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FACIL:50-389 St. Lucie Plant, Unit 2, Florida Power & Light Co. 05000389
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SUBJECT: LER 93-005-01 on 930112,vibration level began to increase on 2A1 reactor coolant pump.Caused by growing circumferential crack in pump shaft.Corrective action:new motor rotor assembly was installed on 2A1 RCP.W/940418 ltr.

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P.O. Box 128, Ft. Pierce, FL 34954-0128

April 18, 1994

L-94-099

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D. C. 20555

Re: St. Lucie Unit 2
Docket No. 50-389
Reportable Event: 93-005-01
Date of Event: January 4, 1993
High Reactor Coolant Pump Vibration Resulting in a Controlled Unit Shutdown due to a Cracked Shaft

The attached Licensee Event Report is being submitted voluntarily, as a revision to the original Licensee Event Report.

Very truly yours,

D. A. Sager
Vice President
St. Lucie Plant

DAS/JWH/kw

Attachment

cc: Stewart D. Ebneter, Regional Administrator, USNRC Region II
Senior Resident Inspector, USNRC, St. Lucie Plant

DAS/PSL #1103-94

JE22

FPL Facsimile of NRC Form 366 (9-89)

U.S. NUCLEAR REGULATORY COMMISSION

LICENSEE EVENT REPORT (LER)

FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
St. Lucie Unit 2	0 5 0 0 0 3 8 9	1 OF 0 4

TITLE (4) High Reactor Coolant Pump vibration resulting in a controlled Unit shutdown due to a cracked shaft

EVENT DATE (5)			LER NUMBER (6)			REPORT DATE (7)			OTHER FACILITIES INVOLVED (8)	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	MONTH	DAY	YEAR	FACILITY NAMES	DOCKET NUMBER(S)
									N/A	0 5 0 0 0
0 1	1 2	9 3	9 3	-- 0 0 5	-- 0 1	0 4	1 8	9 4	N/A	0 5 0 0 0

OPERATING MODE (9)	1	THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR : (Check one or more of the following) (11)							
POWER LEVEL (10)	1 0 0		20.402(b)		20.405(c)		50.73(a)(2)(iv)		73.71(b)
			20.405(a)(1)(i)		50.36(c)(1)		50.73(a)(2)(v)		73.71(c)
			20.405(a)(1)(ii)		50.36(c)(2)		50.73(a)(2)(vii)	X	OTHER (Specify in Abstract below and in Text NRC Form 366A)
			20.405(a)(1)(iii)		50.73(a)(2)(i)		50.73(a)(2)(viii)(A)		
			20.405(a)(1)(iv)		50.73(a)(2)(ii)		50.73(a)(2)(viii)(B)		
			20.405(a)(1)(v)		50.73(a)(2)(iii)		50.73(a)(2)(x)		

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER
James R. Williams, Shift Technical Advisor	AREA CODE 4 0 7 4 6 5 - 3 5 5 0

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

CAUSE	SYSTEM	COMPONENT	MANUFAC-TURER	REPORTABLE TO NPRDS		CAUSE	SYSTEM	COMPONENT	MANUFAC-TURER	REPORTABLE TO NPRDS
X	A B	P	B 5 8 0	Y						

SUPPLEMENTAL REPORT EXPECTED (14)		EXPECTED SUBMISSION DATE (15)	MONTH	DAY	YEAR
YES (If yes, complete EXPECTED SUBMISSION DATE)	X NO				

ABSTRACT (Limit to 1400 spaces. i.e. approximately fifteen single-space typewritten lines) (16)

On January 4, 1993, vibration levels began to increase on the 2A1 reactor coolant pump. The 1X (synchronous speed) and 2X (2 times synchronous speed) vibration levels increased at the upper motor, 1X and 2X phase angles wandered, and the orbit exhibited a non-uniform shaft rotation. Overall vibration levels continued to trend upwards. At 2315 on January 12th, a controlled plant shutdown was commenced at a vibration level of 15 mils and increasing. A root cause team was assembled and subsequently developed a detailed inspection plan. Disassembly of the reactor coolant pump and inspection of the pump shaft revealed two cracks just above the hydrostatic bearing. Upon replacement of the pump internals the 2A1 reactor coolant pump was restarted with satisfactory vibration readings. The unit was returned to Mode 1 on April 1, 1993.

