TENNESSEE VALLEY AUTHORITY

Post Office Box 2000, Decatur, Alabama 35609-2000

July 19, 2023

10 CFR 50.73
10 CFR 50.4(a)

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

Browns Ferry Nuclear Plant, Unit 1
Renewed Facility Operating License No. DPR-33
NRC Docket No. 50-259

Subject: **Licensee Event Report 50-259/2023-002-00 – Full Reactor Scram due to an Oscillation Power Range Monitor (OPRM) Confirmation Density Algorithm (CDA) Trip**

The enclosed Licensee Event Report provides the details of the full reactor scram from 80% power due to an Oscillation Power Range Monitor (OPRM) Confirmation Density Algorithm (CDA) trip . The Tennessee Valley Authority is submitting this report in accordance with Title 10 of the Code of Federal Regulations (10 CFR) 50.73(a)(2)(iv)(A), as any event or condition that resulted in a manual or automatic actuation of any of the systems listed in paragraph (a)(2)(iv)(B).

There are no new regulatory commitments contained in this letter. Should you have any questions concerning this submittal, please contact Michael W. Oliver, Acting Site Licensing Manager, at (256) 729-7874.

Respectfully,

Manu Sivaraman
BFN Site Vice President

Enclosure: Licensee Event Report 50-259/2023-002-00 – Full Reactor Scram due to an Oscillation Power Range Monitor (OPRM) Confirmation Density Algorithm (CDA) Trip cc (w/ Enclosure):

NRC Regional Administrator - Region II
NRC Senior Resident Inspector - Browns Ferry Nuclear Plant
NRC Project Manager - Browns Ferry Nuclear Plant

U.S. NUCLEAR REGULATORY COMMISSION

LICENSEE EVENT REPORT (LER)

(See Page 2 for required number of digits/characters for each block)
(See NUREG-1022, R.3 for instruction and guidance for completing this form http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1022/r3/)

1. Facility Name	2. Docket Number	3. Page
Browns Ferry Nuclear Plant, Unit 1	05000259	1 OF 7

4. Title
Full Reactor Scram due to an Oscillation Power Range Monitor Confirmation Density Algorithm Trip

5. Event Date			6. LER Number			7. Report Date			8. Other Facilities Involved	
Month	Day	Year	Year	Sequential Number	Revision No.	Month	Day	Year	Facility Name	Docket Number
05	20	2023	2023	- 002 -	00	07	19	2023	N/A	05000 N/A
									N/A	05000 N/A

9. Operating Mode	10. Power Level
1	080

11. This Report is Submitted Pursuant to the Requirements of 10 CFR §: (Check all that apply)

10 CFR Part 20		10 CFR Part 50		
☐ 20.2201(b)	☐ 20.2203(a)(2)(vi)	☐ 50.36(c)(1)(i)(A)	☐ 50.73(a)(2)(ii)(A)	☐ 50.73(a)(2)(viii)(A)
☐ 20.2201(d)	☐ 20.2203(a)(3)(i)	☐ 50.36(c)(1)(ii)(A)	☐ 50.73(a)(2)(ii)(B)	☐ 50.73(a)(2)(viii)(B)
☐ 20.2203(a)(1)	☐ 20.2203(a)(3)(ii)	☐ 50.36(c)(2)	☐ 50.73(a)(2)(iii)	☐ 50.73(a)(2)(ix)(A)
☐ 20.2203(a)(2)(i)	☐ 20.2203(a)(4)	☐ 50.46(a)(3)(ii)	☒ 50.73(a)(2)(iv)(A)	☐ 50.73(a)(2)(x)
☐ 20.2203(a)(2)(ii)	**10 CFR Part 21**	☐ 50.69(g)	☐ 50.73(a)(2)(v)(A)	**10 CFR Part 73**
☐ 20.2203(a)(2)(iii)	☐ 21.2(c)	☐ 50.73(a)(2)(i)(A)	☐ 50.73(a)(2)(v)(B)	☐ 73.77(a)(1)
☐ 20.2203(a)(2)(iv)		☐ 50.73(a)(2)(i)(B)	☐ 50.73(a)(2)(v)(C)	☐ 73.77(a)(2)(i)
☐ 20.2203(a)(2)(v)		☐ 50.73(a)(2)(i)(C)	☐ 50.73(a)(2)(v)(D)	☐ 73.77(a)(2)(ii)
			☐ 50.73(a)(2)(vii)	

☐ **OTHER** (Specify here, in abstract, or NRC 366A).

