODEL ASSESSMENTS

SBLOCTA Cladding Strain Requirement For Fuel Rod Burst (Note 38)	ΔPCT = 0 °F
Total PCT change from current assessments	$\sum$ ΔPCT = 0 °F
Cumulative PCT change from current assessments	$\sum$ |ΔPCT| = 0 °F

NET PCT **PCT = 1749.0°F**

Attachment 1
Byron and Braidwood Units 1 and 2
10 CFR 50.46 Report

PLANT NAME: Braidwood Station Unit 1
ECCS EVALUATION MODEL: Large Break Loss of Coolant Accident (LBLOCA)
REPORT REVISION DATE: 04/07/14
CURRENT OPERATING CYCLE: 18

AOR

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 (Note 14)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 6, 2011 (Note 15)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 6, 2012 (Note 17)	ΔPCT = 0 °F
10 CFR 50.46 report dated May 21, 2012 (Note 18)	ΔPCT = 44 °F
10 CFR 50.46 report dated April 5, 2013 (Note 19)	ΔPCT = 0 °F
10 CFR 50.46 report dated February 27, 2014 (Note 20)	ΔPCT = 66 °F

NET PCT **PCT = 2023.0°F**

B. CURRENT LOCA MODEL ASSESSMENTS

General Code Maintenance (Note 34)	ΔPCT = 0 °F
Burst Elevation Selection (Note 35)	ΔPCT = 0 °F
Vessel Section 7 Mid-Level Elevation Modeling (Note 36)	ΔPCT = 0 °F
Grid Heat Transfer Enhancement (Note 37)	ΔPCT = 0 °F
Total PCT change from current assessments	$\sum$ ΔPCT = 0 °F
Cumulative PCT change from current assessments	$\sum \lvert$ ΔPCT $\rvert$ = 0 °F

NET PCT **PCT = 2023.0°F**

Attachment 1
Byron and Braidwood Units 1 and 2
10 CFR 50.46 Report

PLANT NAME: Braidwood Station Unit 2
ECCS EVALUATION MODEL: Small Break Loss of Coolant Accident (SBLOCA)
REPORT REVISION DATE: 04/07/14
CURRENT OPERATING CYCLE: 17

AOR

Evaluation Model: NOTRUMP
Calculation: Westinghouse CN-LIS-00-208, December 2000
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: 2-inch Break in the Bottom of the Cold Leg
Reference PCT PCT = 1627.0°F

MARGIN ALLOCATION

A. PRIOR LOCA MODEL ASSESSMENTS

10 CFR 50.46 report dated June 11, 2001 (Note 1)	ΔPCT = 3 °F
10 CFR 50.46 report dated April 18, 2002 (Note 2)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 14, 2003 (Note 3)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 14, 2004 (Note 4)	ΔPCT = 35 °F
10 CFR 50.46 report dated April 14, 2005 (Note 5)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 14, 2006 (Note 6)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 13, 2007 (Note 7)	ΔPCT = 0 °F
10 CFR 50.46 report dated June 22, 2007 (Note 9)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 11, 2008 (Note 11)	ΔPCT = 90 °F
10 CFR 50.46 report dated April 9, 2009 (Note 12)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 8, 2010 (Note 13)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 6, 2011 (Note 15)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 6, 2012 (Note 17)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 5, 2013 (Note 19)	ΔPCT = 0 °F

NET PCT **PCT = 1755.0°F**

B. CURRENT LOCA MODEL ASSESSMENTS

SBLOCTA Cladding Strain Requirement For Fuel Rod Burst (Note 38)	ΔPCT = 0 °F
Total PCT change from current assessments	Σ ΔPCT = 0 °F
Cumulative PCT change from current assessments	Σ |ΔPCT| = 0 °F

NET PCT **PCT = 1755.0°F**

Attachment 1
Byron and Braidwood Units 1 and 2
10 CFR 50.46 Report

PLANT NAME: Braidwood Station Unit 2
ECCS EVALUATION MODEL: Large Break Loss of Coolant Accident (LBLOCA)
REPORT REVISION DATE: 04/07/14
CURRENT OPERATING CYCLE: 17

AOR

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 = 2041.0°F

MARGIN ALLOCATION

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

10 CFR 50.46 report dated March 15, 2011 (Note 14)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 6, 2011 (Note 15)	ΔPCT = 0 °F
10 CFR 50.46 report dated March 19, 2012 (Note 16)	ΔPCT = -42 °F
10 CFR 50.46 report dated April 6, 2012 (Note 17)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 5, 2013 (Note 19)	ΔPCT = 0 °F

