FPL Energy
Seabrook Station

FPL Energy Seabrook Station
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February 5, 2007

Docket No. 50-443
SBK-L-07018

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

Reference: SBK-L-06207, Licensee Event Report (LER) 2006-006-00, Plant Shutdown Due to Inoperable Diesel Generators, October 27, 2006

Seabrook Station
Licensee Event Report (LER) 2006-006-01
Plant Shutdown Due to Inoperable Diesel Generators

Enclosed is Licensee Event Report (LER) 2006-006-01. This LER reports an event that occurred at Seabrook Station on August 31, 2006 and supplements LER 2006-006-00 submitted on October 27, 2006. This event is being reported pursuant to the requirements of 10CFR50.73(a)(2)(i)(B).

Should you require further information regarding this matter, please contact Mr. James M. Peschel, Regulatory Programs Manager, at (603) 773-7194.

Very truly yours,

FPL Energy Seabrook, LLC

Michael Kiff for Gene St. Pierre
Gene St. Pierre
Site Vice President

cc: S. J. Collins, NRC Region I Administrator
G. E. Miller, NRC Project Manager, Project Directorate I-2
G. T. Dentel, NRC Senior Resident Inspector

IE22

ENCLOSURE TO SBK-L-07018

NRC FORM 366 (6-2004) U.S. NUCLEAR REGULATORY COMMISSION

APPROVED BY OMB: NO. 3150-0104 EXPIRES: 06/30/2007

Estimated burden per response to comply with this mandatory collection request: 50 hours. Reported lessons learned are incorporated into the licensing process and fed back to industry. Send comments regarding burden estimate to the Records and FOIA/Privacy Service Branch (T-5 F52), U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, or by internet e-mail to infocollects@nrc.gov, and to the Desk Officer, Office of Information and Regulatory Affairs, NEOB-10202, (3150-0104), Office of Management and Budget, Washington, DC 20503. If a means used to impose an information collection does not display a currently valid OMB control number, the NRC may not conduct or sponsor, and a person is not required to respond to, the information collection.

LICENSEE EVENT REPORT (LER)

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

1. FACILITY NAME	2. DOCKET NUMBER	3. PAGE
Seabrook Station	05000 443	1 OF 6

4. TITLE

Plant Shutdown Due to Inoperable Emergency Diesel Generators

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
									N/A	05000
08	31	2006	2006	- 006 -	01	02	05	2007	N/A	05000

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)
- ☐ 20.2201(d)
- ☐ 20.2203(a)(1)
- ☐ 20.2203(a)(2)(i)
- ☐ 20.2203(a)(2)(ii)
- ☐ 20.2203(a)(2)(iii)
- ☐ 20.2203(a)(2)(iv)
- ☐ 20.2203(a)(2)(v)
- ☐ 20.2203(a)(2)(vi)
- ☐ 20.2203(a)(3)(i)
- ☐ 20.2203(a)(3)(ii)
- ☐ 20.2203(a)(4)
- ☐ 50.36(c)(1)(i)(A)
- ☐ 50.36(c)(1)(ii)(A)
- ☐ 50.36(c)(2)
- ☐ 50.46(a)(3)(ii)
- ☒ 50.73(a)(2)(i)(A)
- ☐ 50.73(a)(2)(i)(B)
- ☐ 50.73(a)(2)(i)(C)
- ☐ 50.73(a)(2)(ii)(A)
- ☐ 50.73(a)(2)(ii)(B)
- ☐ 50.73(a)(2)(iii)
- ☐ 50.73(a)(2)(iv)(A)
- ☐ 50.73(a)(2)(v)(A)
- ☐ 50.73(a)(2)(v)(B)
- ☐ 50.73(a)(2)(v)(C)
- ☐ 50.73(a)(2)(v)(D)
- ☐ 50.73(a)(2)(vii)
- ☐ 50.73(a)(2)(viii)(A)
- ☐ 50.73(a)(2)(viii)(B)
- ☐ 50.73(a)(2)(ix)(A)
- ☐ 50.73(a)(2)(x)
- ☐ 73.71(a)(4)
- ☐ 73.71(a)(5)
- ☐ OTHER

Specify in Abstract below or in NRC Form 366A

12. LICENSEE CONTACT FOR THIS LER

FACILITY NAME	TELEPHONE NUMBER (Include Area Code)
James M. Peschel, Regulatory Programs Manager	603-773-7194

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
X	EK	SCR	BO93	Y	X	EK	XMFR	B093	N

