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PSEG
Nuclear LLC

10 CFR 50.46

LR-N22-0095
20 December 2022

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

Salem Generating Station, Units 1 and 2
Renewed Facility Operating License Nos. DPR-70 and DPR-75
NRC Docket Nos. 50-272 and 50-311

Subject: Salem Loss of Coolant Accident Peak Cladding Temperature Margin Tracking – Annual Report 2022

References: (1) PSEG Letter LR-N21-0083, "Salem Loss of Coolant Accident Peak Cladding Temperature Margin Tracking – Annual 2021 & 30 Day Report for Salem Unit 2 Upflow Conversion"

Pursuant to the requirements of 10 CFR 50.46, PSEG Nuclear LLC (PSEG) hereby reports changes in the application of the Emergency Core Cooling System (ECCS) evaluation models for Salem Generating Station, Units 1 and 2. In accordance with 10 CFR 50.46(a)(3)(ii), licensees are required to report, at least annually, each change to or error discovered in evaluation models used for calculating ECCS performance and the estimated effect on the limiting ECCS analysis.

There are no notable changes from the previous annual report submitted in 2021 (Reference 1).

There are no regulatory commitments in this correspondence.

Should you have any questions regarding this submittal, please contact Ms. Bernadette Cizin (856) 339-2206.

Sincerely,

Rick DeSanctis, Jr.
Plant Manager, Salem Generating Station

Enclosure 1 - SALEM LOSS OF COOLANT ACCIDENT PEAK CLADDING TEMPERATURE MARGIN TRACKING - ANNUAL REPORT

cc: USNRC Regional Administrator − Region 1
USNRC Licensing Project Manager – Salem
USNRC Senior Resident Inspector – Salem
NJ Bureau of Nuclear Engineering
Corporate Commitment Coordinator, PSEG Nuclear, LLC

Enclosure 1

**SALEM LOSS OF COOLANT ACCIDENT
PEAK CLADDING TEMPERATURE
MARGIN TRACKING - ANNUAL REPORT**

**Attachment 1, Peak Cladding Temperature
Rack-up Sheets**

(9 Pages)

Attachment 2, Assessment Notes

(11 Pages)

Attachment 1
Peak Cladding Temperature Rack-Up Sheets

SALEM UNITS 1 AND 2

Docket Nos. 50-272 and 50-311

10 CFR 50.46, “Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors”

Report of the Emergency Core Cooling System Evaluation Model Changes and Errors Assessments

Attachment 1
Peak Cladding Temperature Rack-Up Sheets

PLANT NAME: Salem Unit 1
ECCS EVALUATION MODEL: Small Break Loss of Coolant Accident (SBLOCA)
REPORT REVISION DATE: November 2022
CURRENT OPERATING CYCLE: 29

ANALYSIS OF RECORD (AOR)

Evaluation Model: NOTRUMP
Calculation: Westinghouse PSE-93-568, March 1993
Fuel: RFA 17 x 17
Limiting Fuel Type: RFA 17x17
Heat Flux Hot Channel Factor (F_Q) = 2.4
Nuclear Enthalpy Rise Hot Channel Factor ($F_{\Delta H}$) = 1.65
Steam Generator Tube Plugging = 10%
Limiting Break Size: 2 inches
Break Location: Cold Leg
Limiting Single Failure: loss of one train of ECCS flow

Reference Peak Cladding Temperature (PCT) PCT = 1580°F

MARGIN ALLOCATION

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

10 CFR 50.46 report dated October 29, 1993 (See Note 1)	ΔPCT = -13°F
10 CFR 50.46 report dated July 27, 1994 (See Note 2)	ΔPCT = -16°F
10 CFR 50.46 report dated December 8, 1994 (See Note 3)	ΔPCT = +109°F
10 CFR 50.46 report dated January 18, 1995 (See Note 4)	ΔPCT = 0°F
10 CFR 50.46 report dated December 7, 1995 (See Note 5)	ΔPCT = 0°F
10 CFR 50.46 report dated August 2, 1996 (See Note 6)	ΔPCT = -8°F
10 CFR 50.46 report dated July 11, 1997 (See Note 7)	ΔPCT = 0°F
10 CFR 50.46 report dated June 10, 1998 (See Note 8)	ΔPCT = 0°F
10 CFR 50.46 report dated April 27, 1999 (See Note 9)	ΔPCT = 0°F
10 CFR 50.46 report dated October 18, 1999 (See Note 10)	ΔPCT = +10°F
10 CFR 50.46 report dated September 21, 2000 (See Note 11)	ΔPCT = +27°F
10 CFR 50.46 report dated August 27, 2001 (See Note 12)	ΔPCT = 0°F
10 CFR 50.46 report dated August 27, 2002 (See Note 13)	ΔPCT = 0°F
10 CFR 50.46 report dated August 08, 2003 (See Note 14)	ΔPCT = 0°F
10 CFR 50.46 report dated July 29, 2004 (See Note 15)	ΔPCT = +40°F
10 CFR 50.46 report dated July 28, 2005 (See Note 16)	ΔPCT = 0°F
10 CFR 50.46 report dated July 28, 2006 (See Note17)	ΔPCT = 0°F
10 CFR 50.46 report dated July 25, 2007 (See Note 18)	ΔPCT = 0°F
10 CFR 50.46 report dated July 22, 2008 (See Note 19)	ΔPCT = 0°F
10 CFR 50.46 report dated July 20, 2009 (See Note 20)	ΔPCT = 0°F
10 CFR 50.46 report dated July 20, 2010 (See Note 21)	ΔPCT = 0°F
10 CFR 50.46 report dated July 18, 2011 (See Note 22)	ΔPCT = 0°F
10 CFR 50.46 report dated July 16, 2012 (See Note 23)	ΔPCT = 0°F
10 CFR 50.46 report dated October 19, 2012 (See Note 24)	ΔPCT = 0°F
10 CFR 50.46 report dated October 11, 2013 (See Note 25)	ΔPCT = 0°F