NET PCT **PCT = 1999.0°F**

B. CURRENT LOCA MODEL ASSESSMENTS

Initial Fuel Pellet Average Temperature Uncertainty Calculation (Note 21)	ΔPCT = 0 °F
Heat Transfer Model Error Corrections (Note 22)	ΔPCT = 0 °F
Correction to Heat Transfer Node Initialization (Note 23)	ΔPCT = 0 °F
Mass Conservation Error Fix (Note 24)	ΔPCT = 0 °F
Correction to Split Channel Momentum Equation (Note 25)	ΔPCT = 0 °F
Heat Transfer Logic Correction For Rod Burst Calculation (Note 26)	ΔPCT = 0 °F
Changes to Vessel Superheated Steam Properties (Note 27)	ΔPCT = 0 °F
Update to Metal Density Reference Temperatures (Note 28)	ΔPCT = 0 °F
Decay Heat Model Error Corrections (Note 29)	ΔPCT = 0 °F
Correction to The Pipe Exit Pressure Drop Error (Note 30)	ΔPCT = 0 °F
Revised Heat Transfer Multiplier Distributions (Note 31)	ΔPCT = 7 °F
Changes to Grid Blockage Ratio and Porosity (Note 32)	ΔPCT = 24 °F
Error in Burst Strain Application (Note 33)	ΔPCT = 15 °F
General Code Maintenance (Note 34)	ΔPCT = 0 °F
Burst Elevation Selection (Note 35)	ΔPCT = 0 °F
Vessel Section 7 Mid-Level Elevation Modeling (Note 36)	ΔPCT = 0 °F
Grid Heat Transfer Enhancement (Note 37)	ΔPCT = 0 °F
Total PCT change from current assessments	$\sum$ ΔPCT = +46 °F
Cumulative PCT change from current assessments	$\sum \lvert$ ΔPCT $\rvert$ = 46 °F

NET PCT **PCT = 2045.0°F**

Attachment 1
Byron and Braidwood Units 1 and 2
10 CFR 50.46 Report

PLANT NAME: Byron Station Unit 1
ECCS EVALUATION MODEL: Small Break Loss of Coolant Accident (SBLOCA)
REPORT REVISION DATE: 04/07/14
CURRENT OPERATING CYCLE: 20

AOR

Evaluation Model: NOTRUMP
Calculation: Westinghouse CN-LIS-00-208, December 2000
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: 2-inch Break in the Bottom of the Cold Leg
Reference PCT PCT = 1624.0°F

MARGIN ALLOCATION

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

10 CFR 50.46 report dated June 11, 2001 (Note 1)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 18, 2002 (Note 2)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 14, 2003 (Note 3)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 14, 2004 (Note 4)	ΔPCT = 35 °F
10 CFR 50.46 report dated April 14, 2005 (Note 5)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 14, 2006 (Note 6)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 13, 2007 (Note 7)	ΔPCT = 0 °F
10 CFR 50.46 report dated June 22, 2007 (Note 9)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 11, 2008 (Note 11)	ΔPCT = 90 °F
10 CFR 50.46 report dated April 9, 2009 (Note 12)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 8, 2010 (Note 13)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 6, 2011 (Note 15)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 6, 2012 (Note 17)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 5, 2013 (Note 19)	ΔPCT = 0 °F

NET PCT **PCT = 1749.0°F**

B. CURRENT LOCA MODEL ASSESSMENTS

SBLOCTA Cladding Strain Requirement For Fuel Rod Burst (Note 38)	ΔPCT = 0 °F
Total PCT change from current assessments	$\sum$ ΔPCT = 0 °F
Cumulative PCT change from current assessments	$\sum \lvert \Delta PCT \rvert$ = 0 °F

NET PCT **PCT = 1749.0°F**

Attachment 1
Byron and Braidwood Units 1 and 2
10 CFR 50.46 Report

PLANT NAME: Byron Station Unit 1
ECCS EVALUATION MODEL: Large Break Loss of Coolant Accident (LBLOCA)
REPORT REVISION DATE: 04/07/14
CURRENT OPERATING CYCLE: 20