14. SUPPLEMENTAL REPORT EXPECTED

☐ YES *(If yes, complete 15. EXPECTED SUBMISSION DATE)* ☒ NO

15. EXPECTED SUBMISSION DATE

MONTH	DAY	YEAR

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

On August 31, 2006 at 1409 while in Mode 1 at 100% power, Seabrook Station entered the action statement of Technical Specification (TS) 3.8.1.1, AC Sources – Operating, for two inoperable emergency diesel generators (EDG). During a planned maintenance test run, the train A EDG received a voltage regulator diode failure light. During subsequent testing to confirm operability, the train B EDG displayed a diode failure light, experienced an over-voltage condition, and was declared inoperable. With two EDGs inoperable, the station entered action f of TS 3.8.1.1, which requires restoration of one EDG within two hours or a shutdown to Hot Standby within the next 6 hours. A plant shutdown commenced at 1530. The NRC was notified in a four-hour report (event # 42820) in accordance with 10CFR50.72(b)(2)(i). The plant entered Mode 3 at 2052 on August 31, 2006. EDG-B was restored to operable status at 1359 on September 1, and the unit remained in mode 3 during repair of EDG-A. EDG-A was restored to operable status at 1928 on September 2, 2006. A Root Cause evaluation determined that the EDG-A diode failure light was caused by an imbalanced voltage input to the gate firing card. The EDG-B overvoltage was caused by a high flyback diode circuit resistance in conjunction with a fast start voltage transient. No adverse consequences resulted from this event.

LICENSEE EVENT REPORT (LER)

FACILITY NAME (1)	DOCKET (2)	LER NUMBER (6)			PAGE (3)
		YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	
Seabrook Station	0500-0443	2006	- 006	- 01	2 OF 6

17. NARRATIVE *(If more space is required, use additional copies of NRC Form 366A)* (17)

I. Description of Event

On August 31, 2006 at 1409 while in Mode 1 at 100% power, Seabrook Station entered the action statement of Technical Specification (TS) 3.8.1.1, AC Sources – Operating, for two inoperable emergency diesel generators (EDG) [EK, DG]. During a planned maintenance test run, the train A EDG received a voltage regulator [EK, EC] diode [EK, SCR] failure light. During subsequent testing to confirm operability in accordance with TS 3.8.1.1, action b.1, the train B EDG displayed a diode failure light with an over-voltage condition, which resulted in EDG-B being declared inoperable. With two EDGs inoperable, the station entered action f of TS 3.8.1.1, which requires restoration of one EDG to operable status within two hours or a shutdown to Hot Standby within the next 6 hours. A plant shutdown commenced at 1530 and the plant entered Mode 3 at 2052 on August 31, 2006. The NRC was notified of the initiation of this TS-required shutdown in a four-hour report (event # 42820) in accordance with 10CFR50.72(b)(2)(i). EDG-B was restored to operable status at 1359 on September 1, and the unit remained in mode 3 during repair of EDG-A. EDG-A was restored to operable status at 1928 on September 2, 2006. A Root Cause evaluation determined that the EDG-A diode failure light was caused by an imbalanced voltage input to the gate firing card. The EDG-B overvoltage was caused by a high flyback-diode circuit resistance in conjunction with a fast start voltage transient.

II. Cause of Event

EDG-A Failure

On August 30, 2006, during the second maintenance start of the EDG-A at the completion of a planned maintenance outage, a diode failure light illumination was received. The EDG responded as expected with normal voltage, frequency, and response time. During the maintenance outage, the voltage regulator had been instrumented at critical signal points with a high-speed recorder. The recorder waveforms showed anomalies with the rectifier gate firing pulses.

Based on the recorder plots and vendor discussion, it was determined that the EDG-A diode failure light illumination was most likely a problem with the gate firing card (GFC) or the T-5 transformer [XMFR]. The GFC and the T-5 transformer, along with its associated capacitors (C1 – C6) [EX, CAP] and inductors (L1 – L3) were replaced and sent to an offsite testing lab for analysis. Based on the work history on EDG-B, capacitors C1 through C7 on the power chassis were also replaced. Laboratory analysis found the T-5 transformer to be degraded.

As an interim corrective action, the EDGs were placed on a shortened surveillance frequency to demonstrate reliability. During the period of increased surveillance, EDG-A experienced a second diode failure light illumination on September 27, 2006. However, additional instrumentation that was installed on EDG-A prior to this run indicated a phase imbalance to the voltage regulator circuit.

FACILITY NAME (1)	DOCKET (2)	LER NUMBER (6)			PAGE (3)
		YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	
Seabrook Station	0500-0443	2006 -	006 -	01	Page 3 of 6

17. NARRATIVE *(If more space is required, use additional copies of NRC Form 366A)* (17)

II. Cause of Event (Continued)

Since the T-5 transformer had already been replaced following the August 30 failure with one that tested satisfactory, further circuit analysis indicated that the most likely cause was a high resistance/open contact on the K-1 contactor [CONTR]. The K-1 contactor was replaced. Inspection of the removed contactor found a bent arc chute and indication of arcing at other than the main contactor points. It appears that the bent arc chute was the result of previous maintenance activities and may have caused misoperation of one of the phase contacts. Both EDG-A diode failure light illuminations were caused by an imbalanced voltage input to the gate firing card caused by either the degraded T-5 transformer or K-1 contactor.

