



June 21, 2019

10 CFR 50.46

U.S. Nuclear Regulatory Commission
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Washington, DC 20555

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NPF-4/7
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DOMINION ENERGY NUCLEAR CONNECTICUT, INCORPORATED (INC.)
VIRGINIA ELECTRIC AND POWER COMPANY
MILLSTONE POWER STATION UNITS 2 AND 3
NORTH ANNA POWER STATION UNITS 1 AND 2
SURRY POWER STATION UNITS 1 AND 2
2018 ANNUAL REPORT OF EMERGENCY CORE COOLING SYSTEM (ECCS) MODEL
CHANGES PURSUANT TO THE REQUIREMENTS OF 10 CFR 50.46

In accordance with 10 CFR 50.46(a)(3)(ii), Dominion Energy Nuclear Connecticut, Inc. (DENC) and Virginia Electric and Power Company (Dominion Energy Virginia) hereby submit the annual summary of permanent changes to the ECCS evaluation models (EMs) for Millstone Power Station (MPS) Units 2 and 3, North Anna Power Station (NAPS) Units 1 and 2, and Surry Power Station (SPS) Units 1 and 2, respectively.

Attachment 1 to this letter provides a report describing plant-specific EM changes associated with the Westinghouse and Framatome Small Break Loss of Coolant Accident (SBLOCA) and Large Break Loss of Coolant Accident (LBLOCA) ECCS EMs for MPS 2 and 3, NAPS 1 and 2, and SPS 1 and 2, as applicable.

Information regarding the effect of the ECCS EM changes upon the reported SBLOCA and LBLOCA analyses of record results is provided for MPS 2 and 3, NAPS 1 and 2, and SPS 1 and 2 in Attachments 2, 3, and 4, respectively. The calculated Peak Cladding Temperatures (PCT) for the SBLOCA and LBLOCA analyses for MPS 2 and 3, NAPS 1 and 2, and SPS 1 and 2 are summarized below:

Millstone Unit 2	Small Break - Framatome EM:	1714°F
Millstone Unit 2	Large Break - Framatome EM (Zr4 fuel):	1845°F
Millstone Unit 2	Large Break - Framatome EM (M5 fuel):	1615°F
Millstone Unit 3	Small Break - Westinghouse EM:	1193°F
Millstone Unit 3	Large Break - Westinghouse EM:	1933°F
North Anna Units 1 and 2	Small Break - Westinghouse EM:	1834.1°F
North Anna Units 1 and 2	Large Break - Westinghouse EM:	1982°F
Surry Units 1 and 2	Small Break - Westinghouse EM:	2012°F
Surry Units 1 and 2	Large Break - Westinghouse EM:	2071°F

ADDZ
NRR

The LOCA results for MPS 2 and 3, NAPS 1 and 2, and SPS 1 and 2 are confirmed to have sufficient margin to the 2200°F limit for PCT specified in 10 CFR 50.46. Based on the evaluation of this information and the resulting changes in the applicable licensing basis PCT results, no further action is required to demonstrate compliance with the 10 CFR 50.46 requirements.

The information contained herein satisfies the 2018 annual reporting requirements of 10 CFR 50.46(a)(3)(ii).

If you have any questions regarding this submittal, please contact Mr. Gary D. Miller at (804) 273-2771.

Respectfully,



Mark D. Sartain
Vice President - Nuclear Engineering and Fleet Support
Dominion Energy Nuclear Connecticut, Inc.
Virginia Electric and Power Company

Commitments made in this letter: None

Attachments:

1. Report of Changes in Framatome and Westinghouse ECCS Evaluation Models
2. 2018 Annual Reporting of 10 CFR 50.46 Margin Utilization - Millstone Power Station Units 2 and 3
3. 2018 Annual Reporting of 10 CFR 50.46 Margin Utilization – North Anna Power Station Units 1 and 2
4. 2018 Annual Reporting of 10 CFR 50.46 Margin Utilization – Surry Power Station Units 1 and 2

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Attachment 1

**2018 ANNUAL REPORT OF EMERGENCY CORE
COOLING SYSTEM (ECCS) MODEL CHANGES
PURSUANT TO THE REQUIREMENTS OF 10 CFR 50.46**

**REPORT OF CHANGES IN
FRAMATOME AND WESTINGHOUSE ECCS EVALUATION MODELS**

**DOMINION ENERGY NUCLEAR CONNECTICUT, INC.
VIRGINIA ELECTRIC AND POWER COMPANY
MILLSTONE POWER STATION UNITS 2 AND 3
NORTH ANNA POWER STATION UNITS 1 AND 2
SURRY POWER STATION UNITS 1 AND 2**

REPORT OF CHANGES IN
FRAMATOME AND WESTINGHOUSE ECCS EVALUATION MODELS

Millstone Power Station Unit 2

1. Framatome identified no changes or errors applicable to the EMF-2328(P)(A), Revision 0, with Supplement 1 evaluation model for Small Break LOCA (SBLOCA) for Millstone Unit 2 during 2018.
2. Framatome identified no changes or errors applicable to the SEM/PWR-98 evaluation model for Large Break LOCA (LBLOCA) for Millstone Unit 2 during 2018. This evaluation model is applicable to the Millstone Unit 2 fuel with Zr-4 cladding.
3. On January 24, 2017, a new LBLOCA analysis was approved by the NRC, based upon the EMF-2103(P)(A), Revision 3, "Realistic Large Break LOCA (RLBLOCA) Methodology for Pressurized Water Reactors." The new analysis is applicable to the Framatome Standard CE14 HTP fuel product with the M5™ fuel rod cladding.

Framatome identified no changes or errors applicable to the EMF-2103(P)(A), Revision 3, evaluation model for RLBLOCA for Millstone Unit 2 during 2018.