AOR

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 (Note 14)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 6, 2011 (Note 15)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 6, 2012 (Note 17)	ΔPCT = 0 °F
10 CFR 50.46 report dated May 21, 2012 (Note 18)	ΔPCT = 44 °F
10 CFR 50.46 report dated April 5, 2013 (Note 19)	ΔPCT = 0 °F
10 CFR 50.46 report dated February 27, 2014 (Note 20)	ΔPCT = 66 °F

NET PCT **PCT = 2023.0°F**

B. CURRENT LOCA MODEL ASSESSMENTS

General Code Maintenance (Note 34)	ΔPCT = 0 °F
Burst Elevation Selection (Note 35)	ΔPCT = 0 °F
Vessel Section 7 Mid-Level Elevation Modeling (Note 36)	ΔPCT = 0 °F
Grid Heat Transfer Enhancement (Note 37)	ΔPCT = 0 °F
Total PCT change from current assessments	$\sum$ ΔPCT = 0 °F
Cumulative PCT change from current assessments	$\sum$ |ΔPCT| = 0 °F

NET PCT **PCT = 2023.0°F**

Attachment 1
Byron and Braidwood Units 1 and 2
10 CFR 50.46 Report

PLANT NAME: Byron Station Unit 2
ECCS EVALUATION MODEL: Small Break Loss of Coolant Accident (SBLOCA)
REPORT REVISION DATE: 04/07/14
CURRENT OPERATING CYCLE: 18

AOR

Evaluation Model: NOTRUMP
Calculation: Westinghouse CN-LIS-00-208, December 2000
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: 2-inch Break in the Bottom of the Cold Leg
Reference PCT PCT = 1627.0°F

MARGIN ALLOCATION

A. PRIOR LOCA MODEL ASSESSMENTS

10 CFR 50.46 report dated June 11, 2001 (Note 1)	ΔPCT = 3 °F
10 CFR 50.46 report dated April 18, 2002 (Note 2)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 14, 2003 (Note 3)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 14, 2004 (Note 4)	ΔPCT = 35 °F
10 CFR 50.46 report dated April 14, 2005 (Note 5)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 14, 2006 (Note 6)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 13, 2007 (Note 7)	ΔPCT = 0 °F
10 CFR 50.46 report dated May 10, 2007 (Note 8)	ΔPCT = 90 °F
10 CFR 50.46 report dated June 22, 2007 (Note 9)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 11, 2008 (Note 11)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 9, 2009 (Note 12)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 8, 2010 (Note 13)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 6, 2011 (Note 15)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 6, 2012 (Note 17)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 5, 2013 (Note 19)	ΔPCT = 0 °F

NET PCT **PCT = 1755.0°F**

B. CURRENT LOCA MODEL ASSESSMENTS

SBLOCTA Cladding Strain Requirement For Fuel Rod Burst (Note 38)	ΔPCT = 0 °F
Total PCT change from current assessments	Σ ΔPCT = 0 °F
Cumulative PCT change from current assessments	$\Sigma \lvert \Delta PCT \rvert$ = 0 °F

NET PCT **PCT = 1755.0°F**

Attachment 1
Byron and Braidwood Units 1 and 2
10 CFR 50.46 Report

PLANT NAME: Byron Station Unit 2
ECCS EVALUATION MODEL: Large Break Loss of Coolant Accident (LBLOCA)
REPORT REVISION DATE: 04/07/14
CURRENT OPERATING CYCLE: 18

AOR

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 = 2041.0°F

MARGIN ALLOCATION

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

10 CFR 50.46 report dated March 15, 2011 (Note 14)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 6, 2011 (Note 15)	ΔPCT = 0 °F
10 CFR 50.46 report dated March 19, 2012 (Note 16)	ΔPCT = -42 °F
10 CFR 50.46 report dated April 6, 2012 (Note 17)	ΔPCT = 0 °F
10 CFR 50.46 report dated April 5, 2013 (Note 19)	ΔPCT = 0 °F

