UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

September 20, 2018

MEMORANDUM TO: Jennifer Dixon-Herrity, Chief
Licensing Branch 4
Division of Licensing, Siting,
and Environmental Analysis
Office of New Reactors

FROM: Paul Kallan, Senior Project Manager ***/RA/***
Licensing Branch 4
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Office of New Reactors

SUBJECT: AUDIT REPORT FOR VOGTLE ELECTRIC GENERATING PLANT UNITS 3 AND 4, REQUEST FOR LICENSE AMENDMENT: EFFECT OF ROD SHADOWING ON EXCORE POWER RANGE DETECTORS, CHANGES TO NUCLEAR OVERPOWER REACTOR TRIPS, AND CHANGES TO MONITORING OF MODERATOR TEMPERATURE COEFFICIENT AND CORE POWER DISTRIBUTION (LAR 17-031)

By letter dated September 8, 2017 (Agencywide Documents Access and Management System (ADAMS) Accession Number ML17251A458), (Southern Nuclear Operating Company (the licensee) requested an amendment to Combined License (COL) Numbers NPF-91 and NPF-92, for Vogtle Electric Generating Plant (VEGP) Units 3 and 4.

The requested amendment requires changes to the Updated Final Safety Analysis Report (UFSAR) in the form of departures from the Plant-Specific Design Control Document Tier 2 information and involves changes to the VEGP Units 3 and 4 COL Appendix A, Technical Specifications (TS).

The requested amendment proposes to revise the licensing basis information for the design of the protection and safety monitoring system (PMS) automatic reactor trips and the crediting of PMS automatic reactor trips necessary to prevent exceeding fuel design limits including the power range high neutron flux (high setpoint), the power range high positive flux rate trip, the overpower ΔT trip, and the overtemperature ΔT trip. Also, changes to the COL Appendix A TS for maintaining moderator temperature coefficient and maintaining power distributions within the required absolute power generation limits.

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The Systems, Nuclear Performance and Code Review Branch staff conducted an audit on July 26 – August 17, 2018, to gain better understanding of proposed changes to reach reasonable assurance findings and review related documentation and non-docketed information to evaluate conformance with the regulations.

Docket Nos.: 52-025 and 52-026

Enclosure:
Regulatory Audit Plan (non-proprietary version)

cc: See next page

U.S. NUCLEAR REGULATORY COMMISSION AUDIT PLAN FOR VOGTLE ELECTRIC GENERATING PLANT UNITS 3 AND 4 REQUEST FOR LICENSE AMENDMENT: EFFECT OF ROD SHADOWING ON EXCORE POWER RANGE DETECTORS, CHANGES TO NUCLEAR OVERPOWER REACTOR TRIPS, AND CHANGES TO MONITORING OF MODERATOR TEMPERATURE COEFFICIENT AND CORE POWER DISTRIBUTION (LAR 17-031) DATED: SEPTEMBER 20, 2018

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ML18234A127 –Audit Plan (Proprietary)
ML18262A098 – Audit Report (Non-Proprietary) NRO-008

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Vogtle Units 3 & 4 Mailing List (Revised 08/16/2018)

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REPORT OF REGULATORY AUDIT
LICENSE AMENDMENT RELATED TO
EFFECT OF ROD SHADOWNING ON EXCORE POWER RANGE DETECTORS, CHANGES TO NUCLEAR OVERPOWER REACTOR TRIPS, AND CHANGES TO MONITORING OF MODERATOR TEMPERATURE COEFFICIENT AND CORE POWER DISTRIBUTION
VOGTLE ELECTRIC GENERATING PLANT, UNITS 3 AND 4 (LAR 17-031)

A. Background

By letter dated September 8, 2018 (Reference 1) Southern Nuclear Operating Company (SNC/licensee) submitted License Amendment Request (LAR) 17-031 requesting that the U.S. Nuclear Regulatory Commission (NRC or the Commission) amend the combined licenses (COL) for Vogtle Electric Generating Plant (VEGP) Units 3 and 4, COL Numbers NPF-91 and NPF-92, respectively.

