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10 CFR 50.73

ONS-2014-001

January 10, 2014

Attn: Document Control Desk
U. S. Nuclear Regulatory Commission
11555 Rockville Pike
Rockville, MD 20852-2746

Subject: Duke Energy Carolinas LLC (Duke Energy)
Oconee Nuclear Station (ONS) Unit 1
Docket No. 50-269
Licensee Event Report 269/2013-04, Revision 0
Problem Investigation Program No.: O-13-13168

Enclosed is Licensee Event Report 269/2013-04, Revision 0 for Oconee Nuclear Station, Unit 1. This report is being submitted in accordance with 10 CFR 50.73 (a)(2)(i)(A), completion of a nuclear plant shutdown required by Technical Specifications, 10 CFR 50.73 (a)(2)(i)(B), operation or condition prohibited by Technical Specifications, and 10 CFR 50.73 (a)(2)(ii)(A), degradation of a principal safety barrier.

There are no regulatory commitments contained in this report. Any questions regarding the content of this report should be directed to Sandra N. Severance, Regulatory Affairs, at (864) 873-3466.

Sincerely,

Scott L. Batson
Vice President
Oconee Nuclear Site

Enclosure

IE22
NRR

cc: Mr. Victor McCree
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NRC FORM 366 U.S. NUCLEAR REGULATORY COMMISSION
(10-2010)

LICENSEE EVENT REPORT (LER)

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

1. FACILITY NAME	2. DOCKET NUMBER	3. PAGE
Oconee Nuclear Station, Unit 1	05000269	1 OF 6

4. TITLE

High Cycle Fatigue Resulted in Reactor Coolant Leak and Unit 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
11	11	13	2013	- 04	- 0	01	10	14	FACILITY NAME	DOCKET NUMBER

9. OPERATING MODE

1

10. POWER LEVEL

100

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

NAME	TELEPHONE NUMBER (Include Area Code)
Sandra N. Severance	(864) 873-3466

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

CAUSE	SYSTEM	COMPONENT	MANU-FACTURER	REPORTABLE TO ICES	CAUSE	SYSTEM	COMPONENT	MANU-FACTURER	REPORTABLE TO EPIX
D	AB	PSP	X000	Yes					

14. SUPPLEMENTAL REPORT EXPECTED

☐ YES (If yes, complete EXPECTED SUBMISSION DATE) ☒ NO

15. EXPECTED SUBMISSION DATE

MONTH	DAY	YEAR

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

On November 8, 2013, the Oconee Unit 1 Control Room received an alarm associated with the containment atmosphere particulate radiation monitor. Reactor Coolant System (RCS) leakage of <0.1 gpm was identified. On November 11, 2013, upon verification of un-isolable reactor coolant system pressure boundary leakage on the 1B2 High Pressure Injection (HPI) Injection line, Oconee Unit 1 was shut down as required by Technical Specifications. The shutdown was orderly and without complication. The cause evaluation determined that mechanical, high-cycle fatigue resulted in a through wall crack in the stainless steel butt weld between the HPI nozzle safe end and HPI piping. Inadequate procedural guidance existed for the conduct of Augmented Examinations and appropriate disposition of Ultrasonic Testing (UT) examination results where conditions limited the weld volume that could be examined.

This event is reportable under 10 CFR 50.73(a)(2)(i)(A), as completion of a shutdown required by Technical Specifications, 10 CFR 50.73(a)(2)(i)(B), operation or condition prohibited by Technical Specifications, and 10 CFR 50.73(a)(2)(ii)(A), degradation of a principal safety barrier. High pressure injection capability was maintained, and containment integrity was not impacted.