NET PCT **PCT = 1999.0°F**

B. CURRENT LOCA MODEL ASSESSMENTS

Initial Fuel Pellet Average Temperature Uncertainty Calculation (Note 21)	ΔPCT = 0 °F
Heat Transfer Model Error Corrections (Note 22)	ΔPCT = 0 °F
Correction to Heat Transfer Node Initialization (Note 23)	ΔPCT = 0 °F
Mass Conservation Error Fix (Note 24)	ΔPCT = 0 °F
Correction to Split Channel Momentum Equation (Note 25)	ΔPCT = 0 °F
Heat Transfer Logic Correction For Rod Burst Calculation (Note 26)	ΔPCT = 0 °F
Changes to Vessel Superheated Steam Properties (Note 27)	ΔPCT = 0 °F
Update to Metal Density Reference Temperatures (Note 28)	ΔPCT = 0 °F
Decay Heat Model Error Corrections (Note 29)	ΔPCT = 0 °F
Correction to The Pipe Exit Pressure Drop Error (Note 30)	ΔPCT = 0 °F
Revised Heat Transfer Multiplier Distributions (Note 31)	ΔPCT = 7 °F
Changes to Grid Blockage Ratio and Porosity (Note 32)	ΔPCT = 24 °F
Error in Burst Strain Application (Note 33)	ΔPCT = 15 °F
General Code Maintenance (Note 34)	ΔPCT = 0 °F
Burst Elevation Selection (Note 35)	ΔPCT = 0 °F
Vessel Section 7 Mid-Level Elevation Modeling (Note 36)	ΔPCT = 0 °F
Grid Heat Transfer Enhancement (Note 37)	ΔPCT = 0 °F
Total PCT change from current assessments	$\sum$ ΔPCT = +46 °F
Cumulative PCT change from current assessments	$\sum \lvert$ ΔPCT $\rvert$ = 46 °F

NET PCT **PCT = 2045.0°F**

Attachment 2
Byron and Braidwood Units 1 and 2
10 CFR 50.46 Report
Assessment Notes

1. Prior LOCA Model Assessment

   The 10 CFR 50.46 report dated June 11, 2001 reported new small break loss of coolant accident (SBLOCA) analyses to support operations at uprated power conditions. The same report assessed the impact from annular axial blankets on SBLOCA analysis, which determined a 0°F PCT penalty for Units 1 and a 3°F PCT penalty for Units 2. Evaluations for plant conditions and SBLOCA model changes which resulted in 0 °F PCT change were reported.

2. Prior LOCA Model Assessment

   The 10 CFR 50.46 report dated April 18, 2002 reported evaluations for SBLOCA model changes which resulted in 0 °F PCT change.

3. Prior LOCA Model Assessment

   The 10 CFR 50.46 report dated April 14, 2003 reported evaluations for SBLOCA model changes which resulted in 0 °F PCT change.

4. Prior LOCA Model Assessment

   The 10 CFR 50.46 report dated April 14, 2004 reported evaluations for a SBLOCA assessment related to NOTRUMP bubble rise/drift flux model inconsistency corrections, which resulted in 35 °F PCT assessment.

5. Prior LOCA Model Assessment

   The 10 CFR 50.46 report dated April 14, 2005 reported evaluations for SBLOCA model changes which resulted in 0 °F PCT change for Byron and Braidwood Unit 1 and Unit 2. The Braidwood Station, Unit 1 assembly N10S was reconstituted with two stainless steel filler rods during Braidwood Unit 1 Refueling Outage 11. This assembly is reloaded into the core and is in use during Braidwood Unit 1 Cycle 12 operation. The introduction of up to five stainless steel filler rods has been evaluated and shown to have no impact on SBLOCA analysis. The estimated PCT effect is 0°F for Braidwood Unit 1. This assembly was discharged during Reload 12.

6. Prior LOCA Model Assessment

   The 10 CFR 50.46 report dated April 14, 2006 reported evaluations for SBLOCA NOTRUMP General Code Maintenance which resulted in 0 °F change.

7. Prior LOCA Model Assessment

   The 10 CFR 50.46 report dated April 13, 2007 reported evaluations for SBLOCA model changes and errors. The report documented general code maintenance for NOTRUMP, AXIOM lead test assembly evaluation and NOTRUMP refined break spectrum, which resulted in 0 °F PCT impact.

Attachment 2
Byron and Braidwood Units 1 and 2
10 CFR 50.46 Report
Assessment Notes

8. Prior LOCA Model Assessment

   The 30-day 10 CFR 50.46 report dated May 10, 2007 applicable to Byron Unit 2 reported an assessment of the Emergency Core Cooling System (ECCS), which evaluated changes in ECCS flow during the recirculation phase due to Generic Safety Issue (GSI) - 191 related safety injection (SI) throttle valve replacements. The evaluation of recirculation phase ECCS flow changes relative to impact on the current Analysis of Record (AOR) was performed for the SBLOCA. Based on the NOTRUMP and SBLOCTA calculations performed for Byron Unit 2, a conservative, bounding PCT assessment of +90°F was applied to the current Byron Unit 2 SBLOCA PCT.