Attachment 1
Peak Cladding Temperature Rack-Up Sheets

10 CFR 50.46 report dated October 9, 2014 (See Note 26)	ΔPCT = 0°F
10 CFR 50.46 report dated October 21, 2015 (See Note 27)	ΔPCT = 0°F
10 CFR 50.46 report dated October 24, 2016 (See Note 28)	ΔPCT = 0°F
10 CFR 50.46 report dated December 20, 2017 (See Note 29)	ΔPCT = 0°F
10 CFR 50.46 report dated December 14, 2018 (See Note 30)	ΔPCT = 0°F
10 CFR 50.46 report dated November 26, 2019 (See Note 31)	ΔPCT = 0°F
10 CFR 50.46 report dated December 10, 2020 (See Note 32)	ΔPCT = 0°F
10 CFR 50.46 report dated November 24, 2021 (See Note 33)	ΔPCT = 0°F

NET PCT **PCT = 1729°F**

B. CURRENT LOCA MODEL ASSESSMENTS

None (See Note 34)	ΔPCT = 0°F
Total PCT change from current assessments	ΣΔPCT = 0°F
Cumulative PCT change from current assessments	Σ│ΔPCT│ = 0°F

NET PCT **PCT = 1729°F**

Attachment 1
Peak Cladding Temperature Rack-Up Sheets

PLANT NAME: Salem Unit 1
ECCS EVALUATION MODEL: Large Break Loss of Coolant Accident (LBLOCA)
REPORT REVISION DATE: November 2022
CURRENT OPERATING CYCLE: 29

ANALYSIS OF RECORD (AOR)

Evaluation Model: BASH
Calculation: Westinghouse 93-PSE-G-0080, September 1993
Fuel: RFA 17 x 17
Limiting Fuel Type: RFA 17x17
Heat Flux Hot Channel Factor (F_Q) = 2.4
Nuclear Enthalpy Rise Hot Channel Factor ($F_{\Delta H}$) = 1.65
Steam Generator Tube Plugging = 10%
Limiting Break Size: Cd = 0.4
Break Location: Cold leg
Limiting Single Failure: Loss of one train of ECCS flow

Reference Peak Cladding Temperature (PCT) PCT = 1978°F

MARGIN ALLOCATION

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

10 CFR 50.46 report dated January 18, 1995 (See Note 4)	ΔPCT = +36°F
10 CFR 50.46 report dated December 7, 1995 (See Note 5)	ΔPCT = 0°F
10 CFR 50.46 report dated August 2, 1996 (See Note 6)	ΔPCT = 0°F
10 CFR 50.46 report dated July 11, 1997 (See Note 7)	ΔPCT = +15°F
10 CFR 50.46 report dated June 10, 1998 (See Note 8)	ΔPCT = 0°F
10 CFR 50.46 report dated April 27, 1999 (See Note 9)	ΔPCT = 0°F
10 CFR 50.46 report dated October 18, 1999 (See Note 10)	ΔPCT = +12°F
10 CFR 50.46 report dated September 21, 2000 (See Note 11)	ΔPCT = +9°F
10 CFR 50.46 report dated August 27, 2001 (See Note 12)	ΔPCT = +6°F
10 CFR 50.46 report dated August 27, 2002 (See Note 13)	ΔPCT = +20°F
10 CFR 50.46 report dated August 08, 2003 (See Note 14)	ΔPCT = +7°F
10 CFR 50.46 report dated July 29, 2004 (See Note 15)	ΔPCT = +5°F
10 CFR 50.46 report dated July 28, 2005 (See Note 16)	ΔPCT = 0°F
10 CFR 50.46 report dated July 28, 2006 (See Note 17)	ΔPCT = -50°F
10 CFR 50.46 report dated July 25, 2007 (See Note 18)	ΔPCT = +4°F
10 CFR 50.46 report dated July 22, 2008 (See Note 19)	ΔPCT = 0°F
10 CFR 50.46 report dated July 20, 2009 (See Note 20)	ΔPCT = 0°F
10 CFR 50.46 report dated July 20, 2010 (See Note 21)	ΔPCT = 0°F
10 CFR 50.46 report dated July 18, 2011 (See Note 22)	ΔPCT = 0°F
10 CFR 50.46 report dated July 16, 2012 (See Note 23)	ΔPCT = 0°F
10 CFR 50.46 report dated October 19, 2012 (See Note 24)	ΔPCT = +87°F
10 CFR 50.46 report dated October 11, 2013 (See Note 25)	ΔPCT = 0°F
10 CFR 50.46 report dated October 9, 2014 (See Note 26)	ΔPCT = 0°F
10 CFR 50.46 report dated October 21, 2015 (See Note 27)	ΔPCT = 0°F
10 CFR 50.46 report dated October 24, 2016 (See Note 28)	ΔPCT = 0°F

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Peak Cladding Temperature Rack-Up Sheets

10 CFR 50.46 report dated December 20, 2017 (See Note 29)	ΔPCT = 0°F
10 CFR 50.46 report dated December 14, 2018 (See Note 30)	ΔPCT = 0°F
10 CFR 50.46 report dated November 26, 2019 (See Note 31)	ΔPCT = 0°F
10 CFR 50.46 report dated December 10, 2020 (See Note 32)	ΔPCT = 0°F
10 CFR 50.46 report dated November 24, 2021 (See Note 33)	ΔPCT = 0°F

NET PCT **PCT = 2129°F**

B. CURRENT LOCA MODEL ASSESSMENTS

None (See Note 34)	ΔPCT = 0°F
Total PCT change from current assessments	ΣΔPCT = 0°F
Cumulative PCT change from current assessments	$\Sigma \lvert \Delta PCT \rvert = 0°F$

NET PCT **PCT = 2129°F**

Attachment 1
Peak Cladding Temperature Rack-Up Sheets

PLANT NAME: Salem Unit 2
ECCS EVALUATION MODEL: Small Break Loss of Coolant Accident (SBLOCA)
REPORT REVISION DATE: November 2022
CURRENT OPERATING CYCLE: 26

ANALYSIS OF RECORD (AOR)

Evaluation Model: NOTRUMP
Calculation: Westinghouse (PSE-04-131), December 2004
Fuel: RFA 17 x 17
Limiting Fuel Type: RFA 17x17
Heat Flux Hot Channel Factor (F_Q) = 2.5
Nuclear Enthalpy Rise Hot Channel Factor ($F_{\Delta H}$) = 1.65
Steam Generator Tube Plugging = 10%
Limiting Break Size: 3 inches
Break Location: Cold Leg
Single Failure: loss of one train ECCS flow