12. Licensee Contact for this LER

Licensee Contact	Phone Number (Include area code)
Justin K. Garner, Licensing Engineer	256-729-7955

13. Complete One Line for each Component Failure Described in this Report

Cause	System	Component	Manufacturer	Reportable to IRIS	Cause	System	Component	Manufacturer	Reportable to IRIS
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

14. Supplemental Report Expected)		15. Expected Submission Date	Month	Day	Year
☒ No	☐ Yes (If yes, complete 15. Expected Submission Date		N/A	N/A	N/A

16. Abstract (Limit to 1560 spaces, i.e., approximately 15 single-spaced typewritten lines)

On May 20, 2023, at 0315 Central Daylight Time (CDT), while performing quarterly turbine control valve (TCV) testing at 80 percent reactor thermal power (RTP) and 70 percent core flow, Unit 1 automatically scrammed due to an Oscillation Power Range Monitor (OPRM) Confirmation Density Algorithm (CDA) trip. The plant responded to the reactor scram as expected and there were no human performance challenges during the turbine control valve testing or subsequent plant shutdown.

The root cause of the event was determined to be that the sensitivity of the CDA trip during off-normal plant conditions was not embedded into processes or procedures, thus preventing development of appropriate risk elimination or mitigation actions.

The Corrective Actions to Prevent Recurrence are to revise Surveillance Requirements for the Turbine Control Valve Fast Closure on Turbine Trip and RPT Initiate Logic to specify the appropriate power level and associated valve position for performing the test to ensure no control valve oscillations and that conditions remain outside of the OPRM trip enabled region when possible; revise Technical Instructions for the Reactivity Control Plan Development and Implementation to increase awareness of entry into the OPRM trip enabled region due to the risk of spurious scrams from the CDA instability detection method; revise Design Criteria for the Turbine Electro Hydraulic Control System (EHC) systems to add details with regards to the interrelationship between EHC and OPRM; and revise Design Criteria for Neutron Monitoring Systems to add details on OPRM Algorithms.

1. FACILITY NAME		2. DOCKET NUMBER	3. LER NUMBER		
			YEAR	SEQUENTIAL NUMBER	REV NO.
Browns Ferry Nuclear Plant, Unit 1	☒ 050 ☐ 052	00259	2023	- 002	- 00

NARRATIVE

I. Plant Operating Conditions before the Event

At the time of discovery, Browns Ferry Nuclear Plant (BFN) Unit 1 was in Mode 1 at approximately 80 percent power.

II. Description of Event

A. Event Summary

On May 20, 2023, at 0315 Central Daylight Time (CDT), while performing quarterly turbine control valve (TCV) testing at 80 percent Reactor Thermal Power (RTP) and 70 percent core flow, Unit 1 automatically scrammed due to an Oscillating Power Range Monitor (OPRM) Confirmation Density Algorithm (CDA) trip. The plant responded to the reactor scram as expected and there were no human performance challenges during the TCV testing or subsequent plant shutdown.

The Tennessee Valley Authority (TVA) is submitting this report in accordance with Title 10 of the Code of Federal Regulations (10 CFR) 50.73(a)(2)(iv)(A), as any event or condition that resulted in a manual or automatic actuation of any of the systems listed in paragraph (a)(2)(iv)(B), including: the reactor protection system (RPS) [EIIS: JC] which includes a reactor scram or a reactor trip, and general containment isolation signals affecting containment isolation valves in more than one system.

B. Status of structures, components, or systems that were inoperable at the start of the event and that contributed to the event

There were no structures, systems, or components (SSCs) whose inoperability contributed to this event.

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C. Dates and approximate times of occurrences

Dates and Approximate Times	Occurrence
October 2018	Implementation of Confirmation Density Algorithm (CDA) Option 3. CDA initiated and inhibited during Unit 1 Refueling Outage 12 (U1R12) [Engineering Change Package (ECP) 72409]
Approximately June 2020	Initiated ECP for TCVs and Turbine Stop Valves (TSV) linear variable differential transformers (LVDTs). ECP issued. (ECP BFN-20-1688)
October 2020	CDA was enabled during 1R13 (ECP BFN-20-1688, Stages 28-31)
October 2022	Implemented ECP for U1 during U1R14 to install redundant LVDTs to the U1 stop valves and control valves (ECP BFN-20-1688, Stage 1)
February – March 2023	ECP BFN-20-1688, Stage 2, revised to address concerns with installing redundant LVDT on the U2 stop valves and control valves. (ECP BFN-20-1688, Stage 2)
March 2023	ECP BFN-20-1688, Stage 2, implemented for installing redundant LVDTs during U2R22 (ECP BFN-20-1688, Stage 2)
May 20, 2023, at 0315	Unit 1 Reactor Scram due to an OPRM CDA trip

D. Manufacturer and model number of each component that failed during the event

No components failed during this event.