EVALUATION:

BACKGROUND

At the time elevated Reactor Coolant System (RCS) [EIIS:AB] leakage was identified, Oconee Nuclear Station (ONS) Unit 1 was operating in Mode 1 at approximately 100 percent power. No significant structures, systems or components were out of service at the time of this event that contributed to this event. Unit 1 [EIIS:NH] experienced reactor coolant pressure boundary leakage in the High Pressure Injection (HPI) System [EIIS:BG] that required a plant shutdown. Technical Specification (TS) 3.4.13, RCS Operational Leakage, Required Actions B.1 and B.2 require that the unit be in Mode 3 within 12 hours and in Mode 5 within 36 hours of identification of pressure boundary leakage.

During normal operation, the HPI System controls the RCS inventory, provides the seal water for the Reactor Coolant Pumps (RCP) [EIIS:P], and recirculates RCS letdown for water quality maintenance and reactor coolant boric acid concentration control. The discharge of the HPI pumps connects to a nozzle on each of the four reactor inlet pipes downstream of the reactor coolant pumps. The reactor coolant which is letdown is normally returned to the RCS through two of these nozzles (1A1 and 1A2).

During emergency operation, the HPI System supplies borated water from the Borated Water Storage Tank (BWST) to the RCS and the RCP seals. Three parallel HPI pumps have the capability to take suction from the BWST and discharge through two redundant flow headers into the RCS, utilizing four injection lines (two per header). The stainless steel HPI injection lines terminate at injection nozzle [EIIS:NZL] assemblies located on each of the reactor inlet pipes downstream of the RCPs. Each nozzle assembly consists of a carbon steel nozzle (stainless steel clad on the inside), to which a stainless steel safe end is welded. The HPI piping is welded to the other end of the safe end. Inside the safe end is a stainless steel thermal sleeve, which extends into the main RCS flow path.

EVENT DESCRIPTION

On November 8, 2013, at approximately 1837 hours, while Oconee Unit 1 was operating at approximately 100% Full Power (FP), the Control Room received an alarm associated with the containment atmosphere particulate radiation monitor (i.e., RIA-47 [EIIS:IL]) used for RCS leakage detection. At 2324 hours, an RCS Leakage Calculation was performed and unidentified leakage of 0.020 gpm was noted, consistent with leakage calculation values obtained within the prior week. Reactor building particulate sample results indicated no detected activity, and the radiation monitor counts stabilized.

On November 9, 2013, at 0323 hours, another RIA-47 alarm was received. No immediate signs of RCS leakage were observed. At 0614 hours, a second RCS Leakage Calculation was performed, and unidentified leakage was found to be 0.088 gpm. This value exceeded the baseline mean by three standard deviations, indicating the leakage results were valid and action was warranted. Based on the leakage calculation results, increased activity on the radiation monitor, and an observable increase in reactor building normal sump rates, a reactor building entry was conducted to identify the leakage

source. Although the general location of the leak was identified, the source could not be determined. On November 10, 2013, at 1630 hours, a second reactor building entry was conducted and video images and robotically obtained leakage samples were evaluated. Absent conclusive evidence of the leak source, the Shift Manager initiated a power reduction to allow for a direct visual inspection.

A normal downpower to 20% was initiated on November 10, 2013, at 2141 hours. On November 11, 2013, at 0520 hours, the approximately 0.1 gpm leakage was visually determined to be un-isolable RCS pressure boundary leakage from the 1B2 HPI Injection Line. TS 3.4.13, RCS Operational Leakage, Conditions B.1 and B.2 were entered. At 0848 hours, an Emergency Notification System call to the NRC was made reporting the degraded condition and the TS required shutdown. On November 12, 2013, at 0244, Unit 1 entered Mode 5 and exited the TS Mode of Applicability. Upon confirmation that the unidentified leakage being investigated was RCS pressure boundary leakage, the pressure boundary leakage had existed for a time period greater than the Technical Specification allowed COMPLETION TIME.

CAUSAL FACTORS

A Failure Investigation Team was created to develop a repair plan, and a Root Cause team was created to investigate the causal factors for this event. Although the Root Cause Evaluation is still being finalized, two Root Causes for this event have been identified. If the final root cause conclusions result in substantive changes to the results presented below, Duke Energy will submit a supplement to this LER.