Reference Peak Cladding Temperature (PCT) PCT = 987°F

MARGIN ALLOCATION

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

10 CFR 50.46 report dated July 22, 2008 (See Note 19)	ΔPCT = 0°F
10 CFR 50.46 report dated July 20, 2009 (See Note 20)	ΔPCT = 0°F
10 CFR 50.46 report dated July 20, 2010 (See Note 21)	ΔPCT = 0°F
10 CFR 50.46 report dated July 18, 2011 (See Note 22)	ΔPCT = 0°F
10 CFR 50.46 report dated July 16, 2012 (See Note 23)	ΔPCT = 0°F
10 CFR 50.46 report dated October 19, 2012 (See Note 24)	ΔPCT = 0°F
10 CFR 50.46 report dated October 11, 2013 (See Note 25)	ΔPCT = 0°F
10 CFR 50.46 report dated October 9, 2014 (See Note 26)	ΔPCT = 0°F
10 CFR 50.46 report dated October 21, 2015 (See Note 27)	ΔPCT = 0°F
10 CFR 50.46 report dated October 24, 2016 (See Note 28)	ΔPCT = 0°F
10 CFR 50.46 report dated December 20, 2017 (See Note 29)	ΔPCT = 0°F
10 CFR 50.46 report dated December 14, 2018 (See Note 30)	ΔPCT = 0°F
10 CFR 50.46 report dated November 26, 2019 (See Note 31)	ΔPCT = 0°F
10 CFR 50.46 report dated December 10, 2020 (See Note 32)	ΔPCT = 0°F
10 CFR 50.46 report dated November 24, 2021 (See Note 33)	ΔPCT = +14°F

NET PCT **PCT = 1001°F**

Attachment 1
Peak Cladding Temperature Rack-Up Sheets

B. CURRENT LOCA MODEL ASSESSMENTS

None (See Note 34)	ΔPCT = 0°F
Total PCT change from current assessments	ΣΔPCT = 0°F
Cumulative PCT change from current assessments	Σ|ΔPCT| = 0°F

NET PCT **PCT = 1001°F**

Attachment 1
Peak Cladding Temperature Rack-Up Sheets

PLANT NAME: Salem Unit 2
ECCS EVALUATION MODEL: Large Break Loss of Coolant Accident (LBLOCA)
REPORT REVISION DATE: November 2022
CURRENT OPERATING CYCLE: 26

ANALYSIS OF RECORD (AOR)

Evaluation Model: BASH
Calculation: Westinghouse 93-PSE-G-0080, September 1993
Fuel: RFA 17 x 17
Limiting Fuel Type: RFA 17x17
Heat Flux Hot Channel Factor (F_Q) = 2.4
Nuclear Enthalpy Rise Hot Channel Factor ($F_{\Delta H}$) = 1.65
Steam Generator Tube Plugging = 25% (Reduced to 10% for RSG)
Limiting Break Size: Cd = 0.4
Break Location: Cold Leg
Limiting Single Failure: loss of one train ECCS flow

Reference Peak Cladding Temperature (PCT) PCT = 1978°F

MARGIN ALLOCATION

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

10 CFR 50.46 report dated January 18, 1995 (See Note 4)	ΔPCT = +36°F
10 CFR 50.46 report dated December 7, 1995 (See Note 5)	ΔPCT = 0°F
10 CFR 50.46 report dated August 2, 1996 (See Note 6)	ΔPCT = 0°F
10 CFR 50.46 report dated July 11, 1997 (See Note 7)	ΔPCT = +15°F
10 CFR 50.46 report dated June 10, 1998 (See Note 8)	ΔPCT = 0°F
10 CFR 50.46 report dated April 27, 1999 (See Note 9)	ΔPCT = +24°F
10 CFR 50.46 report dated October 18, 1999 (See Note 10)	ΔPCT = -12°F
10 CFR 50.46 report dated September 21, 2000 (See Note 11)	ΔPCT = +9°F
10 CFR 50.46 report dated August 27, 2001 (See Note 12)	ΔPCT = +6°F
10 CFR 50.46 report dated August 27, 2002 (See Note 13)	ΔPCT = +20°F
10 CFR 50.46 report dated August 08, 2003 (See Note 14)	ΔPCT = +7°F
10 CFR 50.46 report dated July 29, 2004 (See Note 15)	ΔPCT = -45°F
10 CFR 50.46 report dated July 28, 2005 (See Note 16)	ΔPCT = 0°F
10 CFR 50.46 report dated July 28, 2006 (See Note 17)	ΔPCT = 0°F
10 CFR 50.46 report dated July 25, 2007 (See Note 18)	ΔPCT = +4°F
10 CFR 50.46 report dated July 22, 2008 (See Note 19)	ΔPCT = -41°F
10 CFR 50.46 report dated July 20, 2009 (See Note 20)	ΔPCT = 0°F
10 CFR 50.46 report dated July 20, 2010 (See Note 21)	ΔPCT = 0°F
10 CFR 50.46 report dated July 18, 2011 (See Note 22)	ΔPCT = 0°F
10 CFR 50.46 report dated July 16, 2012 (See Note 23)	ΔPCT = 0°F
10 CFR 50.46 report dated October 19, 2012 (See Note 24)	ΔPCT = +87°F
10 CFR 50.46 report dated October 11, 2013 (See Note 25)	ΔPCT = 0°F
10 CFR 50.46 report dated October 9, 2014 (See Note 26)	ΔPCT = 0°F
10 CFR 50.46 report dated October 21, 2015 (See Note 27)	ΔPCT = 0°F
10 CFR 50.46 report dated October 24, 2016 (See Note 28)	ΔPCT = 0°F