9. Prior LOCA Model Assessment

   A 30-day report was submitted to the NRC dated June 22, 2007 to report an error in the HOT SPOT Code which did not impact the SBLOCA analysis. The 30-day report also reported minor errors with the reactor vessel data collections that potentially affected the vessel inlet and outlet fluid volume, metal mass and surface area. The corrected values were evaluated for impact, and a 0°F penalty was assessed for Byron Units 1 and 2, and Braidwood Units 1 and 2, SBLOCA analysis.

10. Prior LOCA Model Assessment

    The 30-day 10 CFR 50.46 report dated November 19, 2007 applicable to Braidwood Unit 1 reported an assessment of the Emergency Core Cooling System (ECCS), which evaluated changes in ECCS flow during the recirculation phase due to GSI-191 related SI throttle valve replacements. The evaluation of recirculation phase ECCS flow changes relative to impact on the current Analysis of Record (AOR) was performed for the small break loss of coolant accident (SBLOCA). Based on the NOTRUMP and SBLOCTA calculations performed for Braidwood Unit 1, a conservative, bounding PCT assessment of +90°F was applied to the Braidwood Unit 1 SBLOCA PCT.

11. Prior LOCA Model Assessment

    The 10 CFR 50.46 report dated April 11, 2008 reported evaluations for LOCA model changes and errors. Applicable to Braidwood Unit 2 and Byron Unit 1, the ECCS assessment evaluated changes in ECCS flow during the recirculation phase due to GSI-191 related safety injection SI throttle valve replacements. A conservative, bounding PCT assessment of +90°F was applied to the Braidwood Unit 2 and Byron Unit 1 SBLOCA PCTs. The report also documented general code maintenance for SBLOCA and evaluation for pump wear resistance modeling for SBLOCA analyses, which resulted in 0 °F PCT impact.

12. Prior LOCA Model Assessment

    The 10 CFR 50.46 report dated April 9, 2009 reported evaluations for LOCA model changes and errors. The report documents general code maintenance for SBLOCA, errors in reactor vessel lower plenum surface area calculations, discrepancies in metal

mass from drawings, and an evaluation of Areva LUAs. All of which have a 0 °F PCT penalty associated with them.

13. Prior LOCA Model Assessment

    The 10 CFR 50.46 report dated April 8, 2010 reported no evaluations for SBLOCA model changes which resulted in 0 °F PCT change.

14. Prior LOCA Model Assessment

    The 30-day 10 CFR 50.46 report dated March 15, 2011 reported a new large break BELOCA (ASTRUM) analysis to support operations for Byron and Braidwood 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.

15. Prior LOCA Model Assessment

    The 10 CFR 50.46 report dated April 6, 2011 reported no evaluations for the LBLOCA model. For the SBLOCA model, the following errors, changes, corrections or enhancements were reported. Two errors relating to urania-gadolinia pellet thermal conductivity calculation, two errors relating to pellet crack and dish volume calculation, a discrepancy involving the treatment of vessel average temperature uncertainty, and general code maintenance were reported for the SBLOCA model. All of these issues were determined to have an estimated impact of 0°F.

16. Prior LOCA Model Assessment

    The 30-day 10 CFR 50.46 report dated March 19, 2012 applicable to Braidwood Unit 2 and Byron Unit 2 reported an assessment of Thermal Conductivity Degradation (TCD) with an associated peaking factor burndown and a design input change consisting of a reduction in upper bound steam generator tube plugging, a reduction in nominal upper bound nominal vessel average temperature, and an increase in the assumed containment pressure boundary condition. As a result, the estimated effect of the TCD with burndown was determined to be +148°F and the estimated effect of the design input changes was determined to be -190°F. These two assessments are coupled together via their evaluations of burnup effects which include thermal conductivity degradation, peaking factor burndown and design input changes. Therefore, the combined affect of these two changes results in a net change in the reported LBLOCA PCT for Braidwood Unit 2 and Byron Unit 2 of -42°F.