RC-1: The un-isolable reactor coolant system leak on the 1B2 HPI line was caused by mechanical, high-cycle fatigue which resulted in a through wall crack in the butt weld between the safe end and HPI piping.

The crack initiated at two separate locations at the weld root due to an unspecified high vibration event, likely associated with the 2008 1B2 reactor coolant pump seal failure. These cracks then merged into a single crack and continued to propagate through wall in the intervening years. Crack propagation is attributed to HPI Full Flow testing in subsequent refueling outages (i.e., for test purposes, flow is directed through a single header, rather than splitting into multiple headers) until normal reactor coolant system operating conditions grew the crack thru-wall. For each unit, HPI line vibration is greatest on the B2 line and is bounded by the 1B2 HPI line. The 1B2 HPI line is dedicated for emergency injection only, and it is generally stagnant during normal plant operation.

RC-2: Inadequate procedural guidance existed for the conduct of Augmented Examinations and appropriate disposition of Ultrasonic Testing (UT) examination results where conditions limited the weld volume that could be examined.

A UT limitation is defined as any obstruction or condition that limits the extent of angle beam scanning or limits the extent of required coverage using straight beam scanning. When adequate weld volumes could not be examined on the 1B2 HPI Nozzle safe end-to-pipe butt weld, no procedural guidance provided weld volume acceptance criteria or directed these limitations to be entered into the corrective action program for evaluation. During the root

cause investigation, metallurgical analysis documented that the crack propagated over several operating cycles. Historical Non-Destructive Examination (NDE) data revealed that the crack was visible in existing radiographs. Had the failed weld volume been adequately interrogated, the crack would have been identified before propagating through wall.

CORRECTIVE ACTIONS

Numerous actions were taken to investigate, determine extent of condition, and repair the HPI line. Those most relevant are included below.

Immediate:

1. Inspected 1B2 injection line pipe and pipe support configuration to verify conformance with design. The piping and supports were installed per design requirements and tolerances. There were no indications of damage or pipe rubbing due to vibration.

2. Performed Radiography Testing (RT) of 1B2 High Pressure Injection (HPI) nozzle and associated original Babcock & Wilcox 2-ply thermal sleeve assembly. RT images were compared to previous, historical RTs of the thermal sleeve and no visible cracks were found on the thermal sleeve. In addition, the position of the thermal sleeve and visible gaps within the expansion area remained unchanged.

3. Removed 1B2 injection line safe end-to-pipe butt weld and adjacent piping for metallurgical analysis. Metallurgical analysis identified high cycle mechanical fatigue (vibration) as the most likely failure mechanism.

4. Performed surface conditioning to achieve maximum coverage of weld volume to be inspected and Non-Destructive Examination (NDE) Evaluations on 1A1, 1A2, and 1B1 HPI nozzle safe end-to-piping stainless welds, including penetrant testing (PT), conventional UT, and phased array encoded UT. UT, PT, and phased array encoded UT results were acceptable for the 1A1, 1A2, and 1B1 HPI nozzle-to-safe end welds.

5. As part of an extent of condition review, performed surface conditioning to achieve maximum coverage of weld volume to be inspected and NDE Evaluations on 2A1, 2A2, 2B1, and 2B2 HPI nozzle safe end-to-piping stainless welds, including PT, conventional UT, and phased array encoded UT during the scheduled refueling outage. UT, PT, and phased array encoded UT results were acceptable for each of the Unit 2 HPI nozzle-to-safe end welds.

6. Performed dimensional checks of Unit 1 and Unit 2 HPI nozzle safe end and stainless steel pipe to determine stress and fatigue sensitivity to any observed discrepancies from design conditions. Of these eight lines, 1B2 safe end-to-pipe dimensions had the largest safe end variation and highest offset angle. The worst case geometry was analyzed and found to meet Code requirements.

7. Replaced 1B2 HPI safe end-to-pipe butt weld and adjacent piping. Replacement allowed for correction of the offset angle that was identified with the previous weld.