Attachment 1
Peak Cladding Temperature Rack-Up Sheets

10 CFR 50.46 report dated December 20, 2017 (See Note 29)	ΔPCT = 0°F
10 CFR 50.46 report dated December 14, 2018 (See Note 30)	ΔPCT = 0°F
10 CFR 50.46 report dated November 26, 2019 (See Note 31)	ΔPCT = 0°F
10 CFR 50.46 report dated December 10, 2020 (See Note 32)	ΔPCT = 0°F
10 CFR 50.46 report dated November 24, 2021 (See Note 33)	ΔPCT = -68°F

NET PCT **PCT = 2020°F**

B. CURRENT LOCA MODEL ASSESSMENTS

None (See Note 34)	ΔPCT = 0°F
Total PCT change from current assessments	ΣΔPCT = 0°F
Cumulative PCT change from current assessments	$\Sigma\lvert\Delta PCT\rvert$ = 0°F

NET PCT **PCT = 2020°F**

Attachment 2
Assessment Notes

SALEM UNITS 1 AND 2

Docket Nos. 50-272 and 50-311

10 CFR 50.46, “Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors”

Report of the Emergency Core Cooling System Evaluation Model Changes and Errors Assessments

Attachment 2
Assessment Notes

1. Prior Loss-of-Coolant Accident (LOCA) Model Assessment

The 10 CFR 50.46 report dated October 29, 1993, implemented the current Analysis of Record for the SBLOCA evaluation model (PCT = 1580°F), in support of the Fuel Upgrade / Margin Recovery Program. However, three PCT assessments were also included, resulting in a PCT benefit of -13°F. The first assessment entailed a +150°F penalty that resulted from explicitly modeling safety injection into the broken loop in the NOTRUMP model. The second assessment entailed a -150°F benefit that resulted from the implementation of an improved condensation model. The third assessment entailed a -13°F benefit that resulted from the correction of drift flux flow regime errors.

2. Prior LOCA Model Assessment

The 10 CFR 50.46 report dated July 27, 1994, provided an assessment to the SBLOCA model, which resulted in a -16°F PCT benefit. This PCT benefit was a result of corrections made to the reactor vessel and steam generator geometric and mass calculations in the VESCAL subroutine in the LUCIFER code.

3. Prior LOCA Model Assessment

The 10 CFR 50.46 report dated December 8, 1994, provided evaluations for the SBLOCA model due to three errors, for a penalty of +109°F. The first assessment entailed a +85°F PCT penalty that was a result of correcting nodalization and overall fluid conservation errors in the SBLOCTA code and implementing a revised transient fuel rod internal pressure model. The second assessment entailed a -6°F PCT benefit that was a result of error corrections made to the boiling heat transfer regime correlations in NOTRUMP. The third assessment entailed a +30°F PCT penalty as a result of errors affecting the steam line isolation logic in the SBLOCA evaluation model.

4. Prior LOCA Model Assessment

The 10 CFR 50.46 report dated January 18, 1995, provided no changes in the SBLOCA model, which caused the PCT to remain unchanged. The current Analysis of Record for the LBLOCA evaluation model (PCT = 1978°F) was implemented in support of the Fuel Upgrade / Margin Recovery Program. However, three PCT assessments were also included, resulting in a PCT penalty of +36°F. The first assessment entailed a +94°F PCT penalty that resulted from the absence of Intermediate Flow Mixers (IFMs) in the core. The second assessment was a PCT benefit of -52°F that resulted from four changes to the LOCBART code; including modifications made to convert the LOCBART code from a Cray to a Unix platform, corrections made to the rod heat-up code, the addition of a new model used to determine zircaloy cladding burst behavior above 1742°F, and the implementation of a revised burst strain limit model for the rod heat-up codes. The third assessment entailed a PCT benefit of -6°F that resulted from corrections made to the LUCIFER code.

5. Prior LOCA Model Assessment

The 10 CFR 50.46 report dated December 7, 1995, provided no changes in the SBLOCA and LBLOCA models for both Salem Units 1 and 2, which caused the PCTs to remain unchanged.

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Assessment Notes

6. Prior LOCA Model Assessment

The 10 CFR 50.46 report dated August 2, 1996, provided no changes in the LBLOCA model, which caused the PCT to remain unchanged. The SBLOCA model was assessed a -8°F PCT benefit as a result of three assessments. The first assessment was a +20°F PCT penalty due to an error in the specific enthalpy equation in NOTRUMP. The second assessment was a +10°F PCT penalty due to an error in the Fuel Rod Initialization algorithm of the SBLOCTA code, as well as several changes in the fuel rod creep and strain model. The third assessment was a -38°F PCT benefit as a result of an error in the relative loop seal elevation of the crossover leg.

7. Prior LOCA Model Assessment

The 10 CFR 50.46 report dated July 11, 1997, provided no changes in the SBLOCA model, which caused the PCT to remain unchanged. The LBLOCA model was assessed a +15°F PCT penalty as a result of translating the fluid conditions used for subchannel analysis of the fuel rods from one computer code (SATAN) to another computer code (LOCTA).

8. Prior LOCA Model Assessment

The 10 CFR 50.46 report dated June 10, 1998, provided no changes in the SBLOCA and LBLOCA models for both Salem Units 1 and 2, which caused the PCTs to remain unchanged.

9. Prior LOCA Model Assessment

The 10 CFR 50.46 report dated April 27, 1999, provided no changes in the Salem Unit 1 SBLOCA and LBLOCA models, which caused the PCTs to remain unchanged. However, unit- and cycle-specific PCT assessments were applied to Salem Unit 2. For the Salem Unit 2 SBLOCA evaluation model, a generic PCT penalty of +10°F was assessed due to the impact of fully enriched annular pellets. For the Salem Unit 2 LBLOCA evaluation model, a partial re-analysis was performed that incorporated the effects of Intermediate Flow Mixers (IFMs), features of the Robust Fuel Assembly (RFA), and other model updates. The cumulative impact of these PCT changes resulted in an increase in the Salem Unit 2 LBLOCA PCT of +24°F.

