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Jeremy G. Browning
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2CAN061405

June 26, 2014

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

Subject: Licensee Event Report 50-368/2014-003-00
Arkansas Nuclear One, Unit 2
Docket No. 50-368
License No. NPF-6

Dear Sir or Madam:

Pursuant to the reporting requirements of 10 CFR 50.73, attached is the subject Licensee Event Report concerning Axial Shape Index Trip at the End-of-Life During Rapid Plant Shutdown.

There are no new commitments contained in this submittal.

Should you have any questions concerning this issue, please contact Stephenie Pyle, Manager, Regulatory Assurance, at 479-858-4704.

Sincerely,

ORIGINAL SIGNED BY TERRY EVANS FOR JEREMY BROWNING

JGB/rwc

Attachment: Licensee Event Report 50-368/2014-003-00

cc: Mr. Marc L. Dapas
Regional Administrator
U. S. Nuclear Regulatory Commission
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Arlington, TX 76011-4511

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NRC FORM 366 (02-2014)	U.S. NUCLEAR REGULATORY COMMISSION	APPROVED BY OMB: NO. 3150-0104 EXPIRES: 01/31/2017

LICENSEE EVENT REPORT (LER)

(See reverse for required number of digits/characters for each block)

1. FACILITY NAME	2. DOCKET NUMBER	3. PAGE
Arkansas Nuclear One – Unit 2	05000368	1 OF 5

4. TITLE

Axial Shape Index Trip at the End-of-Life During Rapid Plant Shutdown

5. EVENT DATE			6. LER NUMBER			7. REPORT DATE			8. OTHER FACILITIES INVOLVED	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REV NO.	MONTH	DAY	YEAR	FACILITY NAME	DOCKET NUMBER
4	27	2014	2014	003	00	06	26	2014	FACILITY NAME	DOCKET NUMBER

9. OPERATING MODE: 1

10. POWER LEVEL: 95%

11. THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: *(Check all that apply)*

☐ 20.2201(b)	☐ 20.2203(a)(3)(i)	☐ 50.73(a)(2)(i)(C)	☐ 50.73(a)(2)(vii)
☐ 20.2201(d)	☐ 20.2203(a)(3)(ii)	☐ 50.73(a)(2)(ii)(A)	☐ 50.73(a)(2)(viii)(A)
☐ 20.2203(a)(1)	☐ 20.2203(a)(4)	☐ 50.73(a)(2)(ii)(B)	☐ 50.73(a)(2)(viii)(B)
☐ 20.2203(a)(2)(i)	☐ 50.36(c)(1)(i)(A)	☐ 50.73(a)(2)(iii)	☐ 50.73(a)(2)(ix)(A)
☐ 20.2203(a)(2)(ii)	☐ 50.36(c)(1)(ii)(A)	☒ 50.73(a)(2)(iv)(A)	☐ 50.73(a)(2)(x)
☐ 20.2203(a)(2)(iii)	☐ 50.36(c)(2)	☐ 50.73(a)(2)(v)(A)	☐ 73.71(a)(4)
☐ 20.2203(a)(2)(iv)	☐ 50.46(a)(3)(ii)	☐ 50.73(a)(2)(v)(B)	☐ 73.71(a)(5)
☐ 20.2203(a)(2)(v)	☐ 50.73(a)(2)(i)(A)	☐ 50.73(a)(2)(v)(C)	☐ OTHER
☐ 20.2203(a)(2)(vi)	☐ 50.73(a)(2)(i)(B)	☐ 50.73(a)(2)(v)(D)	Specify in Abstract below or in NRC Form 366A

12. LICENSEE CONTACT FOR THIS LER

FACILITY NAME	TELEPHONE NUMBER *(Include Area Code)*
Stephenie L. Pyle, Manager, Regulatory Assurance	479-858-4704

13. COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT

CAUSE	SYSTEM	COMPONENT	MANU-FACTURER	REPORTABLE TO EPIX	CAUSE	SYSTEM	COMPONENT	MANU-FACTURER	REPORTABLE TO EPIX

14. SUPPLEMENTAL REPORT EXPECTED	15. EXPECTED SUBMISSION DATE	MONTH	DAY	YEAR
☐ YES *(If yes, complete 15. EXPECTED SUBMISSION DATE)* ☒ NO				

ABSTRACT *(Limit to 1400 spaces, i.e., approximately 15 single-spaced typewritten lines)*

During severe weather on April 27, 2014, both units at Arkansas Nuclear One (ANO) were informed of a system-wide grid emergency and were ordered to come off-line as soon as possible. Both units commenced a rapid plant shutdown. ANO, Unit 2 (ANO-2) was at the end of the core life. During the shutdown, the Axial Shape Index (ASI) became more negative (power rising to the upper portion of the core) during the shutdown. This led to one channel of the Plant Protection System (PPS) to be actuated on an ASI auxiliary trip. At this time, the direction to manually trip the reactor was given, but before the action could be taken, an automatic reactor trip occurred due to the two-out-of-four PPS logic being made up for the ASI conditions.