Millstone Power Station Unit 3

1. Westinghouse identified the following change and error applicable to the 1985 Westinghouse SBLOCA Evaluation Model (EM) with NOTRUMP for Millstone Unit 3 during 2018:
 - **UO2 FUEL PELLETT HEAT CAPACITY.** A typographical error was discovered in the implementation of the UO2 fuel pellet heat capacity as described by Equation C-4 of WCAP-8301 [1] for fuel rod heat-up calculations within the Appendix K Large Break and Small Break LOCA EMs. The erroneous formulation results in an overprediction 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. The small overprediction 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 Peak Clad Temperature (PCT) impact of 0°F.
2. Westinghouse identified the following changes and errors applicable to the 2004 Westinghouse Best Estimate (BE) LBLOCA EM using the Automated Statistical Treatment of Uncertainty Method (ASTRUM) for Millstone Unit 3 during 2018:
 - **VAPOR TEMPERATURE RESETTING.** In the WCOBRA/TRAC and WCOBRA/TRAC-TF2 codes, when the vapor temperature is greater than the wall temperature and several other conditions are met, the vapor temperature is

reset to the saturation temperature for heat transfer calculations. It was discovered that this vapor temperature resetting logic results in an inconsistency between the conduction solution and the hydraulic solution, such that energy is not conserved between the two solutions. Engineering judgement supported by sensitivity calculations showed that correcting this error had minimal impact on LOCA transient calculations leading to an estimated peak cladding temperature impact of 0°F.

- **MILLSTONE UNIT 3 CYCLE 20 PBOT/PMID VIOLATIONS.** The Millstone Unit 3 Cycle 20 reload core design resulted in violations of the PBOT/PMID box used in the LBLOCA analysis. These violations were evaluated for Millstone Unit 3 Cycle 20 operation. This item represents a change in plant configuration or associated set points, distinguished from an EM change in Section 4 of WCAP-13451. The PCT impact of the PBOT/PMID violations for Millstone Unit 3 Cycle 20 was determined via a plant-specific evaluation to be 0°F.

Cycle 20 operation began in spring 2019, and thus the evaluation is included as a planned modification in Attachment 2.

North Anna Power Station Units 1 and 2

1. Westinghouse identified the following change and error applicable to the 1985 Westinghouse SBLOCA EM with NOTRUMP for North Anna Units 1 and 2 during 2018:
 - **UO2 FUEL PELLETT HEAT CAPACITY.** A typographical error was discovered in the implementation of the UO2 fuel pellet heat capacity as described by Equation C-4 of WCAP-8301 [1] for fuel rod heat-up calculations within the Appendix K Large Break and Small Break LOCA EMs. The erroneous formulation results in an overprediction 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. The small over-prediction in UO2 fuel pellet heat capacity has been evaluated to have a negligible effect on existing Large Break and Small Break LOCA analysis results due to the small magnitude of the change, leading to an estimated PCT impact of 0°F.
2. Westinghouse identified the following change and error applicable to the 2004 Westinghouse BE LBLOCA EM using ASTRUM for North Anna Units 1 and 2 during 2018:
 - **VAPOR TEMPERATURE RESETTING.** In the WCOBRA/TRAC and WCOBRA/TRAC-TF2 codes, when the vapor temperature is greater than the wall temperature, and several other conditions are met, the vapor temperature is reset to the saturation temperature for heat transfer calculations. It was discovered that this vapor temperature resetting logic results in an

inconsistency between the conduction solution and the hydraulic solution, such that energy is not conserved between the two solutions. Engineering judgement supported by sensitivity calculations showed that correcting this error had minimal impact on LOCA transient calculations leading to an estimated peak cladding temperature impact of 0°F.

Surry Power Station Units 1 and 2

1. Westinghouse identified the following change and error applicable to the 1985 Westinghouse SBLOCA EM with NOTRUMP for Surry Units 1 and 2 during 2018:
 - **UO2 FUEL PELLETT HEAT CAPACITY.** A typographical error was discovered in the implementation of the UO2 fuel pellet heat capacity as described by Equation C-4 of WCAP-8301 [1] for fuel rod heat-up calculations within the Appendix K Large Break and Small Break LOCA EMs. The erroneous formulation results in an overprediction 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. The small overprediction in UO2 fuel pellet heat capacity has been evaluated to have a negligible effect on existing Large Break and Small Break LOCA analysis results due to the small magnitude of the change leading to an estimated PCT impact of 0°F.
2. Westinghouse identified the following change and error applicable to the 2004 Westinghouse BE LBLOCA EM using ASTRUM for Surry Units 1 and 2 during 2018:
 - **VAPOR TEMPERATURE RESETTING.** In the WCOBRA/TRAC and WCOBRA/TRAC-TF2 codes, when the vapor temperature is greater than the wall temperature, and several other conditions are met, the vapor temperature is reset to the saturation temperature for heat transfer calculations. It was discovered that this vapor temperature resetting logic results in an inconsistency between the conduction solution and the hydraulic solution, such that energy is not conserved between the two solutions. Engineering judgement supported by sensitivity calculations showed that correcting this error had minimal impact on LOCA transient calculations leading to an estimated peak cladding temperature impact of 0°F.

Conclusion

The LOCA results for Millstone Units 2 and 3, North Anna Units 1 and 2, and Surry Units 1 and 2 are confirmed in the PCT rackup tables, Attachments 2 through 4, to have margin to the 2200°F limit for PCT specified in 10 CFR 50.46. Based on the evaluation of this information and the resulting changes in the applicable licensing basis PCT results, no further action is required to demonstrate compliance with the 10 CFR 50.46 requirements. Reporting of this information is required per 10 CFR 50.46(a)(3)(ii),

which obligates each licensee to report the effect upon calculated temperature of any change or error in EMs or their application on an annual basis.