10. Prior LOCA Model Assessment

The 10 CFR 50.46 report dated October 18, 1999, provided evaluations for the SBLOCA and LBLOCA models for both Salem Units due to three errors. The first error resulted from the use of incorrect geometric data related to the accumulator lines and the pressurizer surge line. The second error was discovered in the length-averaging logic for heat transfer coefficient calculations in the LOCBART code. The third error was found in the Baker-Just metal-water reaction calculation in the LOCBART code. These errors were assessed together on a plant-specific basis and resulted in a -12°F PCT benefit for LBLOCA and no change (0°F) in the PCT for SBLOCA for both Salem Units. Thus, the Salem Unit 2 SBLOCA PCT remained unchanged, while the Salem Unit 2 LBLOCA PCT decreased by -12°F. In addition to the assessment above, further unit- and cycle-specific PCT assessments were applied to Salem Unit 1. For the Salem Unit 1 SBLOCA evaluation model, a generic PCT penalty of +10°F was assessed due to the impact of fully enriched annular pellets. For the Salem Unit 1 LBLOCA evaluation model, a partial re-analysis was performed that incorporated the effects of the Robust Fuel Assembly (RFA) features, Intermediate Flow Mixers (IFMs), and other model

Attachment 2
Assessment Notes

updates. In addition, a generic transition core PCT penalty was assessed to account for the effects of mixed fuel types (RFA and V5H) in the core. The cumulative impact of all of these PCT changes resulted in an increase in the Salem Unit 1 LBLOCA PCT of +12°F.

11. Prior LOCA Model Assessment

The 10 CFR 50.46 report dated September 21, 2000, provided evaluations for SBLOCA model changes, which resulted in a +27°F PCT increase. This increase consisted of a +14°F PCT assessment due to an error in the feedwater line volume calculation and a +13°F PCT assessment due to the discovery of several closely related errors dealing with mixture level tracking and region depletion errors in NOTRUMP. The LBLOCA model was assessed a +9°F PCT penalty as a result of an error in the LOCBART vapor film flow regime heat transfer correlation.

12. Prior LOCA Model Assessment

The 10 CFR 50.46 report dated August 27, 2001, provided no changes in the SBLOCA model, which caused the PCT to remain unchanged. The LBLOCA model was assessed a +6°F PCT penalty as a result of using non-conservative cladding surface emissivity values in LOCBART.

13. Prior LOCA Model Assessment

The 10 CFR 50.46 report dated August 27, 2002, provided no changes in the SBLOCA model, which caused the PCT to remain unchanged. The LBLOCA model was assessed a +20°F PCT penalty as a result of using a non-conservative assumption for accumulator water temperature.

14. Prior LOCA Model Assessment

The 10 CFR 50.46 report dated August 8, 2003, provided no changes in the SBLOCA model, which caused the PCT to remain unchanged. A partial re-analysis was performed for the LBLOCA transient using the latest BASH-EM code version that incorporated the “LOCBART transient extension method,” that ensured adequate termination of the fuel rod cladding temperature and oxidation transients predicted by LOCBART. This partial re-analysis allowed several prior PCT “generic evaluation” assessments (Accumulator Line / Pressurizer Surge Line Data Error, LOCBART Spacer Grid Single Phase Heat Transfer Error, LOCBART Zirc-Water Oxidation Error, LOCBART Vapor Film Flow Regime Heat Transfer Error, LOCBART Cladding Emissivity Error, Changes due to RFA Fuel Features, and Non-Conservative Accumulator Water Temperature Evaluation) to be replaced with a plant-specific analytical estimation. In addition, a +15°F PCT penalty was assessed to the LBLOCA model that resulted from corrections to the LOCBART ZIRLO Cladding Specific Heat Model. As a result of this penalty and the partial re-analysis, the LBLOCA PCT increased by +7°F.

Attachment 2
Assessment Notes

15. Prior LOCA Model Assessment

The 10 CFR 50.46 report dated July 29, 2004, provided a +40°F increase in the PCT of the SBLOCA evaluation model as a result of inconsistency corrections made to the NOTRUMP Bubble Rise and Drift Flux models and burst and blockage and time in life. The Salem Unit 1 LBLOCA model was assessed a +5°F PCT penalty as a result of the correction of discrepancies in the LOCBART Fluid Property Logic. The Salem Unit 2 LBLOCA model was also assessed this +5°F penalty, in addition to the removal of a +50°F Transition Core Penalty that resulted from operating with a mixed core of V5H and RFA fuel types, for a decrease in the PCT of -45°F.

16. Prior LOCA Model Assessment

The 10 CFR 50.46 report dated July 28, 2005, provided a 0°F increase in the PCT of the SBLOCA evaluation model due to the SBLOCA model assessment. The model assessment for SBLOCA was performed for reactor coolant pump reference conditions and general code maintenance (NOTRUMP). The report also provided a 0°F increase in the PCT of the LBLOCA evaluation model due to the LBLOCA model assessment. The model assessment for LBLOCA was performed for reactor coolant pump reference conditions, LOCBART fluid property logic, steam generator inlet/outlet plenum flow areas, initial containment relative humidity assumption and general code maintenance (BASH).

17. Prior LOCA Model Assessment

The 10 CFR 50.46 report dated July 28, 2006, provided a 0°F increase in the PCT of the SBLOCA evaluation model due to the SBLOCA model assessment. The model assessment for SBLOCA included replacing previously transmitted pressurizer fluid volumes with nominal cold values, correcting for an error in the lower guide tube assembly weight, corrected modeling of the spilling flows in the RWST draindown calculation and general code maintenance (NOTRUMP). The report also provided a 0°F increase in the PCT of the LBLOCA evaluation model due to the LBLOCA model assessment. The model assessment for LBLOCA included replacing previously transmitted pressurizer fluid volumes with nominal cold values, correcting for an error in the lower guide tube assembly weight, and general code maintenance (BASH). Additionally, the 50°F transition core PCT penalty applied to Salem Unit 1 LBLOCA was removed.

18. Prior LOCA Model Assessment

The 10 CFR 50.46 report dated July 25, 2007, provided a 0°F increase in the PCT of the SBLOCA evaluation model due to the SBLOCA model assessment. The model assessment for SBLOCA included the impact of the SBLOCA break size spectrum, errors in the IMP code vessel nozzle collections, and general code maintenance (NOTRUMP). The report also provided a +4°F increase in the PCT of the LBLOCA evaluation model due to the LBLOCA model assessment. The model assessment for LBLOCA included BASH minimum and maximum time step sizes (0°F), a rebaseline calculation to determine the limiting LOCBART calculated PCT (-8°F), LOCBART code correction for pellet volumetric heat generation rate (+12°F), LOCBART code option to convert user-specified zirconium-oxide thickness to equivalent cladding reacted (0°F), errors in the IMP code vessel nozzle collections (0°F), and general code maintenance (BASH).