17. Prior LOCA Model Assessment

    The 10 CFR 50.46 report dated April 6, 2012 reported evaluations for LOCA model changes and errors. The report documents general code maintenance for both SBLOCA & LBLOCA, errors in Radiation Heat Transfer Logic for SBLOCA, and an error in the Maximum Fuel Rod Time Step Logic for SBLOCA. All of which have a 0 °F PCT penalty associated with them.

Attachment 2
Byron and Braidwood Units 1 and 2
10 CFR 50.46 Report
Assessment Notes

18. Prior LOCA Model Assessment

The 30-day 10 CFR 50.46 report dated May 21, 2012 applicable to Braidwood Unit 1 and Byron Unit 1 reported an assessment of Thermal Conductivity Degradation (TCD) with an associated peaking factor burndown 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, the estimated effect of the TCD with burndown was determined to be +110°F and the estimated effect of the analysis input changes was determined to be -66°F. These two assessments are coupled together via their evaluations of burnup effects which include thermal conductivity degradation, 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 for Braidwood Unit 1 and Byron Unit 1 of +44°F.

19. Prior LOCA Model Assessment

The 10 CFR 50.46 report dated April 5, 2013 reported evaluations for LBLOCA model changes, and HOTSPOT and WCOBRA/TRAC code corrections. For SBLOCA, thermal conductivity degradation (TCD) was evaluated with NOTRUMP to estimate the effect on the limiting cladding temperature model. All evaluations led to PCT impact of 0°F.

20. Prior LOCA Model Assessment

The 30-day 10 CFR 50.46 report dated February 27, 2014 applicable to Braidwood Unit 1 and Byron Unit 1 reported evaluations (Note 21 through 33 herein) for LBLOCA model changes and code corrections. For Braidwood Unit 2 and Byron Unit 2 a net change of 46°F PCT impact did not require inclusion in the 30-day report and is reported herein. Revised heat transfer multiplier distributions, changes to grid blockage ratio and porosity and HOTSPOT burst strain error corrections was determined to be 5°F, 24°F, and 37°F PCT impact, respectively for Braidwood Unit 1 and Byron Unit 1. Other model changes and code corrections sum to 0°F PCT impact. Therefore, the combined effect of the changes resulted in a net change of 66°F PCT impact for Braidwood Unit 1 and Byron Unit 1.

21. Current LOCA Model Assessment – Initial Fuel Pellet Average Temperature Uncertainty Calculation (LBLOCA)

In the ASTRUM LBLOCA Evaluation Model (EM), uncertainties are applied to the gap heat transfer coefficient and pellet thermal conductivity to capture the uncertainty in the initial fuel pellet average temperature. This approach was compared to the initial fuel pellet average temperature uncertainties predicted by the PAD code at beginning-of-life conditions and found to be conservative. However, the initial fuel pellet average temperature uncertainty range analyzed at higher burnups in the ASTRUM EM is much wider than the uncertainty range predicted by the PAD code, which may result in excessively low or high analyzed initial fuel pellet average temperatures. This issue has been evaluated to estimate the impact on existing ASTRUM LBLOCA analysis results. The resolution of this issue led to an estimated PCT impact of 0°F.

Attachment 2
Byron and Braidwood Units 1 and 2
10 CFR 50.46 Report
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22. Current LOCA Model Assessment – Heat Transfer Model Error Corrections (LBLOCA)

    Several related changes were made to WCOBRA/TRAC to correct errors discovered which affected the heat transfer models. These errors included calculation of the entrained liquid fraction used in calculation of the drop wall heat flux, application of the grid enhancement factor for grid temperature calculation, calculation of the Reynold's number used in the Wong-Hochrieter correlation for the heat transfer coefficient from fuel rods to vapor, fuel rod initialization and calculation of cladding inner radius with creep, application of grid and two phase enhancement factors and radiation component in single phase vapor heat transfer, and reset of the critical heat flux temperature when J=2. These errors have been evaluated to estimate the impact on existing LBLOCA analysis results. These changes led to an estimated PCT impact of 0°F.

23. Current LOCA Model Assessment – Correction to Heat Transfer Node Initialization (LBLOCA)

    An error was discovered in the heat transfer node initialization logic in WCOBRA/TRAC whereby the heat transfer node center locations could be inconsistent with the geometric node center elevations. The primary effects of this issue are on the interpolated fluid properties and grid turbulent mixing enhancement at the heat transfer node. This problem has been evaluated for impact on existing analyses and its resolution led to an estimated PCT impact of 0°F.