8. Collected vibration data on the 1B2 line during HPI Full Flow testing. Also collected vibration data on all four Unit 2 HPI lines during HPI Full Flow test during the refueling outage. Based on this review and historical data, the vibration levels observed for the HPI Lines during the Full Flow test are largest for the B2 lines on all three units, with the 1B2 line having the highest reported vibration levels of all 12 HPI Lines. The current vibration levels on the 1B2 line are within the design acceptance criteria of the piping.

9. Reviewed the population of Oconee Unit 3 welds that are inspected by the same NDE UT procedure as the 1B2 HPI safe end-to-pipe weld and determined they were adequately examined in 2010 to detect the presence of cracking. This includes each Unit 3 HPI nozzle safe end-to-pipe weld. The only UT inspections with coverage limitations (i.e., valve-to-valve butt welds) were further dispositioned by RTs at that time. The Unit 3 HPI nozzle thermal sleeve RTs from the spring of 2012, taken to assess thermal sleeve tightness and position, were also reviewed. Where visible in the RTs, the safe end-to-pipe weld showed no crack-like indications. Based on the reviews performed and the current negligible Unit 3 RCS unidentified leakage, there are no concerns with the operation of Unit 3.

Planned:

1. Modify the HPI system to increase 1B2 Emergency Injection line's resistance to piping vibration.

2. Revise NDE procedures to provide prescriptive guidance for maximizing examination coverage when performing augmented examinations, including entry into the corrective action program for evaluation by functional owner when limitations or indications of degradation are detected.

3. Revise the Section XI Functional Area Manual to require augmented examination owners to document evaluation of augmented NDE results, including evaluation of exam limitations, and to take appropriate actions commensurate with risk associated with the NDE results.

SAFETY ANALYSIS

While at 100% power on November 8, 2013, RCS leakage of <0.1 gpm was detected on ONS Unit 1. The leak was later found to be from a circumferential crack located at the safe end-to-pipe butt weld (1-RC-201-105) located between the 1B2 HPI injection nozzle and valve 1HP-152. The total circumferential extent of the aggregate crack was about 1.2 inches on the pipe inside diameter and about 0.1 inch (~1/8") on the outside surface.

The 1B2 HPI line is dedicated for emergency injection only, and it is generally stagnant during normal plant operation. The leak in this line remained small, and an orderly shutdown was performed. The leak was much less than what is considered in the Probabilistic Risk Analysis (PRA). However, an un-isolable leak in the reactor coolant system (RCS) pressure boundary

constitutes degradation of a principal safety barrier and is reportable to the NRC. The leak was entirely within the reactor building containment and no radioactive releases were made.

Based on the metallurgical evidence and comparison of this approximately 0.1 gpm leak to the 1997 ONS Operating Experience associated with a similarly located and larger HPI safe end-to-pipe weld leak, the leak before break capacity of this material was demonstrated. There is reasonable assurance that the line would not have catastrophically broken, even during a design basis event, based on a comparison of the materials (same), loading (similar) and flaw extent (smaller) for these two leaks. Additionally, had the leak location failed catastrophically, the 2 1/2 inch pipe break (approximately 0.025 square feet), would have constituted a small break Loss Of Coolant Accident. Breaks at this location are bounded by analyses in the Oconee UFSAR which concludes that this break can be handled without core damage.

ADDITIONAL INFORMATION

A review of the ONS corrective action program data was conducted to include all Root Causes for the last five years with similar event and cause codes as well as appropriate key word searches for this event. Selected apparent cause evaluations were reviewed as well. Two or more of the same events that involved the same equipment, same administrative controls or the same personnel actions were not discovered during the review of ONS corrective action program data; therefore, a similar/recurring event does not exist.

Energy Industry Identification System (EIIS) codes are identified in the text as [XX]. This event is considered INPO Consolidated Events System (ICES) Reportable. There were no releases of radioactive materials, radiation exposures or personnel injuries associated with this event.