Attachment 2
Assessment Notes

19. Prior LOCA Model Assessment

The 10 CFR 50.46 report dated July 22, 2008, provided a 0°F increase in the PCT of the SBLOCA evaluation model due to the SBLOCA model assessment. The model assessment for SBLOCA included the impact of errors in the reactor vessel lower plenum surface area calculation and general code maintenance (NOTRUMP). A new Small Break LOCA Analysis of Record was implemented for Salem Unit 2 with implementation of the replacement steam generators in Salem 2 Cycle 17. The report also provided a 0°F increase in PCT of the LBLOCA evaluation model for Salem Unit 1 due to the LBLOCA model assessment. The Salem Unit 1 model assessment for LBLOCA included BASH pellet volumetric heat generation rate correction, error in reactor vessel lower plenum surface area calculations, and general code maintenance (BASH). The Salem Unit 2 model assessment for Large Break LOCA included a net -41°F benefit due to implementation of the replacement steam generators and change in steam generator tube plugging limits from 25% to 10% (-47°F), removal of a rebaseline calculation not applicable to Salem Unit 2 with the new steam generators (+8°F); BASH pellet volumetric heat generation rate correction (0°F); LOCBART pellet volumetric heat generation rate correction (-2°F), and errors in the reactor vessel lower plenum surface area calculation (0°F), and general code (BASH) maintenance (0°F).

20. Prior LOCA Model Assessment

The 10 CFR 50.46 report dated July 20, 2009, provided a 0°F increase in the PCT for the Salem Unit 1 and Salem Unit 2 small and large break LOCA model assessments. Discrepancies were discovered in the use of metal masses from drawings. The updated reactor vessel metal masses and fluid volumes have been evaluated for impact on current licensing basis analysis results and will be incorporated on a forward-fit basis. These changes represent a closely-related group of Non-Discretionary Changes in accordance with Section 4.1.2 of WCAP-13451. The differences in the reactor vessel metal mass and fluid volume are relatively minor and produce a negligible effect on large and small break LOCA analysis results, leading to a PCT impact of 0°F for 10 CFR 50.46 reporting purposes. General code maintenance (NOTRUMP for SBLOCA and BASH for LBLOCA) resulted in a 0°F PCT increase for Salem Unit 1 and Salem Unit 2.

21. Prior LOCA Model Assessment

The 10 CFR 50.46 report dated July 20, 2010, provided a 0°F increase in the PCT for the Salem Unit 1 and Salem Unit 2 small and large break LOCA model assessments. No discrepancies were identified in the 10 CFR 50.46 LOCA models or methods for this reporting period for Salem Unit 1 and Salem Unit 2.

22. Prior LOCA Model Assessment

The 10 CFR 50.46 report dated July 18, 2011, provided a 0°F increase in the PCT for the Salem Unit 1 and Salem Unit 2 small and large break LOCA model assessments. Discrepancies were discovered and are summarized. Historically, the overall vessel average temperature uncertainty calculated by Westinghouse considered only "-" instrument uncertainties, corresponding to the indicated temperature being lower than the actual temperature. The uncertainty was then applied as a "+/-" uncertainty in some LOCA analyses, rather than using specific "+" and "-" uncertainties. This discrepancy has been evaluated for impact on existing Large and Small Break LOCA analysis results, and its resolution represents a Non-Discretionary

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Change in accordance with Section 4.1.2 of WCAP-13451. The issue was judged to have a negligible impact on existing Large and Small Break LOCA analysis results, leading to an estimated PCT impact of 0°F. Two issues were identified related to the normalized pellet crack and dish volumes utilized in the LOCA peak clad temperature (PCT) analyses. These issues were: 1) the incorrect tables of normalized volume versus linear heat generation rate were being used (the table for clad outer diameters of <0.4 inches were using tables for clad outer diameters >0.4 inches and vice versa), and 2) the normalized volume at 18 kw/ft was incorrectly programmed in one of the tables as 1.58 instead of 1.59. This discrepancy has been evaluated for impact on existing Large and Small Break LOCA analysis results, and its resolution represents a Non-Discretionary Change in accordance with Section 4.1.2 of WCAP-13451. These issues were judged to have a negligible impact on existing Large and Small Break LOCA analysis results, leading to an estimated PCT impact of 0°F.

23. Prior LOCA Model Assessment

The 10 CFR 50.46 report dated July 16, 2012, provided a 0°F increase in the PCT for the Salem Unit 1 and Salem Unit 2 small and large break LOCA model assessments. Discrepancies were discovered and are summarized. Two errors were discovered in the calculation of the radiation heat transfer coefficient in the SBLOCTA computer code. First, existing diagnostics did not preclude non-physical negative or large (negative or positive) radiation heat transfer coefficients from being calculated. These calculations occurred when the vapor temperature exceeded the cladding surface temperature or when the predicted temperature difference was less than 1 degree. Second, a temperature term incorrectly used degrees Fahrenheit instead of Rankine. These errors have been corrected in the SBLOCTA code and represent a closely related group of Non-Discretionary Changes in accordance with Section 4.1.2 of WCAP-13451. A combination of SBLOCTA sensitivity calculations and engineering judgment led to an estimated PCT effect of 0°F for existing Small Break LOCA analysis results. An error was discovered in the SBLOCTA code that allowed the fuel rod time step to exceed the specified maximum allowable time step. The time step logic has been corrected in the SBLOCTA code. This change represents a Non-Discretionary Change in accordance with Section 4.1.2 of WCAP-13451. A combination of SBLOCTA sensitivity calculations and engineering judgment led to an estimated PCT effect of 0°F for existing Small Break LOCA analysis results.