The cause of this condition was not effectively executing the reactivity management plan by delaying insertion of Control Element Assemblies (CEAs) and not inserting CEAs deep enough to maintain ASI within the desired control band.

Training material is being modified to include details on the dynamic effects of ASI change that occurs at the end-of-cycle. Additionally, improvements to the guidance in the reactivity plans that involve rapid plant shutdowns are being made as are changes to the standards for use of CEAs during transients.

NARRATIVE

A. Plant Status

Arkansas Nuclear One, Unit 2 (ANO-2) was at the end of the core life and had commenced a reactor coast down approximately one week prior to this event. ANO-2 was operating at approximately 95% power. No structures, systems, or components were out-of-service at the time of this event that contributed to this event. The surrounding area was under a series of Severe Thunderstorm Warnings and Tornado Watches at the time.

B. Event Description

At approximately 1912 on April 27, 2014, a switchyard breaker opened due to a fault on one of the 500 kV lines. At approximately 1932, the System Operations Center (SOC) Dispatcher informed ANO of a system-wide grid emergency due to severe weather and ordered both ANO-1 and ANO-2 to come off-line as soon as possible. Both units commenced a rapid plant shutdown.

ANO-2 commenced an emergent power reduction at 1938, using the guidance from an approved one-hour shutdown contingency reactivity plan. Shutdown commenced with emergency boration. The initial CEA insertion occurred at 1952 with a small step (~ three inches). The reactivity plan included target CEA positions that reflected CEA insertions of 17 to 19 inches being necessary over 15 minute intervals to keep the Axial Shape Index (ASI) on the desired target. The Reactor Operator at the controls delayed subsequent CEA insertion due to observing that ASI monitored using the Core Operating Limits Supervisory System (COLSS)[ID], was tracking close to the target Equilibrium Shape Index (ESI) early in the maneuver.

During the shutdown, the operator performed manual turbine load reductions, CEA insertions, and was responsible for the boration. Multiple alarms were received throughout this event due to the continuous storm activity (lightning strikes on the grid). In addition, there were multiple phone calls from the SOC dispatcher concerning the state of the grid, the down-power, and related issues. These distractions were determined to be a contributing cause for the automatic reactor trip.

The above delay and smaller-sized CEA insertions than expected resulted in the normal ASI control band being exceeded at 1954. The Core Operating Limit Report (COLR) limit was exceeded at 2002. At 2010, as ASI continued to trend more negative (power was rising to the upper portion of the core), one channel of the Core Protection Calculators (CPC) [JC][DCC] tripped on hot pin ASI (an auxiliary trip). At this point, a manual reactor trip was directed; however, before this direction could be performed, an automatic reactor trip occurred due to the two-out-of-four Plant Protection System (PPS) logic being made-up when the same ASI auxiliary trip actuated on a redundant CPC channel.

COLSS remained operable throughout this event.

The trip occurred from approximately 46% power. All CEAs fully inserted into the core.

C. Background – System Design

The ANO-2 Technical Specifications (TS) define ASI as the power generated in the lower half of the core less the power generated in the upper half of the core divided by the sum of these powers. ANO-2 TS 3.2.7 is applicable when power is greater than 20% and requires that ASI be maintained within the limits listed in the COLR. If the limits are exceeded, ASI is to be restored to within its limits within two hours or power reduced to less than 20% within the next four hours. The ASI is to be determined to be within its limits using COLSS or any operable CPC channel. The COLSS and CPC systems are described in Section 7.2 of the ANO-2 Safety Analysis Report.

COLSS is a real-time computer program residing on the plant monitoring system computer. Like the CPCs, COLSS calculates Departure from Nucleate Boiling Ratio (DNBR), Linear Power Density (LPD) and ASI. COLSS develops the core power distribution based on incore detector signals and provides a more precise calculation of these three parameters compared to the CPCs, which develops core power distribution based on excore detector signals. COLSS is not required to be operable during any event. Monitoring equivalent to COLSS can be performed using CPCs; however, since the CPC calculations are less accurate, penalties on the operating limits are applied.