24. Current LOCA Model Assessment – Mass Conservation Error Fix (LBLOCA)

    It was identified that mass was not conserved in WCOBRA/TRAC one-dimensional component cells when void fraction values were calculated to be slightly out of the physical range (greater than 1.0 or smaller than 0.0). This was observed to result in artificial mass generation on the secondary side of steam generator components. This correction led to an estimated PCT impact of 0°F.

25. Current LOCA Model Assessment – Correction to Split Channel Momentum Equation (LBLOCA)

    An error was discovered in the momentum equation calculations for split channels in WCOBRA/TRAC. This error impacts the (1) continuity area of the phantom/boundary bottom cell; (2) bottom and top continuity area correction factors for the channel inlet at the bottom of a section and for the channel outlet at the top of a section; and (3) drop entrainment mass rate per unit volume and drop de-entrainment mass rate per unit volume contributions to the momentum calculations for split channels. This problem has been evaluated for impact on existing analyses which led to an estimated PCT impact of 0°F.

26. Current LOCA Model Assessment – Heat Transfer Logic Correction For Rod Burst Calculation (LBLOCA)

A change was made to the WCOBRA/TRAC coding to correct an error which had disabled rod burst in separate effect test simulations. This change led to an estimated PCT impact of 0°F.

27. Current LOCA Model Assessment – Changes to Vessel Superheated Steam Properties (LBLOCA)

    Several related changes were made to the WCOBRA/TRAC coding for the vessel superheated water properties, including updating the HGAS subroutine coding to be consistent with WCAP-12945-P-A Equation 10-6, updating the approximation of the enthalpy in the TGAS subroutine to be consistent with the HGAS subroutine coding, and updating the temperature iteration method and convergence criteria in the TGAS subroutine. These changes led to an estimated PCT impact of 0°F.

28. Current LOCA Model Assessment – Update to Metal Density Reference Temperatures (LBLOCA)

    It was identified that for one-dimensional components in which heat transfer to stainless steel 304 or 316 is modeled, the reference temperature for the metal density calculation was allowed to vary; as a result the total metal mass was not preserved. Correction of this problem led to an estimated PCT impact of 0°F.

29. Current LOCA Model Assessment – Decay Heat Model Error Corrections (LBLOCA)

    The decay heat model in the WCOBRA/TRAC code was updated to correct the erroneously coded value of the yield fraction directly from fission for Group 19 of Pu-239, and to include the term for uncertainty in the prompt energy per fission in the calculation of the decay heat power uncertainty. Correction of these errors led to an estimated PCT impact of 0°F.

30. Current LOCA Model Assessment – Correction to The Pipe Exit Pressure Drop Error (LBLOCA)

    An error was discovered in WCOBRA/TRAC whereby the frictional pressure drop at the split break TEE connection to the BREAK component was incorrectly calculated using the TEE hydraulic diameter instead of the BREAK component length input. This error has been evaluated for impact on existing analyses and its resolution led to an estimated PCT impact of 0°F.

31. Current LOCA Model Assessment – Revised Heat Transfer Multiplier Distributions (LBLOCA)

    Several changes and error corrections were made to WCOBRA/TRAC and the impacts of these changes on the heat transfer multiplier uncertainty distributions were investigated. During this investigation, errors were discovered in the development of the original multiplier distributions, including errors in the grid locations specified in the WCOBRA/TRAC models for the G2 Refill and G2 Reflood tests, and errors in processing test data used to develop the reflood heat transfer multiplier distribution. Therefore, the

blowdown heatup, blowdown cooling, refill, and reflood heat transfer multiplier distributions were redeveloped. For the reflood heat transfer multiplier development, the evaluation time windows for each set of test experimental data and each test simulation were separately defined based on the time at which the test or simulation exhibited dispersed flow film boiling heat transfer conditions characteristic of the reflood time period. The revised heat transfer multiplier distributions have been evaluated for impact on existing analyses. These changes led to an estimated PCT impact of 5°F for Byron Unit 1 and Braidwood Unit 1 and 7°F for Byron Unit 2 and Braidwood Unit 2.