24. Prior LOCA Model Assessment

The 10 CFR 50.46 report dated October 19, 2012, provided a rebaseline +87°F increase in the PCT for the Salem Unit 1 and Salem Unit 2 large break LOCA model assessments. Evaluations have been completed to estimate the effect of fuel pellet thermal conductivity degradation (TCD) on peak cladding temperature (PCT) for analyses using the 1981 Westinghouse Large-Break Loss of-Coolant Accident Evaluation Model with BASH (BASH-EM) with the LOCBART Transient Extension Method. Note the impact on PCT due to TCD was 0°F. These evaluations utilized fuel rod performance input from a version of the PAD code that accounts for pellet TCD and considered the beneficial effects of assembly power and peaking factor burndown resulting from the depletion of fissionable isotopes. This change represents a Non-Discretionary Change in accordance with Section 4.1.2 of WCAP-13451. The estimated effect was determined on a plant-specific basis. The peaking factor burndown used in the evaluation is provided in LTR-LIS-12-512; it is conservative for the current cycle and will be validated as part of the reload design process. PSEG Nuclear and its vendor, Westinghouse Electric Company LLC, utilize processes which ensure that the corresponding LOCA analysis input parameters conservatively bound the as-operated plant values. The utilization of the LOCBART Transient

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Extension Method led to an estimated rebaseline PCT impact of +87°F for existing Large Break LOCA analysis results.

25. Prior LOCA Model Assessment

The 10 CFR 50.46 report dated October 11, 2013, provided a 0°F increase in the PCT for the Salem Unit 1 and Salem Unit 2 small and large break LOCA model assessments. Discrepancies were discovered and are summarized. An evaluation has been completed to estimate the effect of fuel pellet thermal conductivity degradation (TCD) on peak cladding temperature (PCT) for plants in the Unites States with analyses using the 1985 Westinghouse Small Break LOCA Evaluation Model with NOTRUMP (NOTRUMP-EM). This change represents a Non-Discretionary Change in accordance with Section 4.1.2 of WCAP-13451. Based on phenomena and physics of the SBLOCA transient, in combination with limited sensitivity calculations, it is concluded that TCD has a negligible effect on the limiting cladding temperature transient, leading to an estimated PCT impact of 0°F.

26. Prior LOCA Model Assessment

The 10 CFR 50.46 report dated October 9, 2014, provided a 0°F increase in the PCT for the Salem Unit 1 and Salem Unit 2 small and large break LOCA model assessments. Discrepancies were discovered and are summarized. 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. Resolution of this issue represents a Non-Discretionary Change to the Evaluation Model as described in Section 4.1.2 of WCAP-13451. Based on a review of current licensing basis analyses, and the phenomena and physics of a small break LOCA transient, it is concluded that this error has a negligible effect on small break LOCA analysis results, leading to an estimated Peak Cladding Temperature (PCT) impact of 0°F. An error was discovered in the LOCBART code that impacts the calculation of the rod-to-rod radiation heat transfer coefficient. The error was corrected and test cases were performed to determine the potential impact on the results. The test case results demonstrated that correcting the code error had a negligible impact on calculated results. This change represents a Non-Discretionary change to the evaluation model as described in Section 4.1.2 of WCAP-13451. Validation testing showed a negligible impact on calculated results, leading to an estimated Peak Cladding Temperature (PCT) impact of 0°F. Two errors were identified in the SATAN6 calculation of the radiation term of the fuel rod gap heat transfer coefficient. First, an incorrect temperature is used in the cladding emissivity calculation; second, a geometrical term is missing from the radiation heat transfer coefficient calculation. These errors correspond to a closely related group of Non-Discretionary Changes as described in Section 4.1.2 of WCAP-13451. A set of hand calculations was completed showing a negligible impact on the fuel rod gap heat transfer coefficient in SATAN6, leading to an estimated effect of 0°F on peak cladding temperature. A condition was observed in calculations completed with the BASH computer code relating to an isotherm indexing variable in the quench front model that results in oscillatory quench front behavior above the peak power elevation for select cases. An updated version of the BASH computer code was used to estimate the effect of the quench front oscillations on the resulting core inlet flooding rate used by LOCBART for calculating the peak cladding temperature (PCT). This represents a Non-Discretionary Change as described in Section 4.1.2 of WCAP-13451. An updated version of the BASH computer code was developed to assess the impact of the oscillations for all impacted analyses. The validation results show a negligible impact on the resulting core inlet

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flooding rate, leading to an estimated effect of 0°F on PCT. 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 1981 Appendix K Large Break LOCA Evaluation Model with BASH (BASH-EM), which affects the grid heat transfer in the LOCBART fuel rod heat up calculation. This change represents a Non-Discretionary Change in accordance with Section 4.1.2 of WCAP-13451. The impact of the recalculated grid blockage ratio and porosity for 17x17 RFA and 17x17 RFA-2 fuel, used as input in the BASH-EM LOCBART model, was qualitatively evaluated as having a negligible impact on reported results, leading to an estimated peak cladding temperature (PCT) effect of 0°F.

27. Prior LOCA Model Assessment

The 10 CFR 50.46 report dated October 21, 2015, provided a 0°F increase in the PCT for the Salem Unit 1 and Salem Unit 2 small and large break LOCA model assessments. Discrepancies were discovered and are summarized. An error was identified in the fuel rod gap conductance model in the NOTRUMP computer code (reactor coolant system response model). The error is associated with the use of an incorrect temperature in the calculation of the cladding emissivity term. This error corresponds to a Non-Discretionary Change as described in Section 4.1.2 of WCAP-13451. The estimated effect was determined based on a combination of engineering judgment of the phenomena and physics of a small break LOCA and sensitivity calculations performed with the advanced plant version of NOTRUMP. It was concluded that this error has a negligible effect on small break LOCA analysis results, leading to an estimated Peak Cladding Temperature (PCT) impact of 0°F. Two errors were discovered in the calculation of the radiation heat transfer coefficient within the fuel rod model of the NOTRUMP computer code (reactor coolant system response model). First, existing logic did not preclude non-physical negative or large (negative or positive) radiation heat transfer coefficients from being calculated. These erroneous calculations occurred when the vapor temperature exceeded the cladding surface temperature or when the predicted temperature difference was less than 1°F. Second, a temperature term incorrectly used degrees Fahrenheit instead of Rankine. These errors represent a closely related group of Non-Discretionary problems in accordance with Section 4.1.2 of WCAP-13451. The estimated effect was determined based on a combination of engineering judgment of the phenomena and physics of a small break LOCA and sensitivity calculations performed with the advanced plant version of NOTRUMP. It was concluded that this error has a negligible effect on small break LOCA analysis results, leading to an estimated Peak Cladding Temperature (PCT) impact of 0°F. Two errors were discovered in the pre-departure from nucleate boiling (pre-DNB) cladding surface heat transfer coefficient calculation in the SBLOCTA code (cladding heat-up calculations). The first error is a result of inconsistent time units (hours vs. seconds) in the parameters used for the calculation of the Reynolds and Prandtl numbers, and the second error relates to an incorrect diameter used to develop the area term in the cladding surface heat flux calculation. Both of these issues impact the calculation of the pre-DNB convective heat transfer coefficient, representing a closely related group of Non-Discretionary