The cause of the 2A1 reactor coolant pump high vibration was the result of a growing circumferential crack in the pump shaft. The root cause of the crack initiation was the use of seal injection on an idle reactor coolant pump.

The corrective actions as a result of this event were: 1) Unit 1 and Unit 2 operating and emergency procedures have been revised to limit the use of seal injection to Design Basis Events and isothermal conditions experienced during reactor coolant system fill and vent. 2) Replaced the motor rotor assembly on the 2A1 reactor coolant pump. 3) Replaced the motor upper radial bearing assembly (shoes, adjusting bolts), upper and lower thrust bearing shoes, reset the upper and lower radial and thrust bearing clearances. 4) Installed a new pump rotating element and seal. 5) The defective pump rotating element was sent to an off-site examination facility for non-destructive examination and subsequent metallurgical examination of the crack area. 6) New vibration probes were installed to monitor all Unit 1 and Unit 2 reactor coolant pump shafts. This voluntary Licensee Event Report is being submitted for industry informational purposes.

DESCRIPTION OF THE EVENT

On January 4, 1993, the 2A1 reactor coolant pump (RCP) (EIIS:P) experienced changing vibration characteristics and levels. The 1X and 2X vibration levels increased at the upper motor (EIIS:MO), 1X and 2X phase angles wandered, and the orbit exhibited an unusual shaft rotation. The St. Lucie Unit 2 RCP's had two sets of vibration probes located on the motor rotor. One set is positioned between the lower motor bearing and the motor to pump coupling while the other set is mounted above the upper motor bearing. There is a thrust monitor located at the top end of the rotor. There were no permanently mounted vibration probes on the pump or pump shaft. At 2315 on January 12, a controlled unit shutdown was commenced based on motor vibration levels reaching 15 mils displacement. Although all RCP seal pressures, controlled bleed off flow, and bearing temperatures were normal, it was conservatively decided to perform a unit shutdown.

Unit 2 reached Mode 3 at 0233 on January 13. A root cause team, composed of members from the Technical, Maintenance, Operations, and Engineering Departments, vibration analysis consultant, RCP motor vendor, RCP pump vendor, and NSSS vendor, was formed. At this point, a rigorous inspection plan was developed and instituted.

The pump was disassembled and the rotating element was sent to an off-site contaminated material exam facility for dimensional measurements and nondestructive examination. Preliminary inspection results revealed two cracks in the RCP pump shaft. The largest crack was located just below the thermal barrier zone and above the hydrostatic bearing's upper side plate . A .005" feeler gauge penetrated the crack from 22 degrees to 180 degrees while a .003" feeler gauge penetrated the crack 1.5" radially from 180 degrees to 240 degrees. The smaller crack was located at the toe of the fillet weld between the shaft and the upper side plate. New RCP internals were installed and Unit 2 was returned to service at 0144 on April 1, 1993.

CAUSE OF THE EVENT

The cause of the 2A1 reactor coolant pump high vibration was the result of a growing circumferential crack in the pump shaft. The root cause of the crack initiation was the use of seal injection on an idle reactor coolant pump. Analysis by independent consultants in cooperation with Byron Jackson Company disclosed that when a pump is idle, with seal injection on, the thermal mixing region oscillations are slower than when the shaft is rotating. These slower oscillations result in greater soak time, which translates into significantly higher thermal stresses. These thermal stresses were found to be significantly above material yield and capable of initiating a crack, and growing it to where normal mechanical loadings would drive it to failure.