The requested amendment (LAR 17-031) would revise the Updated Final Safety Analysis Report (UFSAR) in the form of departures from the incorporated plant-specific Design Control Document (DCD) Tier 2 information, with corresponding changes to the associated COL Appendix A, Technical Specifications. Specifically, the requested amendment proposes changes to (1) the design of the Protection and Safety Monitoring (PMS) system, (2) the crediting of trips in Chapter 15 transient and accident analyses, and (3) additional changes to technical specifications for the moderator temperature coefficient, power distributions, and the On-Line Power Distribution Monitoring System. The proposed changes to the PMS system and the crediting of trips in the Chapter 15 transient and accident analyses address issues caused by increased uncertainties in the ex-core nuclear instrumentation during mechanical shim (MSHIM) operations.

The purpose of this audit is to gain a better understanding of the uncertainties introduced by MSHIM operation and the proposed approach for addressing these uncertainties.

B. Bases

This regulatory audit is based on the following:

- LAR-17-031, Enclosure 1, Section 2.1, Section 2.2, and Section 2.3 (Reference 1)
- Vogtle Electric Generating Plant, Units 3 and 4, UFSAR, Section 15.4.2, and Section 15.4.8 (Reference 2)
- COL, Appendix A, Voglte Electric Generating Plant, Units 3 and 4, Technical Specificiations (Reference 3 and Reference 4)

The audit plan is available in Agencywide Documents Access and Management System (ADAMS) under Accession Number ML18192B091.

C. Logistics

Date: July 26, 2018 – August 17, 2018

Location: The audit was conducted primarily through the Westinghouse Electric Company's (Westinghouse) electronic reading room. A meeting with Westinghouse subject matter experts was conducted on August 7, 2018 at Westinghouse's (the vendor's) office at 11333 Woodglen Drive, Suite 202, Rockville, Maryland 20852.

D. Audit Team Members

The following staff members participated in substantive discussions during the audit:

- Paul Kallan, Senior Project Manager (Licensing Branch 4)
- Timothy Drzewiecki, Reactor Systems Engineer (Systems, Nuclear Performance and Code Review Branch)
- Antonio Barrett, Reactor Systems Engineer (Systems, Nuclear Performance and Code Review Branch)

E. Applicant and Industry Staff Participants

- Wesley Sparkman
- Daniel Spaulding
- Walter Moomau
- Michael Hone
- Anthony Schoedel
- Ryan Rossman (via telephone)
- Micheal Patterson (via telephone)
- Robert Fetterman (via telephone)

F. Documents Audited

MSHIM Operation

- APP-GW-GEE-1551, Rev. 0, "Rod Shadowing on Excore Detectors"

- APP-GW-GEE-5331, Rev. 0, "OTDT and OPDT Reactor Trip Setpoint Margin Recovery".

Axial Flux Difference Penalties

- CN-AP1000-SA-087, Rev. 5, "Revised 3D FAC Analysis for the AP1000 Pressurized Water Reactor Cycle 1"

Setpoint Uncertainty

- APP-PMS-M3C-117, Rev. 1, "Power Range Neutron Flux Reactor Trip Setpoint and High Positive Rate Uncertainty Calculations for the AP1000 Plant"

- APP-PMS-M3C-124, Rev. 1, "Overpower ΔT and Overtemperature ΔT Reactor Trip Setpoint Uncertainty Calculations for the AP1000 Plant"

- APP-PMS-M3C-135, Rev. 1, “Insulation Resistance Degradation Uncertainties for the Domestic AP1000 Plants”

Transient and Accident Analyses

- APP-SSAR-GEF-065, Rev. 0, “Revising AP1000 Safety Analysis Checklist (SAC) for OPDT and OTDT FdI”

- APP-SSAR-GSC-137, Rev. 2, “AP1000 - Advanced First Core Rod Cluster Control Assembly (RCCA) Bank Withdrawal at Power”

- CN-AP1000-3DRE-013, Rev. 0, “AP1000 3D Rod Ejection HZP Enthalpy Analyses with ANC 9.4.0”

- CN-AP1000-3DRE-014, Rev. 0, “AP1000 3D Rod Ejection DNBR Analyses for the Core Reference Report and FSAR”

- CN-AP1000-3DRE-016, Rev. 0, “AP1000 3D Rod Ejection HFP Enthalpy Analyses with ANC 9.4.0”

- CN-AP1000-3DRE-017, Rev. 0, “Assessment of Revised Rod Drop Time on RIA Inputs to the AP1000 PWR Core Reference Report”

- CN-AP1000-SA-029, Rev. 2, “AP1000 Cycle 1 HFP SLB for Chapter 15 Analysis”

G. Description of Audit Activities and Summary of Observations

Staff examined documentation supporting LAR-17-031 and discussed material with subject matter experts in the areas of MSHIM Operation, Axial Flux Difference (AFD) Penalty Functions, Setpoint Uncertainty, and Transient and Accident Analyses. Audit activities within each of these areas is described below.