This information satisfies the annual reporting requirements of 10 CFR 50.46(a)(3)(ii) for calendar year 2018.

Reference:

- [1] WCAP-8301, "LOCTA-IV Program: Loss-of-Coolant Transient Analysis," June 1974.

Attachment 2

**2018 ANNUAL REPORT OF EMERGENCY CORE
COOLING SYSTEM (ECCS) MODEL CHANGES
PURSUANT TO THE REQUIREMENTS OF 10 CFR 50.46**

2018 ANNUAL REPORTING OF 10 CFR 50.46 MARGIN UTILIZATION

**DOMINION ENERGY NUCLEAR CONNECTICUT, INC.
MILLSTONE POWER STATION UNITS 2 AND 3**

10 CFR 50.46 MARGIN UTILIZATION - SMALL BREAK LOCA

Plant Name: Millstone Power Station, Unit 2
Utility Name: Dominion Energy Nuclear Connecticut, Inc.

Analysis Information

EM: 2015, Supp. 1, SBLOCA, S-RELAP5 Based **Limiting Break Size:** 3.78 Inches
Analysis Date: April 2015
Vendor: Framatome
Peak Linear Power: 15.1 kW/ft
Notes: None

	<u>Clad Temp (°F)</u>
LICENSING BASIS	
Analysis of Record PCT	1707
PCT ASSESSMENTS (Delta PCT)	
A. Prior ECCS Model Assessments	
1. Zirc-4 Product Penalty	4
2. M5 LOCA Swelling and Rupture	0
3. S-RELAP5 Oxidation Calculations	3
B. Planned Plant Modification Evaluations	
1. None	0
C. 2018 ECCS Model Assessments	
1. None	0
D. Other	
1. None	0

LICENSING BASIS PCT + PCT ASSESSMENTS **PCT = 1714**

10 CFR 50.46 MARGIN UTILIZATION - LARGE BREAK LOCA

Plant Name: Millstone Power Station, Unit 2
Utility Name: Dominion Energy Nuclear Connecticut, Inc.

Analysis Information

EM: SEM/PWR-98 **Limiting Break Size:** 1.0 DECLG
Analysis Date: November 1998
Vendor: Framatome
Peak Linear Power: 15.1 kW/ft
Notes: None

Clad Temp (°F)

LICENSING BASIS

Analysis of Record PCT 1814

PCT ASSESSMENTS (Delta PCT)

A. Prior ECCS Model Assessments

- | | | |
|-----|--|----|
| 1. | Corrected Corrosion Enhancement Factor | -1 |
| 2. | ICECON Coding Errors | 0 |
| 3. | Setting RFPAC Fuel Temperatures at Start of Reflood | -2 |
| 4. | SISPUNCH/ujun98 Code Error | 0 |
| 5. | Error in Flow Blockage Model in TOODEE2 | 0 |
| 6. | Change in TOODEE2-Calculation of QMAX | 0 |
| 7. | Change in Gadolinia Modeling | 0 |
| 8. | PWR LBLOCA Split Break Modeling | 0 |
| 9. | TEOBY Calculation Error | 0 |
| 10. | Inappropriate Heat Transfer in TOODEE2 | 0 |
| 11. | End-of-Bypass Prediction by TEOBY | 0 |
| 12. | R4SS Overwrite of Junction Inertia | 0 |
| 13. | Incorrect Junction Inertia Multipliers | 1 |
| 14. | Errors Discovered During RODEX2 V&V | 0 |
| 15. | Error in Broken Loop SG Tube Exit Junction Inertia | 0 |
| 16. | RFPAC Refill and Reflood Calculation Code Errors | 16 |
| 17. | Incorrect Pump Junction Area Used in RELAP4 | 0 |
| 18. | Error in TOODEE2 Clad Thermal Expansion | -1 |
| 19. | Accumulator Line Loss Error | -1 |
| 20. | Inconsistent Loss Coefficients Used for Robinson LBLOCA | 0 |
| 21. | Pump Head Adjustment for Pressure Balance Initialization | -3 |
| 22. | ICECON Code Errors | 0 |
| 23. | Containment Sump Modification and Replacement PZR | 2 |
| 24. | Non-Conservative RODEX Fuel Pellet Temperature | 20 |
| 25. | Array Index Issues in the RELAP4 Code | 0 |

B. Planned Plant Modification Evaluations

- | | | |
|----|--|---|
| 1. | Millstone Unit 3 Cycle 20 PBOT/PMID Violations | 0 |
|----|--|---|

C. 2018 ECCS Model Assessments

- | | | |
|----|------|---|
| 1. | None | 0 |
|----|------|---|

D. Other

1. None

0

LICENSING BASIS PCT + PCT ASSESSMENTS

PCT = 1845

10 CFR 50.46 MARGIN UTILIZATION - LARGE BREAK LOCA

Plant Name: Millstone Power Station, Unit 2 (M5 Fuel)
Utility Name: Dominion Energy Nuclear Connecticut, Inc.

Analysis Information

EM: EMF-2103 **Limiting Break Size: 1.0 DEGB**
Analysis Date: January 2017
Vendor: Framatome
Peak Linear Power: 15.1 kW/ft
Notes: None

		<u>Clad Temp (°F)</u>
LICENSING BASIS		
	Analysis of Record PCT	1615
PCT ASSESSMENTS (Delta PCT)		
A.	Prior ECCS Model Assessments	
	1. Placement of Hot Leg Piping Form Loss Coefficient	0
	2. M5 LOCA Swelling and Rupture	0
	3. S-RELAP5 Oxidation Calculations	0
B.	Planned Plant Modification Evaluations	
	1. None	0
C.	2018 ECCS Model Assessments	
	1. None	0
D.	Other	
	1. None	0
LICENSING BASIS PCT + PCT ASSESSMENTS		PCT = 1615

10 CFR 50.46 MARGIN UTILIZATION - SMALL BREAK LOCA

Plant Name: Millstone Power Station, Unit 3
Utility Name: Dominion Energy Nuclear Connecticut, Inc.