The findings of a metallurgical failure analysis were consistant with this analysis of thermal and mechanical stresses. It showed that the main crack which was oriented perpendicular to the shaft axis grew initially by high stress low cycle fatigue, and then continued on by low stress high cycle fatigue.

ANALYSIS OF THE EVENT

This event is not reportable under 10CFR50.73; however, it is being submitted for industry informational purposes.

The Updated Final Safety Analysis Report (UFSAR) addresses decrease in RCS flow rate events in Section 15.3. Concerning Limiting Fault-3 events in this category, the limiting offsite dose event is an RCP shaft seizure with a loss of offsite power (LOOP) as a result of a main generator trip with Technical Specification steam generator tube leakage and a failure to restore offsite power within 2 hours. This worst case event produces offsite doses within acceptance guidelines.

The accident analyses in the UFSAR do not specifically address shaft shearing scenarios. However, Section 15.3.5.1.5.2 of the UFSAR addresses the relationship between a sheared shaft and shaft seizure. A sheared shaft will offer less resistance to flow during the post-LOOP flow coast down phase than a shaft seizure since the shaft is still capable of rotating. During the long term portion of the event, the reverse flow through the affected RCP is greater during the shaft shear event than the shaft seizure event. However, the lower core flow experienced during long term portion of the event has no impact on the minimum Departure from Nucleate Boiling Ratio (DNBR) which has been proven to occur during the first two to four seconds of the transient. It is during this time frame that the shaft seizure event is most limiting due to the lower core flow. Therefore, the margin to design limits is smaller for a shaft seizure event and as a result the shaft shearing event is bounded by the shaft seizure accident analysis.

Based on actual plant conditions at the time of the unit shutdown, a more credible event would have been a loss of flow through one RCP. This event is considered an infrequent type with an insignificant approach to off-site dose limits. Although a partial loss of RCS flow event is not specifically analyzed in the UFSAR, the core and system performance is considered to be no more adverse than a total loss of RCS flow that would occur during a LOOP since, by design, a low RCS flow trip (93% core flow) would automatically initiate a plant trip. In this situation, the minimum DNBR would be higher, due to a lower power to flow ratio, than for a total loss of core flow event. A partial loss of RCS flow through one RCP due to shaft shear is bounded well within the UFSAR accident analysis since 1) There was no existing steam generator tube leakage, 2) a shaft shear event is less limiting than a shaft seizure event, and 3) no LOOP occurred.

The health and safety of the public was not adversely affected by this event.

CORRECTIVE ACTIONS

1) Unit 1 and Unit 2 operating and emergency procedures have been revised to limit the use of seal injection to Design Basis Events and isothermal conditions experienced during reactor coolant system fill and vent.

2) A new motor rotor assembly was installed on the 2A1 RCP.

3) The motor upper radial bearing assembly (shoes and adjusting bolts), lower thrust bearing shoes were replaced (housing was reused) and the motor upper and lower radial bearing and thrust bearing clearances were reset.

4) A new pump rotating element and seal were installed.

5) The existing pump rotating element was sent to an off-site contaminated material examination facility for dimensional measurements, non-destructive examination, and subsequent metallurgical examination of the crack area.

6) New vibration probes were installed to monitor all Unit 1 and Unit 2 reactor coolant pump shafts just above the pump seal. The output of these probes was directed to the control room instrumentation previously associated with the lower motor bearing. Although the lower motor vibration probes no longer provide control room indication, they will remain on the pump motor as permanently installed test equipment.

7) New vibration monitoring equipment was installed on Unit 2 during the 1994 refueling outage which will provide more advanced warning of reactor coolant pump problems. Similiar equipment is scheduled to be installed on Unit 1 during the fall 1994 refueling outage.

ADDITIONAL INFORMATION

Failed Component Identification

Reactor Coolant Pump Rotating Assembly
Byron Jackson Co.
Serial # 741-N-0001
Model 35x35x43 DFSS

Previous Similar Events

Unit 1 1A1 RCP failed due to a bent shaft in 1990.