MSHIM Operation

Staff examined APP-GW-GEE-1551 and noted that this document identifies additional uncertainties associated with MSHIM that needed to be addressed.

Staff examined APP-GW-GEE-5331 with respect to the impacts of MSHIM operation on AFD uncertainties and the generation of the associated Overpower ΔT and Overtemperature ΔT AFD penalty functions. In particular, the staff noted:

- AFD is the difference in thermal power between the top and bottom halves of a reactor core. Historically, AFD has been determined by the Core Average Axial Flux Difference (CAAFD), which is a representation of the difference between the average thermal power in the top and bottom halves of the reactor core. Excore detector measurements are calibrated to average thermal power in the top and bottom halves of the reactor core to determine the CAAFD. [
  ].
- The AP1000 AFD is determined by Weighted Peripheral Axial Flux Difference (WPAFD), which is a representation of the difference between the thermal power in the top and

bottom halves of the nearest peripheral fuel assemblies. Excore detector measurements are calibrated to weighted thermal power in the top and bottom halves of the peripheral fuel assemblies to determine the WPAFD.

- Since the excore detectors are primarily exposed to neutrons leaking out of the core from the nearest peripheral fuel assemblies, the excore indicated power and AFD closely track the weighted peripheral assembly power and AFD values.
- [
  ].
- [
  ].

Axial Flux Difference Penalty Functions

Staff examined CN-AP1000-SA-087 Revision 5, "Revised 3D FAC Analysis for the AP1000 Pressurized Water Reactor Cycle 1." During this examination staff noted the purpose of the calculation, important input into the analysis, and the main results. In particular, staff noted:

- The purpose of this analysis is to document the Condition II 3D FAC analysis.
- The calculation examines [:
  -
  -
  -
  -
  -
  -
  -]
- The calculations in this analysis are performed [
  ]. Additionally, [ ].
- Core Power Distribution Calculations (PDC) [
  ].
- A large spectrum of core states is analyzed [
  ].
- AFD [
  ].
- [
  ]
- The analysis resulted in the revised AFD penalties provided below:

Overtemperature ΔT AFD Penalty Function

WPAFD	Trip Setpoint Reduction (percent rated thermal power (RTP))
[ ]	[ ]
[ ]	[ ]
[ ]	[ ]
[ ]	[ ]

Overpower ΔT AFD Penalty Function [ ]

WPAFD	Trip Setpoint Reduction (RTP)
[ ]	[ ]
[ ]	[ ]
[ ]	[ ]
[ ]	[ ]

Overpower ΔT AFD Penalty Function [ ]

WPAFD	Trip Setpoint Reduction (RTP)
[ ]	[ ]
[ ]	[ ]
[ ]	[ ]
[ ]	[ ]

Setpoint Uncertainty

Staff examined APP-PMS-M3C-117, "Power Range Neutron Flux Reactor Trip Setpoint and High Positive Rate Uncertainty Calculations for the AP1000 Plant." During this examination staff noted the purpose of the calculation, important input into the analysis, and the main results. In particular, staff noted:

- The purpose of the calculation note is to document instrumentation uncertainty for the excore Power Range Neutron Flux-High, Power Range Neutron Flux-Low, and High Positive Rate reactor trip setpoints for the PMS.

- The Process Measurement Accuracy is updated in the setpoint calculation to be [ ].

- The Process Measurement Accuracy Mismatch Allowance is calculated to be [ ].

- The Process Measurement Accuracy Mismatch Allowance is only applicable to the [ ].

- Reactor Trip Setpoints (RTS)
  - Safety Analysis Limit – High Neutron Flux (high setting) [ ]
  - Nominal Trip Setpoint – High Neutron Flux (high setting) [ ]
  - Safety Analysis Limit – High Neutron Flux (low setting) [ ]
  - Nominal Trip Setpoint – High Neutron Flux (low setting) [ ]
  - Safety Analysis Limit – High Positive Rate RTS [ ]
  - Nominal Trip Setpoint – High Positive Rate RTS [ ]

- The calculation concluded that:
  - The Power Range Neutron Flux – High setpoint is acceptable because (1) it has no safety analysis limit, and (2) the setpoint plus uncertainties does not exceed the top of the range of the calibration span.
  - The Power Range Neutron Flux – Low setpoint is acceptable because it provides margin to the safety analysis limit.
  - The High Positive Rate setpoint is acceptable because it provide margin to the safety analysis limit.