The CPC system is a subsystem of the Reactor Protection System (RPS). The CPCs initiate two of the trips (DNBR and LPD) provided by the RPS. DNBR and LPD pre-trip alarms are initiated to provide audible and visual indication of approach to a trip condition. The conditions which will cause a DNBR or LPD trip without initiating a pre-trip alarm are referred to as auxiliary trips. The DNBR algorithm used in the CPCs is valid only within the limits listed in the bases of ANO-2 TS 2.2.1. Operations outside these limits results in a CPC-initiated trip. The auxiliary trip for this event is the hot pin ASI out-of-range trip.

D. Event Cause

The reactivity management plan was not effectively executed due to lack of specific training on understanding the magnitude and rate of ASI shift that occurs at the end of a fuel cycle and the optimal approach to control ASI during the performance of a rapid plant shutdown at the end of core life. The approved reactivity plan that was being used during this event included target CEA positions that reflected CEA insertions of 17 to 19 inches being necessary to keep ASI on target between each of the provided 15-minute intervals. Reactivity plans are written to 15-minute intervals for timing the expected CEA insertions and boration rates needed to maintain ASI on target through the prescribed maneuver. The rate of CEA insertion needed was only evident in the numerical CEA position targets provided in the plan. There was no additional guidance on rate of insertion or size of insertion steps provided in the text of the plan. The operator delayed CEA insertion over the initial interval because it was noted that ASI was tracking closely with the target ESI early into the maneuver. This delay in CEA insertions was found to be a direct contributor to the challenges associated with maintaining ASI in the desired control band which ultimately led to the automatic reactor trip.

Due to the negative moderator temperature coefficient that exists at low boron concentrations, control of ASI in the ANO-2 core, is challenging during end-of-cycle maneuvers. The magnitude of the temperature-driven ASI shift requires aggressive insertion of CEAs during end-of-cycle power reductions. The delay in the insertion of the CEAs and the smaller rate of insertion than needed resulted in the TS limit being exceeded.

E. Corrective Actions

Training material is being modified to include details on the potential rate of ASI change that can occur at end-of-cycle. As part of these changes a discussion of the accuracy difference between COLSS and CPC ASI and how this can be significant with respect to trip margin and potential operation beyond TS ASI limits is being added.

Improvements to the guidance in ANO-2 reactivity plans that involve one-hour shutdown or control of ASI to non-ESI versus power targets are being made. The revised guidance will address the recommended increment of CEA change (three-inch, five-inch, etc.) and establish deviation of ASI on the positive side of target as being optimal.

Other off-normal conditions (e.g., loss of Main Feed Pump, loss of turbine load) that require an aggressive power maneuver to prevent an automatic reactor trip will be evaluated for additional corrective actions.

Additional enhancements to alarms are being considered.

F. Safety Significance Evaluation

COLSS and all four channels of CPCs were operable during this event. No safety limits were challenged or exceeded. Systems or components needed to safely shutdown the reactor, maintain safe shutdown conditions, remove residual heat, control the release of radioactive material, and mitigate the consequences of an accident were available.

G. Basis for Reportability

This event is reported pursuant to the following criteria:

10 CFR 50.73(a)(2)(iv)(A) – Any event or condition that resulted in manual or automatic actuation of any of the systems listed in paragraph (a)(2)(iv)(B) of this section

10 CFR 50.73(a)(2)(iv)(B) - The systems to which the requirements of paragraph (a)(2)(iv)(A) of this section apply are:

Reactor protection system (RPS) including: reactor scram or reactor trip.

H. Additional Information

10 CFR 50.73(b)(5) states that this report shall contain reference to “any previous similar events at the same plant that are known to the licensee.” NUREG-1022, Revision 3 reporting guidance states that term “previous occurrences” should include previous events or conditions that involved the same underlying concern or reason as this event, such as the same root cause, failure, or sequence of events.

A review of the ANO corrective action program and Licensee Event Reports for the previous three years was performed. There was a similar condition relative to the effects of ASI found in 2010 at ANO-2. The ASI TS limit was exceeded during a planned down power. The cause was identified to be an inaccurate reactivity management plan which contributed to the crew not being aggressive enough with ASI control.

Energy Industry Identification System (EIIS) codes and component codes are identified in the text of this report as [XX].