Analysis Information

EM:	NOTRUMP	Limiting Break Size:	4 inches
Analysis Date:	02/07/07		
Vendor:	Westinghouse		
FQ:	2.6	FdH:	1.65
Fuel:	RFA-2	SGTP (%):	10
Notes:	None		

Clad Temp (°F)

LICENSING BASIS

Analysis of Record PCT	1193
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PCT ASSESSMENTS (Delta PCT)

A. Prior ECCS Model Assessments

- | | | |
|-----|---|---|
| 1. | Errors in Reactor Vessel Lower Plenum Surface Area Calculations | 0 |
| 2. | Discrepancy in Metal Masses Used From Drawings | 0 |
| 3. | Urania-Gadolinia Pellet Thermal Conductivity Calculation | 0 |
| 4. | Pellet Crack and Dish Volume Calculation | 0 |
| 5. | Treatment of Vessel Average Temperature Uncertainty | 0 |
| 6. | Maximum Fuel Rod Time Step Logic | 0 |
| 7. | Radiation Heat Transfer Logic | 0 |
| 8. | NOTRUMP-EM Evaluation of Fuel Pellet Thermal Conductivity Degradation | 0 |
| 9. | SBLOCTA Cladding Strain Requirement for Fuel Rod Burst | 0 |
| 10. | Fuel Rod Gap Conductance Error | 0 |
| 11. | Radiation Heat Transfer Model Error | 0 |
| 12. | SBLOCTA Pre-DNB Cladding Heat Transfer Coefficient Calculation | 0 |
| 13. | Insertion of AXIOM™ Cladding LTAs | 0 |
| 14. | Vessel Average Temperature Uncertainty | 0 |
| 15. | Error in the Upper Plenum Fluid Volume Calculation | 0 |

B. Planned Plant Modification Evaluations

- | | | |
|----|------|--|
| 1. | None | |
|----|------|--|

C. 2018 ECCS Model Assessments

- | | | |
|----|---|---|
| 1. | UO ₂ Fuel Pellet Heat Capacity | 0 |
|----|---|---|

D. Other

- | | | |
|----|------|---|
| 1. | None | 0 |
|----|------|---|

LICENSING BASIS PCT + PCT ASSESSMENTS	PCT = 1193
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10 CFR 50.46 MARGIN UTILIZATION - LARGE BREAK LOCA

Plant Name: Millstone Power Station, Unit 3
Utility Name: Dominion Energy Nuclear Connecticut, Inc.

Analysis Information

EM:	ASTRUM (2004)	Limiting Break Size:	Guillotine
Analysis Date:	04/17/07		
Vendor:	Westinghouse		
FQ:	2.6	FdH:	1.65
Fuel:	RFA-2	SGTP (%):	10
Notes:	None		

Clad Temp (°F)

LICENSING BASIS

Analysis of Record PCT	1781
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PCT ASSESSMENTS (Delta PCT)

A. Prior ECCS Model Assessments

- | | | |
|-----|---|-----|
| 1. | HOTSPOT Burst Temperature Logic Errors | 0 |
| 2. | CCFL Global Volume Error | 0 |
| 3. | HOTSPOT Gap Heat Transfer Logic | 0 |
| 4. | Discrepancy in Metal Masses Used From Drawings | 0 |
| 5. | Error in ASTRUM Processing of Average Rod Burnup and Rod Internal Pressure | 0 |
| 6. | Treatment of Vessel Average Temperature Uncertainty | 0 |
| 7. | PBOT and PMID Evaluation | 0 |
| 8. | Evaluation of Fuel Pellet Thermal Conductivity Degradation | 222 |
| 9. | HOTSPOT Burst Temperature Calculation for ZIRLO Cladding | 0 |
| 10. | Rod Internal Pressure Calculation | 0 |
| 11. | HOTSPOT Iteration Algorithm for Calculating the Initial Fuel Pellet Average Temperature | 0 |
| 12. | WCOBRA/TRAC Thermal-Hydraulic History File Dimension used in HSDRIVER Background | 0 |
| 13. | WCOBRA/TRAC Automated Restart Process Logic Error | 0 |
| 14. | Initial Fuel Pellet Average Temperature Uncertainty Calculation | 0 |
| 15. | Elevations for Heat Slab Temperature Initialization | 0 |
| 16. | Heat Transfer Model Error Corrections | 0 |
| 17. | Correction to Heat Transfer Node Initialization | 0 |
| 18. | Mass Conservation Error Fix | 0 |
| 19. | Correction to Split Channel Momentum Equation | 0 |
| 20. | Heat Transfer Logic Correction for Rod Burst Calculation | 0 |
| 21. | Changes to Vessel Superheated Steam Properties | 0 |
| 22. | Update to Metal Density Reference Temperatures | 0 |
| 23. | Decay Heat Model Error Corrections | 0 |
| 24. | Correction to the Pipe Exit Pressure Drop Error | 0 |
| 25. | WCOBRA/TRAC U19 File Dimension Error Correction | 0 |
| 26. | Revised Heat Transfer Multiplier Distributions | -91 |