E. Other systems or secondary functions affected

No other systems or secondary functions were affected.

F. Method of discovery of each component or system failure or procedural error

On May 20, 2023, at 0315, while performing quarterly turbine control valve surveillance testing, the Unit 1 RPS received an OPRM CDA trip resulting in an automatic scram.

NARRATIVE

G. The failure mode, mechanism, and effect of each failed component

No components failed during this event.

H. Operator actions

There were no operator actions associated with this event.

I. Automatically and manually initiated safety system responses

The Unit 1 RPS received an OPRM CDA trip resulting in an automatic scram. The plant responded to the reactor scram as expected, and there were no human performance challenges during the TCV testing or subsequent plant shutdown.

III. Cause of the event

The BFN Unit 1 OPRM SCRAM occurred as a result of the sensitivity of the CDA trip during off-normal plant conditions not being embedded into TVA processes or procedures, thus preventing development of appropriate risk elimination or mitigation actions.

IV. Analysis of the event

During 1R14 (October 2022), redundant ‘B’ LVDTs were installed on all TCVs via ECP BFN-20-1688-01. The redundant LVDTs were a different manufacturer and style than the original (Alliance versus GE Kavlico) but performed the same function. Internal manufacturer wiring errors in the LVDTs caused discrepancies in indicated valve position. During the quarterly TCV test, these deviations caused the three TCVs that remained open to operate in an unstable region of the valve curve and resulted in control system instabilities that manifested as TCV oscillations. These oscillations resulted in reactor pressure swings, which in turn, caused reactor power fluctuations. The OPRM CDA detected these power oscillations and tripped the reactor.

ECP BFN-20-1688-04 was installed to re-configure the redundant LVDTs to a three-wire configuration during the Unit 1 Forced Outage (F110) to match the original LVDTs [Interim Action (INTR) 1857715-003]. This resolved issues with position indication discrepancies between the two different styles of LVDTs despite internal wiring errors and restored the sensed position to the tuned condition. Additionally, 1-SR-3.3.1.1.8(9), Turbine Control Valve Fast Closure or Turbine Trip and RPT Initiate Logic, was revised to change the maximum power level to perform testing from 84 percent to 72 percent to ensure no TCV oscillations would occur during testing [INTR / Procedure Change Request (PCR) 1857840-001].

The OPRM system has four (4) channels, each channel consisting of 33 core cells for monitoring

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core thermal-hydraulic instabilities. Thermal-hydraulic core instabilities can exist during periods of high power with low core flow. OPRMs provide indications and alarms at low levels of thermal-hydraulic instabilities and an automatic reactor scram function trip at higher levels of thermal-hydraulic instability.

Oscillations are detected using any one of four algorithms, Confirmation Density Algorithm (CDA), Period-Based Algorithm (PBA), Growth-Rate Based Algorithm (GRBA), and Amplitude-Based Algorithm (ABA). The CDA trip is the licensed algorithm for Detect and Suppress Solution – Confirmation Density (DSS-CD). The CDA is designed to detect oscillations when they begin and generate a trip signal earlier than the other algorithms. The OPRM CDA trip is enabled when reactor power is >23 percent RTP and recirc flow is <75 percent of rated flow (Unit 1<90 percent).

The CDA Amplitude Discriminator Setpoint of 1.10 is just above noise level. The system prevents invalid scrams by requiring five (5) cells to confirm the oscillation. A true oscillation will affect many cells. CDA counts oscillations with a period of 1.2 to 4 seconds and looks for a value exceeding the setpoint of 1.10. The OPRM output for a reactor scram requires two CDA trips or two Defense in Depth Algorithm (DIDA) trips. PBA, GRBA, and ABA are grouped together as DIDAs, and provide a backup to CDA, but are not required by Technical Specifications.

Following the Unit 1 scram on May 20, 2023, an evaluation for thermal hydraulic stability was conducted by GEH. GEH stated the OPRM trip was not due to a Thermal Hydraulic Instability (THI) event but from TCV oscillations that fell within the frequency range of the CDA algorithm for the OPRM trip signal. The results revealed that the plant was inherently stable from a thermal hydraulic instability perspective. The CDA trip of the Unit 1 OPRM system was initiated by power changes driven by control valve oscillations experienced during the performance of 1-SR-3.3.1.1.8(9), Turbine Control Valve Fast Closure or Turbine Trip and RPT Initiate Logic (DC).

V. Assessment of Safety Consequences

Defense-in-depth to Nuclear Safety was not compromised by this event. The RPS system worked as designed to automatically shut down the reactor once the CDA trip setpoint was exceeded on the OPRMs. No loss of safety function occurred, nor were there any equipment failures as a result of the event.