32. Current LOCA Model Assessment – Changes to Grid Blockage Ratio and Porosity (LBLOCA)

    A change in the methodology used to calculate grid blockage ratio and porosity for Westinghouse fuel resulted in a change to the grid inputs used in the Byron Unit 1 and Unit 2 and Braidwood Unit 1 and Unit 2 large break loss-of-coolant accident (LBLOCA) analyses. Grid inputs affect heat transfer in the core during a LBLOCA. This change resulted in an estimated PCT effect of 24°F.

33. Current LOCA Model Assessment – Error in Burst Strain Application (LBLOCA)

    An error in the application of the burst strain was discovered in HOTSPOT. In the equation the outer radius of the cladding after burst occurs should be calculated based on the burst strain, and the inner radius of the cladding should be calculated based on the outer radius. In HOTSPOT, the burst strain is applied to the calculation of the cladding inner radius. The cladding outer radius is then calculated based on the inner radius. As such, the burst strain is incorrectly applied to the inner radius rather than the outer radius, which impacts the resulting cladding geometry at the burst elevation after burst occurs. Correction of the erroneous calculation results in thinner cladding at the burst node and more fuel relocating into the burst node, leading to an increase in the Peak Cladding Temperature (PCT) at the burst node. This issue has been evaluated to estimate the impact on existing Best-Estimate (BE) Large-Break Loss-of-Coolant Accident (LBLOCA) analysis results. The error led to an estimated PCT impact of 37°F for Byron Unit 1 and Braidwood Unit 1 and 15°F for Byron Unit 2 and Braidwood Unit 2.

34. Current LOCA Model Assessment – General Code Maintenance (LBLOCA)

    Various changes have been made to enhance the usability of codes and to streamline future analyses. Examples of these changes include modifying input variable definitions, units and defaults; improving the input diagnostic checks; enhancing the code output; optimizing active coding; and eliminating inactive coding. These changes resulted in an estimated PCT impact of 0°F.

35. Current LOCA Model Assessment – Burst Elevation Selection (LBLOCA)

    It is stated on page 11-20 of WCAP-16009-P-A that the burst option is applied at the elevation corresponding to the (WCOBRA/TRAC) burst elevation for the hot assembly rod. This approach was modified to apply the burst option at the HOTSPOT predicted burst elevation as described on page 19 of Attachment 1 to LTR-NRC-06-8. The

HOTSPOT code has been updated to incorporate the following changes to the burst elevation selection logic if multiple nodes burst at the same time: (1) the node that has the highest cladding temperature at the time of burst is selected; (2) if multiple nodes have the same burst time and cladding temperature at the time of burst, the lowest ordered elevation of those nodes is selected. These changes led to 0°F PCT impact.

36. Current LOCA Model Assessment – Vessel Section 7 Mid-Level Elevation Modeling (LBLOCA)

    Documentation deficiencies have been identified which are associated with the Large Break LOCA Evaluation Model and plant specific analyses. The first is an incorrect statement made on page 20-4-5 of WCAP-12945-P-A. The Section 7 mid-level elevation utilized in the sample analysis is stated as being at the bottom of the deep beam device. In the model, the Section 7 mid-level elevation is at the top of the topmost support column flow slot. In addition, the bottom of Section 7 is characterized as being at the bottom of the Hot Leg, but in the model, the bottom of the section is set at the top of the Hot Leg. The similar statement made at page 12-6 of WCAP-16009-P-A could also be incorrect. These are not considered changes to the methodology, but rather, corrections of the documentation which led to a 0°F PCT impact.

37. Current LOCA Model Assessment – Grid Heat Transfer Enhancement Calculation (LBLOCA)

    An issue was identified which could affect the calculation of the heat transfer at gridded elevations for Best-Estimate (BE) Large-Break Loss-of-Coolant Accident (LBLOCA) Evaluation Models (EMs). For a specific input condition, the grid heat transfer enhancement factor is calculated based on an erroneous core geometry, which can cause an over-prediction of the heat transfer coefficient at gridded elevations. This issue has been evaluated to estimate the impact on existing LBLOCA analysis results. The resolution of this issue led to a 0°F PCT impact.

38. Current LOCA Model Assessment – SBLOCTA Cladding Strain Requirement For Fuel Rod Burst (SBLOCA)

    An error was discovered in the minimum local strain required for burst for **ZIRLO** cladding in the SBLOCTA code. The coding does not enforce reaching the minimum percent local strain threshold prior to calculating fuel rod burst. However, a review of licensing basis analyses revealed no instances of this error impacting calculated results which led to a 0°F PCT impact.