Staff examined APP-PMS-M3C-124, "Overpower ΔT and Overtemperature ΔT Reactor Trip Setpoint Uncertainty Calculations for the AP1000 Plant." During this examination staff noted the purpose of the calculation, important input into the analysis, and the main results. In particular, staff noted:

- The purpose of this calculation is to document instrumentation uncertainty calculations for the Overpower ΔT and Overtemperature ΔT setpoints for the PMS.
- The threshold to adjustment to ΔT° conversion factor is required if the absolute difference between the calculated qΔT and the calorimetric power measurement is greater than 3 percent RTP is incorporated into the Power Mistmatch Allowance in the setpoint calculation consistent with the proposed Technical Specification (TS) SR 3.3.1.3.
- The allowance for the difference between the incore system and the excore power range nuclear instrument channel WPAFD of 1.5 percent is incorporated into the ΔI - Incore/Excore AFD Mismatch Allowance in the setpoint calculation consistent with the proposed TS SR 3.3.1.4.
- The Overpower ΔT total allowance, [

  ].
- The Overpower ΔT total allowance for a steamline break, [

  ].
  - Harsh environment conditions (steamline break) have additional uncertainties of [

    ].
  - [

    ].
- The Overtemperature ΔT total allowance is [ ] below the calculated safety analysis limit.

Transient and Accident Analyses

Document APP-SSAR-GSC-137, Rev. 2 was examined by the staff and is related to the Rod

Cluster Control Assembly (RCCA) Bank Withdrawal at Power safety analysis. During this examination, the staff noted the trips credited in the analyses and results. In particular, the staff noted:

- The High Neutron Flux trip is not credited in the analysis.
- The trips credited in the analyses are the Overtemperature ΔT, Overpower ΔT and the High Positive Flux Rate reactor trips. The analysis models a Positive Flux Rate trip setpoint of 15 percent with a rate time constant of 60 seconds and the Overpower ΔT trip setpoint of 115 percent RTP.
    - Fast reactivity insertion rate – High Positive Flux rate Trip Credited
    - Intermediate reactivity insertion rate – Overpower ΔT Trip Credited
    - Slow reactivity insertion rate – Overtemperature ΔT Trip Credited
- The Overtemperature ΔT, Overpower ΔT, and Positive Flux Rate reactor trips provide adequate core protection over the entire range of possible reactivity insertion rates. The Departure from Nucleate Boiling (DNB) and overpower design bases are met for all cases.
- Appendix C provides an analysis of Inoperable Main Steam Safety Valves (MSSVs). Staff noted:
    - The analysis confirms that secondary side pressures remain below the analysis limit for cases analyzed with the digital Overpower ΔT setpoint reduced to the Maximum Allowable Power specified in TS 3.7.1-1.
    - The analyses are performed using LOFTRAN.
    - The analyses [ ].
    - The analyses [ ].
    - Analyses are performed at [ ].
    - Justification for the MSSV modeling in LOFTRAN is provided in Appendix E of the calculation.
    - The results of the analyses show that the peak secondary side pressure remains below 110 percent design pressure for all cases.

Documents CN-AP1000-3DRE-013, Rev. 0, CN-AP1000-3DRE-014, Rev. 0, CN-AP1000-3DRE-016, Rev. 0 and CN-AP1000-3DRE-017, Rev. 0 were examined by the staff and are related to the rod ejection safety analysis. During this examination, the staff noted the trips credited in the analyses and results. In particular, the staff noted:

- The rod ejection analyses are tripped at [ ].
- Peak nuclear power occurs before the trip time of [ ].
- The time of reactor trip on high neutron flux (high setting) is conservative relative to the high positive neutron flux rate reactor trip for all cases. The existing RCCA ejection analysis successfully demonstrates that the high neutron flux (high setting) trip function provides the necessary protection, therefore the high positive neutron flux rate trip function will also provide the necessary protection.