This event did not reduce Defense-in-Depth to Industrial, Radiological, or Environmental safety. There were no new radioactive effluent pathways, nor were any new Radiation, Airborne, or Contamination Areas created. There was no release, nor potential to release, unmonitored gasses or liquids to the environment in excess of established limits of reportability.

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VI. Corrective Actions

Corrective Actions are being managed by the TVA's corrective action program under Condition Report (CR) 1857715.

A. Immediate Corrective Actions

The Immediate Corrective Actions for this event were:

- A three-wire modification (ECP BFN-20-1688-04) was implemented during F110 to resolve issues with position indication discrepancies between the two different style LVDTs.
- The TCV LVDTs were calibrated during hot conditions during F110 to ensure accuracy.
- 1-SR-3.3.1.1.8(9), Turbine Control Valve Fast Closure or Turbine Trip and RPT Initiate Logic, was revised to change the maximum power level to perform testing from 84 percent to 72 percent to ensure no TCV oscillations would occur during testing.
- Extent of condition actions were taken to determine the appropriate power level to perform control valve testing for Unit 2 on June 3, 2023. The U3 LVDT mod is scheduled for March 2024.

B. Corrective Actions to Prevent Recurrence or to reduce the probability of similar events occurring in the future

Six (6) Corrective Actions to Prevent Recurrence were generated for this event:

- Revise 1-SR-3.3.1.1.8(9), Turbine Control Valve Fast Closure or Turbine Trip and RPT Initiate Logic, to specify the appropriate power level and associated valve position for performing the test to ensure no control valve oscillations [based on Engineering Work Request (EWR) completed in CR action 1857715-013] and outside of the OPRM trip enabled region if required.
- Revise 2-SR-3.3.1.1.8(9), Turbine Control Valve Fast Closure or Turbine Trip and RPT Initiate Logic, to specify the appropriate power level and associated valve position for performing the test to ensure no control valve oscillations (based on EWR completed in action 1857715-013) and outside of the OPRM trip enabled region if required.
- Revise 3-SR-3.3.1.1.8(9), Turbine Control Valve Fast Closure or Turbine Trip and RPT Initiate Logic, to specify the appropriate power level and associated valve position for performing the test to ensure no control valve oscillations (based on EWR completed in action 1857715-013) and outside of the OPRM trip enabled region if required.
- Revise 0-TI-464, Reactivity Control Plan Development and Implementation, to increase awareness of entry into the OPRM trip enabled region due to the risk of spurious scrams from the CDA instability detection method.
- Revise Design Criteria BFN-50-7047 – Turbine Elecrto Hydraulic Control System (EHC) systems to add details with regards to interrelationship between EHC and

NARRATIVE

OPRM. Details should include a precaution that incorporates changes to the turbine control EHC system (including testing methodologies) could cause periodic perturbations. These periodic perturbations can be introduced into the thermal-hydraulic behavior of the reactor system (e.g., from control system feedback, System gains including controller settings and mechanical components like the diode function generator or valve flow position, deviation of process monitoring such as pressure or signals between two LVDTs). These changes can impact delay or combined control and mechanical gains to create perturbations that can potentially drive prolonged neutron flux oscillations within a frequency range expected for reactor instability. The presence of these oscillations is recognized by the CDA as reactor instability, independent of the actual stability of the reactor.

- Revise Design Criteria BFN-50-7092 - Neutron Monitoring Systems to add details on OPRM Algorithms. Details should include different types of OPRM Trip Algorithms: a) CDA, b) PBA, c) GRBA, and d) ABA and an explanation about each. It should also include guidance on the sensitivities of CDA trip, GEH information about susceptibility to spurious scrams, and discussion about changes to Turbine Control EHC can impact OPRM Trip Algorithms.

VII. Previous Similar Events at the Same Site

The BFN Unit 1 OPRM scram is not considered to be a Repeat Event or Operating Experience (OE) Preventable. The CDA trip was added to the OPRM system with the implementation of Maximum Extended Load Line Limit Analysis Plus (MELLLA+) in 2018. Since its implementation, this is the first time BFN has received the OPRM CDA trip, which resulted in an automatic reactor scram. A search of LERs from BFN Units 1, 2, and 3 over the last five years identified no similar events.

A review of OE and IRIS reports associated with MELLLA+, CDA, EHC Systems, and LVDTs did not identify any that would have prevented or mitigated the event, as the CDA trip is relatively new to the industry with no known previous SCRAMs.

All plants in the industry that have implemented MELLLA+ (and therefore CDA logic) were benchmarked and determined that none have restrictions on performing either TCV or Scram Time Testing inside the OPRM trip enabled region.

VIII. Additional Information

There is no additional information.

IX. Commitments

There are no new commitments.