27.	HOTSPOT Burst Strain Error Correction	21
28.	Changes to Grid Blockage Ratio and Porosity	0
29.	Grid Heat Transfer Enhancement Calculation	0
30.	Burst Elevation Selection	0
31.	Errors in Decay Group Uncertainty Factors	0
32.	Errors in Support Plate, Core Barrel, and Vessel Wall Unheated Conductor	0
33.	Error in Oxidation Calculations	0
34.	Error in use of ASME Steam Tables	0
35.	Insertion of AXIOM™ Cladding LTAs	0
36.	Vessel Average Temperature Uncertainty	0
37.	Inconsistent Application of Numerical Ramp Applied to the Entrained Liquid / Vapor Interfacial Drag Coefficient	0
38.	Inappropriate Resetting of Transverse Liquid Mass Flow	0
39.	Steady-State Fuel Temperature Calibration Method	0

B. Planned Plant Modification Evaluations

- 1. None

C. 2018 ECCS Model Assessments

- 1. Vapor Temperature Resetting 0

D. Other

- 1. None 0

LICENSING BASIS PCT + PCT ASSESSMENTS	PCT =	1933
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Attachment 3

**2018 ANNUAL REPORT OF EMERGENCY CORE
COOLING SYSTEM (ECCS) MODEL CHANGES
PURSUANT TO THE REQUIREMENTS OF 10 CFR 50.46**

2018 ANNUAL REPORTING OF 10 CFR 50.46 MARGIN UTILIZATION

**VIRGINIA ELECTRIC AND POWER COMPANY
(DOMINION ENERGY VIRGINIA)
NORTH ANNA POWER STATION UNITS 1 AND 2**

10 CFR 50.46 MARGIN UTILIZATION - WESTINGHOUSE SMALL BREAK LOCA

Plant Name: North Anna Power Station, Unit 1
Utility Name: Virginia Electric and Power Company

Analysis Information

EM:	NOTRUMP	Limiting Break Size:	2.75 inches
Analysis Date:	12/20/2010		
Vendor:	Westinghouse		
FQ:	2.32	FΔH:	1.65
Fuel:	RFA-2	SGTP (%):	7
Notes:	None		

Clad Temp (°F)

LICENSING BASIS

Analysis of Record PCT	1834.1
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PCT ASSESSMENTS (Delta PCT)

A. Prior ECCS Model Assessments

- | | | |
|----|---|---|
| 1. | NOTRUMP-EM Evaluation of Fuel Pellet Thermal Conductivity Degradation | 0 |
| 2. | SBLOCA Cladding Strain Requirement for Fuel Rod Burst | 0 |
| 3. | Fuel Rod Gap Conductance Error | 0 |
| 4. | Radiation Heat Transfer Model Error | 0 |
| 5. | SBLOCTA Pre-DNB Cladding Heat Transfer Coefficient Calculation | 0 |
| 6. | Error in the Upper Plenum Fluid Volume Calculation | 0 |

B. Planned Plant Modification Evaluations

- | | | |
|----|------|---|
| 1. | None | 0 |
|----|------|---|

C. 2018 ECCS Model Assessments

- | | | |
|----|-------------------------------|---|
| 1. | UO2 Fuel Pellet Heat Capacity | 0 |
|----|-------------------------------|---|

D. Other

- | | | |
|----|------|---|
| 1. | None | 0 |
|----|------|---|

LICENSING BASIS PCT + PCT ASSESSMENTS

PCT = 1834.1

10 CFR 50.46 MARGIN UTILIZATION - WESTINGHOUSE LARGE BREAK LOCA

Plant Name: North Anna Power Station, Unit 1
Utility Name: Virginia Electric and Power Company

Analysis Information

EM:	ASTRUM (2004)	Limiting Break Size:	DEGB
Analysis Date:	8/25/2010		
Vendor:	Westinghouse		
FQ:	2.32	FΔH:	1.65
Fuel:	RFA-2	SGTP (%):	7

Notes: Core Power ≤ 100% of 2951 MWt; SG Model 54F; 17x17 RFA-2 Fuel with ZIRLO® or Optimized ZIRLO™ cladding, Non-IFBA or IFBA, IFMs

Clad Temp (°F)

LICENSING BASIS

Analysis of Record PCT	1852
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PCT ASSESSMENTS (Delta PCT)

A. Prior ECCS Model Assessments

- | | |
|--|-----|
| 1. Evaluation of Fuel Pellet Thermal Conductivity Degradation | 135 |
| 2. HOTSPOT Burst Temperature Calculation for ZIRLO Cladding | 0 |
| 3. Rod Internal Pressure Calculation | 0 |
| 4. HOTSPOT Iteration Algorithm for Calculating the Initial Fuel Pellet Average Temperature | 0 |
| 5. WCOBRA/TRAC Thermal-Hydraulic History File Dimension used in HSDRIVER Background | 0 |
| 6. WCOBRA/TRAC Automated Restart Process Logic Error | 0 |
| 7. Initial Fuel Pellet Average Temperature Uncertainty Calculation | 1 |
| 8. Elevations for Heat Slab Temperature Initialization | 0 |
| 9. Heat Transfer Model Error Corrections | 0 |
| 10. Correction to Heat Transfer Node Initialization | 0 |
| 11. Mass Conservation Error Fix | 0 |
| 12. Correction to Split Channel Momentum Equation | 0 |
| 13. Heat Transfer Logic Correction for Rod Burst Calculation | 0 |
| 14. Changes to Vessel Superheated Steam Properties | 0 |
| 15. Update to Metal Density Reference Temperatures | 0 |
| 16. Decay Heat Model Error Corrections | 0 |
| 17. Correction to the Pipe Exit Pressure Drop Error | 0 |
| 18. WCOBRA/TRAC U19 File Dimension Error Correction | 0 |
| 19. Revised Heat Transfer Multiplier Distributions | -27 |
| 20. HOTSPOT Burst Strain Error Correction | 21 |
| 21. Changes to Grid Blockage Ratio and Porosity | 0 |
| 22. Grid Heat Transfer Enhancement Calculation | 0 |
| 23. Vessel Section 7 Mid-Level Elevation Modeling | 0 |