Document CN-AP1000-SA-029, Rev. 2 was examined by the staff and are related to the hot full power steamline break safety analysis. During this examination, the staff noted the trips credited in the analyses, trip setpoint and results. In particular, the staff noted:

- The analysis is performed for the hot full power steamline break for the AP1000 first cycle

core design.

- The hot full power steamline break accident analysis incorporates increased uncertainty in the application of the Overpower ΔT trip setpoint when the f(ΔI) penalty function is credited in conjunction with adverse (i.e., high temperature) containment environment conditions.
- The analysis is applicable for the AP1000 plant first cycle core design using the MSHIM operation and Control Strategy.
- The Overpower ΔT trip setpoint is [
  ].
- Margin to the peak linear heat rate limit associated with fuel centerline melt was confirmed.
  - The most limiting PLHR result of [
    ].
- The limiting DNBR results from remain bounding.

H. Exit Briefing

The staff's audit exit briefing was conducted on the morning of August 17, 2018. The vendor and staff discussed the staff's findings from the audit, and the staff indicated the necessary information within the scope of the audit was provided to assist the staff in their review.

I. Requests for Additional Information (RAI) Resulting from Audit

No RAIs were asked as a result of this audit.

J. Open Items and Proposed Closure Paths

No open items were identified as a result of the audit.

K. Deviations from the Audit Plan

No deviations from the audit plan were identified or required.

L. References

1. Request for License Amendment 17-031: Effect of Rod Shadowing on Excore Power Range Detectors, Changes to Nuclear Overpower Reactor Trips, and Changes to Monitoring of Moderator Temperature Coefficient and Core Power Distribution, dated September 8, 2017 (ADAMS Accession Number ML17251A458).

2. Vogtle Electric Generating Plant Units 3 and 4, Updated Final Safety Analysis Report, Revision 6 and Tier 1, Revision 5, dated June 15, 2017 (ADAMS Accession Number ML17172A218).

3. Combined License NPF-91 for Vogtle Electric Generating Plant Unit 3, Southern Nuclear Operating Company (ADAMS Accession Number ML14100A106).

4. Combined License NPF-91 for Vogtle Electric Generating Plant Unit 4, Southern Nuclear Operating Company (ADAMS Accession Number ML14100A135).

5. NRO-REG-108, "Regulatory Audits," dated April 2, 2009 (ADAMS Accession Number ML081910260).

6. APP-GW-GEE-1551, Rev. 0, “Rod Shadowing on Excore Detectors,” dated November 1, 2010.

7. APP-GW-GEE-5331, Rev. 0, “OTDT and OPDT Reactor Trip Setpoint Margin Recovery,” dated July 29, 2016.

8. CN-AP1000-SA-087, Rev. 5, “Revised 3D FAC Analysis for the AP1000 Pressurized Water Reactor Cycle 1.”

9. APP-PMS-M3C-117, Rev. 1, “Power Range Neutron Flux Reactor Trip Setpoint and High Positive Rate Uncertainty Calculations for the AP1000 Plant.”

10. APP-PMS-M3C-124, Rev. 1, “Overpower ΔT and Overtemperature ΔT Reactor Trip Setpoint Uncertainty Calculations for the AP1000 Plant.”

11. APP-PMS-M3C-135, Rev. 1, “Insulation Resistance Degradation Uncertainties for the Domestic AP1000 Plants.”

12. APP-SSAR-GEF-065, Rev. 0, “Revising AP1000 Safety Analysis Checklist (SAC) for OPDT and OTDT FdI.”

13. APP-SSAR-GSC-137, Rev. 2, “AP1000 - Advanced First Core Rod Cluster Control Assembly (RCCA) Bank Withdrawal at Power.”

14. CN-AP1000-3DRE-013, Rev. 0, “AP1000 3D Rod Ejection HZP Enthalpy Analyses with ANC 9.4.0.”

15. CN-AP1000-3DRE-014, Rev. 0, “AP1000 3D Rod Ejection DNBR Analyses for the Core Reference Report and FSAR.”

16. CN-AP1000-3DRE-016, Rev. 0, “AP1000 3D Rod Ejection HFP Enthalpy Analyses with ANC 9.4.0.”

17. CN-AP1000-3DRE-017, Rev. 0, “Assessment of Revised Rod Drop Time on RIA Inputs to the AP1000 PWR Core Reference Report.”

18. CN-AP1000-SA-029, Rev. 2, “AP1000 Cycle 1 HFP SLB for Chapter 15 Analysis.”