Changes to the Evaluation Model as described in Section 4.1.2 of WCAP-13451. These errors have been corrected in the SBLOCTA code. Because this condition occurred prior to DNB, it was judged that these errors had no direct impact on the cladding heat-up related to the core uncovery period. A series of validation tests were performed and confirmed that these errors have a negligible effect on SBLOCA analysis results, leading to an estimated Peak Cladding Temperature (PCT) impact of 0°F.

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28. Prior LOCA Model Assessment

The 10 CFR 50.46 report dated October 24, 2016, provided a 0°F increase in the PCT for the Salem Unit 1 and Salem Unit 2 small and large break LOCA model assessments. There were no Errors or Discrepancies identified.

29. Prior LOCA Model Assessment

The 10 CFR 50.46 report dated December 20, 2017, provided a 0°F increase in the PCT for the Salem Unit 1 and Salem Unit 2 small and large break LOCA model assessments. There were no Errors or Discrepancies identified.

30. Prior LOCA Model Assessment

The 10 CFR 50.46 report dated December 14, 2018, provided a 0°F increase in the PCT for the Salem Unit 1 and Salem Unit 2 small and large break LOCA model assessments An error was found in the fluid volume calculation in the upper plenum where the support column outer diameter was being used instead of the inner diameter. The correction of this error lead to a reduction in the upper plenum fluid volume used in the Appendix K Large Break LOCA and Small Break LOCA analyses. The corrected values represent a less than 1% change in the total RCS fluid volume and will be incorporated on a forward-fit basis, based on the evaluated impact on the current licensing basis analysis results. These changes represent a Non-Discretionary Change in accordance with Section 4.1.2 of WCAP-13451. The differences in the upper plenum fluid volume are relatively minor and have been evaluated to have a negligible effect on large and small break LOCA analysis results, leading to an estimated PCT impact of 0°F.

31. Prior LOCA Model Assessment

The 10 CFR 50.46 report dated November 26, 2019: A typographical error was discovered in the implementation of the UO2 fuel pellet heat capacity as described by Equation C-4 of WCAP-8301 [WCAP-8301, “LOCTA-IV Program: Loss-of-Coolant Transient Analysis,” June 1974.] for fuel rod heat-up calculations within the Appendix K Large Break and Small Break LOCA evaluation models. The erroneous formulation results in an over-prediction of heat capacity that increases with fuel temperature. The corrected formulation results in a maximum decrease in heat capacity on the order of approximately 1.2% for existing analyses of record. This represents a Non-Discretionary Change in accordance with Section 4.1.2 of WCAP-13451. The small over-prediction in UO2 fuel pellet heat capacity has been evaluated to have a negligible effect on existing large and small break LOCA analysis results due to the small magnitude of the change, leading to an estimated PCT impact of 0°F.

32. Prior LOCA Model Assessment

The 10 CFR 50.46 report dated December 10, 2020: The impact of introducing Plasma Arc Spray (PAS) lead demonstration rods (LDRs) on the Salem Unit 1 Appendix K large break loss-of-coolant accident (LBLOCA) and Appendix K small break loss-of-coolant accident (SBLOCA) analyses was evaluated for Cycle 27. This represents a Change in Plant Configuration or Set Points, distinguished from an evaluation model change in Section 4 of WCAP-13451. The introduction of PAS LDRs has a negligible effect on the Appendix K LBLOCA analysis results and no impact on the Appendix K SBLOCA analysis results, leading to an estimated PCT effect of 0°F for Salem Unit 1 Cycle 27.

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33. Prior LOCA Model Assessment

The 10 CFR 50.46 Annual Notification and Reporting for 2020: The Westinghouse 10 CFR 50.46 annual report did not yield any changes from the previous report to the NRC, PSEG letter LR-N20-0078. The SBLOCA and LBLOCA PCT values for Salem 1 and 2 remain unchanged. Westinghouse did not report any code errors related to NOTRUMP or BASH for this reporting period.

Salem Unit 2 (PNJ) 10 CFR 50.46 Reporting Text and Peak Cladding Temperature Summary Sheet for the Upflow Conversion Program: The impact of converting Salem Unit 2 from a downflow to upflow configuration on the Appendix K large break loss of coolant accident (LBLOCA) and Appendix K small break loss of coolant accident (SBLOCA) analyses was evaluated for the upcoming Cycle 26. The SBLOCA evaluation consists of revised calculations performed in accordance with the approved NOTRUMP Evaluation Model that explicitly model the upflow barrel-baffle configuration. The evaluation resulted in a net increase in the SBLOCA peak cladding temperature (PCT) of 14°F. The LBLOCA evaluation consists of revised calculations performed in accordance with the approved BASH Evaluation Model that explicitly model the upflow barrel baffle configuration. The evaluation resulted in a net decrease in the LBLOCA PCT of 68°F.

34. Current LOCA Model Assessment

The 10 CFR 50.46 Annual Notification and Reporting for 2021: The Westinghouse 10 CFR 50.46 annual report did not yield any changes from the previous annual and 30-day report to the NRC, PSEG letter LR-N21-0083. The SBLOCA and LBLOCA PCT values for Salem 1 and 2 remain unchanged. Westinghouse did not report any code errors related to NOTRUMP or BASH for this reporting period.