24.	Burst Elevation Selection	0
25.	Errors in Decay Group Uncertainty Factors	0
26.	Error in Oxidation Calculations	0
27.	Error in use of ASME Steam Tables	0
28.	Support Column Core Barrel Unheated Conductor Errors	0
29.	Inconsistent Application of Numerical Ramp Applied to the Entrained Liquid / Vapor Interfacial Drag Coefficient	0
30.	Inappropriate Resetting of Transverse Liquid Mass Flow	0
31.	Steady-State Fuel Temperature Calibration Method	0
32.	Correction to Fuel Pellet TCD Assessment	0
B.	Planned Plant Modification Evaluations	
1.	None	0
C.	2018 ECCS Model Assessments	
1.	Vapor Temperature Resetting	0
D.	Other	
1.	None	

LICENSING BASIS PCT + PCT ASSESSMENTS

PCT = 1982

10 CFR 50.46 MARGIN UTILIZATION - WESTINGHOUSE SMALL BREAK LOCA

Plant Name: North Anna Power Station, Unit 2
Utility Name: Virginia Electric and Power Company

Analysis Information

EM:	NOTRUMP	Limiting Break Size:	2.75 inches
Analysis Date:	12/20/2010		
Vendor:	Westinghouse		
FQ:	2.32	FΔH:	1.65
Fuel:	RFA-2	SGTP (%):	7
Notes:	None		

Clad Temp (°F)

LICENSING BASIS

Analysis of Record PCT	1834.1
------------------------	--------

PCT ASSESSMENTS (Delta PCT)

A. Prior ECCS Model Assessments

- | | | |
|----|---|---|
| 1. | NOTRUMP-EM Evaluation of Fuel Pellet Thermal Conductivity Degradation | 0 |
| 2. | SBLOCTA Cladding Strain Requirement for Fuel Rod Burst | 0 |
| 3. | Fuel Rod Gap Conductance Error | 0 |
| 4. | Radiation Heat Transfer Model Error | 0 |
| 5. | SBLOCTA Pre-DNB Cladding Heat Transfer Coefficient Calculation | 0 |
| 6. | Error in the Upper Plenum Fluid Volume Calculation | 0 |

B. Planned Plant Modification Evaluations

- | | | |
|----|------|---|
| 1. | None | 0 |
|----|------|---|

C. 2018 ECCS Model Assessments

- | | | |
|----|-------------------------------|---|
| 1. | UO2 Fuel Pellet Heat Capacity | 0 |
|----|-------------------------------|---|

D. Other

- | | | |
|----|------|---|
| 1. | None | 0 |
|----|------|---|

LICENSING BASIS PCT + PCT ASSESSMENTS

PCT = 1834.1

10 CFR 50.46 MARGIN UTILIZATION - WESTINGHOUSE LARGE BREAK LOCA

Plant Name: North Anna Power Station, Unit 2
Utility Name: Virginia Electric and Power Company

Analysis Information

EM: ASTRUM (2004) **Limiting Break Size:** DEGB
Analysis Date: 8/25/2010
Vendor: Westinghouse
FQ: 2.32 **FΔH:** 1.65
Fuel: RFA-2 **SGTP (%):** 7

Notes: Core Power ≤ 100% of 2951 MWt; SG Model 54F; 17x17 RFA-2 Fuel with ZIRLO® or Optimized ZIRLO™ cladding, Non-IFBA or IFBA, IFMs

	<u>Clad Temp (°F)</u>
LICENSING BASIS	
Analysis of Record PCT	1852

PCT ASSESSMENTS (Delta PCT)

A. Prior ECCS Model Assessments

- | | | |
|-----|---|-----|
| 1. | Evaluation of Fuel Pellet Thermal Conductivity Degradation | 135 |
| 2. | HOTSPOT Burst Temperature Calculation for ZIRLO Cladding | 0 |
| 3. | Rod Internal Pressure Calculation | 0 |
| 4. | HOTSPOT Iteration Algorithm for Calculating the Initial Fuel Pellet Average Temperature | 0 |
| 5. | WCOBRA/TRAC Thermal-Hydraulic History File Dimension used in HSDRIVER Background | 0 |
| 6. | WCOBRA/TRAC Automated Restart Process Logic Error | 0 |
| 7. | Initial Fuel Pellet Average Temperature Uncertainty Calculation | 1 |
| 8. | Elevations for Heat Slab Temperature Initialization | 0 |
| 9. | Heat Transfer Model Error Corrections | 0 |
| 10. | Correction to Heat Transfer Node Initialization | 0 |
| 11. | Mass Conservation Error Fix | 0 |
| 12. | Correction to Split Channel Momentum Equation | 0 |
| 13. | Heat Transfer Logic Correction for Rod Burst Calculation | 0 |
| 14. | Changes to Vessel Superheated Steam Properties | 0 |
| 15. | Update to Metal Density Reference Temperatures | 0 |
| 16. | Decay Heat Model Error Corrections | 0 |
| 17. | Correction to the Pipe Exit Pressure Drop Error | 0 |
| 18. | WCOBRA/TRAC U19 File Dimension Error Correction | 0 |
| 19. | Revised Heat Transfer Multiplier Distributions | -27 |
| 20. | HOTSPOT Burst Strain Error Correction | 21 |
| 21. | Changes to Grid Blockage Ratio and Porosity | 0 |
| 22. | Grid Heat Transfer Enhancement Calculation | 0 |

23.	Vessel Section 7 Mid-Level Elevation Modeling	0
24.	Burst Elevation Selection	0
25.	Errors in Decay Group Uncertainty Factors	0
27.	Error in Oxidation Calculations	0
28.	Error in use of ASME Steam Tables	0
29.	Support Column Core Barrel Unheated Conductor Errors	0
30.	Inconsistent Application of Numerical Ramp Applied to the Entrained Liquid / Vapor Interfacial Drag Coefficient	0
31.	Inappropriate Resetting of Transverse Liquid Mass Flow	0
32.	Steady-State Fuel Temperature Calibration Method	0
33.	Correction to Fuel Pellet TCD Assessment	0
B.	Planned Plant Modification Evaluations	
1.	None	0
C.	2018 ECCS Model Assessments	
1.	Vapor Temperature Resetting	0
D.	Other	
1.	None	

LICENSING BASIS PCT + PCT ASSESSMENTS

PCT = 1982

Attachment 4

**2018 ANNUAL REPORT OF EMERGENCY CORE
COOLING SYSTEM (ECCS) MODEL CHANGES
PURSUANT TO THE REQUIREMENTS OF 10 CFR 50.46**

2018 ANNUAL REPORTING OF 10 CFR 50.46 MARGIN UTILIZATION

**VIRGINIA ELECTRIC AND POWER COMPANY
(DOMINION ENERGY VIRGINIA)
SURRY POWER STATION UNITS 1 AND 2**

10 CFR 50.46 MARGIN UTILIZATION - WESTINGHOUSE SMALL BREAK LOCA

Plant Name:	Surry Power Station, Unit 1		
Utility Name:	Virginia Electric and Power Company		
Analysis Information			
EM:	NOTRUMP	Limiting Break Size:	2.75 inches
Analysis Date:	5/7/2009		
Vendor:	Westinghouse		
FQ:	2.5	FΔH:	1.7
Fuel:	Upgrade	SGTP (%):	7
Notes:	None		

	<u>Clad Temp (°F)</u>
LICENSING BASIS	
Analysis of Record PCT	2012

PCT ASSESSMENTS (Delta PCT)

A. Prior ECCS Model Assessments	
1. Urania-Gadolinia Pellet Thermal Conductivity Calculation.	0
2. Pellet Crack and Dish Volume Calculation.	0
3. Treatment of Vessel Average Temperature Uncertainty	0
4. 15X15 Upgrade Fuel	0
5. Maximum Fuel Rod Time Step Logic	0
6. Radiation Heat Transfer Logic	0
7. NOTRUMP-EM Evaluation of Fuel Pellet Thermal Conductivity Degradation	0
8. SBLOCTA Cladding Strain Requirement for Fuel Rod Burst	0
9. Fuel Rod Gap Conductance Error	0
10. Radiation Heat Transfer Model Error	0
11. SBLOCTA Pre-DNB Cladding Heat Transfer Coefficient Calculation	0
12. Error in the Upper Plenum Fluid Volume Calculation	0
B. Planned Plant Modification Evaluations	
1. None	0
C. 2018 ECCS Model Assessments	
1. UO ₂ Fuel Pellet Heat Capacity	0
D. Other	
1. None	0

LICENSING BASIS PCT + PCT ASSESSMENTS	PCT = 2012
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10 CFR 50.46 MARGIN UTILIZATION - WESTINGHOUSE LARGE BREAK LOCA

Plant Name:	Surry Power Station, Unit 1		
Utility Name:	Virginia Electric and Power Company		
<u>Analysis Information</u>			
EM:	ASTRUM (2004)	Limiting Break Size:	DEG
Analysis Date:	10/6/2010		
Vendor:	Westinghouse		
FQ:	2.5	FAH:	1.7
Fuel:	Upgrade	SGTP (%):	7
Notes:	None		

	<u>Clad Temp (°F)</u>
LICENSING BASIS	
Analysis of Record PCT	1853

PCT ASSESSMENTS (Delta PCT)

A. Prior ECCS Model Assessments

1.	Evaluation of Fuel Pellet Thermal Conductivity Degradation	183
2.	Pellet Radial Profile Option	-13
3.	HOTSPOT Burst Temperature Calculation for ZIRLO Cladding	0
4.	Rod Internal Pressure Calculation	0
5.	HOTSPOT Iteration Algorithm for Calculating the Initial Fuel Pellet Average Temperature	0
6.	WCOBRA/TRAC Thermal-Hydraulic History File Dimension used in HSDRIVER Background	0
7.	WCOBRA/TRAC Automated Restart Process Logic Error	0
8.	Initial Fuel Pellet Average Temperature Uncertainty Calculation	0
9.	Elevations for Heat Slab Temperature Initialization	0
10.	Heat Transfer Model Error Corrections	0
11.	Correction to Heat Transfer Node Initialization	0
12.	Mass Conservation Error Fix	0
13.	Correction to Split Channel Momentum Equation	0
14.	Heat Transfer Logic Correction for Rod Burst Calculation	0
15.	Changes to Vessel Superheated Steam Properties	0
16.	Update to Metal Density Reference Temperatures	0
17.	Decay Heat Model Error Corrections	0
18.	Correction to the Pipe Exit Pressure Drop Error	0
19.	WCOBRA/TRAC U19 File Dimension Error Correction	0
20.	Revised Heat Transfer Multiplier Distributions	-7
21.	HOTSPOT Burst Strain Error Correction	51
22.	Changes to Grid Blockage Ratio and Porosity	0
23.	Grid Heat Transfer Enhancement Calculation	0
24.	Vessel Section 7 Mid-Level Elevation Modeling	0

25.	Burst Elevation Selection	0
26.	Errors in Decay Group Uncertainty Factors	4
27.	Evaluation of Additional Containment Metal	0
28.	Error in Oxidation Calculations	0
29.	Error in use of ASME Steam Tables	0
30.	Core Barrel Unheated Conductor Errors	0
31.	Discrepancy in Wetted Perimeter Inputs	0
32.	Inconsistent Application of Numerical Ramp Applied to the Entrained Liquid / Vapor Interfacial Drag Coefficient	0
33.	Inappropriate Resetting of Transverse Liquid Mass Flow	0
34.	Steady-State Fuel Temperature Calibration Method	0
B.	Planned Plant Modification Evaluations	
1.	None	0
C.	2018 ECCS Model Assessments	
1.	Vapor Temperature Resetting	0
D.	Other	
1.	None	0

LICENSING BASIS PCT + PCT ASSESSMENTS	PCT = 2071
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10 CFR 50.46 MARGIN UTILIZATION - WESTINGHOUSE SMALL BREAK LOCA

Plant Name:	Surry Power Station, Unit 2		
Utility Name:	Virginia Electric and Power Company		
Analysis Information			
EM:	NOTRUMP	Limiting Break Size:	2.75 inches
Analysis Date:	5/7/2009		
Vendor:	Westinghouse		
FQ:	2.5	FΔH:	1.7
Fuel:	Upgrade	SGTP (%):	7
Notes:	None		

	<u>Clad Temp (°F)</u>
LICENSING BASIS	
Analysis of Record PCT	2012

PCT ASSESSMENTS (Delta PCT)

A. Prior ECCS Model Assessments	
1. Urania-Gadolinia Pellet Thermal Conductivity Calculation.	0
2. Pellet Crack and Dish Volume Calculation.	0
3. Treatment of Vessel Average Temperature Uncertainty	0
4. 15X15 Upgrade Fuel	0
5. Maximum Fuel Rod Time Step Logic	0
6. Radiation Heat Transfer Logic	0
7. NOTRUMP-EM Evaluation of Fuel Pellet Thermal Conductivity Degradation	0
8. SBLOCTA Cladding Strain Requirement for Fuel Rod Burst	0
9. Fuel Rod Gap Conductance Error	0
10. Radiation Heat Transfer Model Error	0
11. SBLOCTA Pre-DNB Cladding Heat Transfer Coefficient Calculation	0
12. Error in the Upper Plenum Fluid Volume Calculation	0
B. Planned Plant Modification Evaluations	
1. None	0
C. 2018 ECCS Model Assessments	
1. UO ₂ Fuel Pellet Heat Capacity	0
D. Other	
1. None	0

LICENSING BASIS PCT + PCT ASSESSMENTS	PCT = 2012
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10 CFR 50.46 MARGIN UTILIZATION - WESTINGHOUSE LARGE BREAK LOCA

Plant Name:	Surry Power Station, Unit 2		
Utility Name:	Virginia Electric and Power Company		
<u>Analysis Information</u>			
EM:	ASTRUM (2004)	Limiting Break Size:	DEG
Analysis Date:	10/6/2010		
Vendor:	Westinghouse		
FQ:	2.5	FΔH:	1.7
Fuel:	Upgrade	SGTP (%):	7
Notes:	None		

	<u>Clad Temp (°F)</u>
LICENSING BASIS	
Analysis of Record PCT	1853

PCT ASSESSMENTS (Delta PCT)

A. Prior ECCS Model Assessments

1.	Evaluation of Fuel Pellet Thermal Conductivity Degradation	183
2.	Pellet Radial Profile Option	-13
3.	HOTSPOT Burst Temperature Calculation for ZIRLO Cladding	0
4.	Rod Internal Pressure Calculation	0
5.	HOTSPOT Iteration Algorithm for Calculating the Initial Fuel Pellet Average Temperature	0
6.	WCOBRA/TRAC Thermal-Hydraulic History File Dimension used in HSDRIVER Background	0
7.	WCOBRA/TRAC Automated Restart Process Logic Error	0
8.	Initial Fuel Pellet Average Temperature Uncertainty Calculation	0
9.	Elevations for Heat Slab Temperature Initialization	0
10.	Heat Transfer Model Error Corrections	0
11.	Correction to Heat Transfer Node Initialization	0
12.	Mass Conservation Error Fix	0
13.	Correction to Split Channel Momentum Equation	0
14.	Heat Transfer Logic Correction for Rod Burst Calculation	0
15.	Changes to Vessel Superheated Steam Properties	0
16.	Update to Metal Density Reference Temperatures	0
17.	Decay Heat Model Error Corrections	0
18.	Correction to the Pipe Exit Pressure Drop Error	0
19.	WCOBRA/TRAC U19 File Dimension Error Correction	0
20.	Revised Heat Transfer Multiplier Distributions	-7
21.	HOTSPOT Burst Strain Error Correction	51
22.	Changes to Grid Blockage Ratio and Porosity	0
23.	Grid Heat Transfer Enhancement Calculation	0

24.	Vessel Section 7 Mid-Level Elevation Modeling	0
25.	Burst Elevation Selection	0
26.	Errors in Decay Group Uncertainty Factors	4
27.	Evaluation of Additional Containment Metal	0
28.	Error in Oxidation Calculations	0
29.	Error in use of ASME Steam Tables	0
30.	Core Barrel Unheated Conductor Errors	0
31.	Discrepancy in Wetted Perimeter Inputs	0
32.	Inconsistent Application of Numerical Ramp Applied to the Entrained Liquid / Vapor Interfacial Drag Coefficient	0
33.	Inappropriate Resetting of Transverse Liquid Mass Flow	0
34.	Steady-State Fuel Temperature Calibration Method	0
B.	Planned Plant Modification Evaluations	
1.	None	0
C.	2018 ECCS Model Assessments	
1.	Vapor Temperature Resetting	0
D.	Other	
1.	None	0
<hr/> LICENSING BASIS PCT + PCT ASSESSMENTS <hr/>		PCT = 2071