EDG-B Failure

The initial investigation of the EDG-B voltage regulator malfunction that occurred on August 31, 2006 attributed the failure to degradation of one of the seven capacitors [EK, CAP] in the noise-reduction circuits in the power chassis. One of the capacitors (C-5) appeared more degraded than the others. Following replacement of the seven capacitors, EDG-B operated satisfactorily and was restored to operable status. The removed components were sent to an off-site laboratory for additional testing. The testing did not confirm that a degraded capacitor was the root cause of the overvoltage event. However, the testing did indicate that a degraded capacitor may have been a contributing factor or symptom of the real root cause.

A rigorous testing and detailed circuit analysis process was subsequently performed at a vendor laboratory. This testing program determined that the EDG-B overvoltage was caused by a high flyback-diode circuit resistance in conjunction with a fast start voltage transient causing a rectifier chassis silicon controlled rectifier (SCR) to remain latched. This resulted in excessive field current leading to the overvoltage condition. The random nature of the latched SCR was caused by the normal interaction of the voltage regulator and the SCR firing sequence.

The rectifier chassis performs its function using a three-phase AC supply, three SCR/diode pairs and a flyback diode circuit. During normal operation, an SCR is gated on for only a short period. An SCR that has been gated on will turn off due to either the firing of the next SCR or conduction of the flyback diode circuit. For the flyback circuit to perform this function it must have a low enough resistance to drop voltage below the SCR remain-on voltage. During periods of low voltage demand (e.g., after EDG fast start voltage overshoot), all SCRs receive gate signals at an angle that does not allow them to produce field voltage pulses. When this occurs, the last SCR to fire must be turned off by the flyback diode circuit. If the flyback circuit has higher than normal resistance it can have enough forward voltage drop to keep an SCR turned on. By not turning off, the latched SCR causes EDG output voltage to remain high. The voltage regulator will continue to not fire any of the SCRs and there is no mechanism to turn off the latched SCR.

Testing at the laboratory confirmed high flyback circuit resistance. Voltage readings across the flyback circuit were of a sufficient value to maintain an SCR on. Testing also confirmed that the SCR/diode pairs had different remain-on values which resulted in the SCR/diode pair with the lowest remain-on value being the one that latched. The resistance in the flyback circuit was adjusted to prove this process. When the resistance was high, the SCR latched consistently. When the resistance was low, the SCR could not be caused to latch.

FACILITY NAME (1)	DOCKET (2)	LER NUMBER (6)			PAGE (3)
		YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	
Seabrook Station	0500-0443	2006 -	006 -	01	Page 4 of 6

17. NARRATIVE *(If more space is required, use additional copies of NRC Form 366A)* (17)

II. Cause of Event (Continued)

An additional cause of this event is that station processes and programs did not require a critical review of previous events and failure analysis results to determine whether the investigations for previous intermittent EDG voltage regulator problems had addressed all possible causes. Another cause is that the definition of repeat events was too narrow, which limited causal analysis of previous events.

Both EDGs had previously experienced voltage regulator problems dating back to 1985. In reviewing these events collectively, the primary corrective actions addressed the symptoms and not the root causes. The root cause and apparent cause teams were not reconvened to further explore additional failure causes when subsequent component analysis did not support the failure conclusions reached in the root cause or apparent cause analyses.

III. Analysis of Event

The two EDGs, each one connected to a redundant emergency bus, comprise the onsite emergency source of AC electrical power. One EDG is capable of supplying sufficient power for operation of the minimum safety features equipment required during a postulated loss-of-coolant accident concurrent with a loss of offsite power. During a loss-of-coolant accident, each diesel generator starts automatically on a safety injection signal and, if offsite power is not available, it is connected to its associated emergency bus. The safety features equipment is then sequentially started.

Both EDGs were inoperable for approximately 24 hours, from 1409 on August 31 to 1359 on September 1, 2006. This event met the reporting criteria of 10CFR50.72(b)(2)(i) and 50.73(a)(2)(i)(A) for initiation and completion of a plant shutdown required by the TS. This event is of regulatory significance because the condition was sufficiently serious to warrant a plant shutdown. Nonetheless, no systems actuations or consequences resulted from the event, and this occurrence had no adverse impact on the plant or on the health and safety of the public. No inoperable structures, systems, or components other than the EDGs contributed to the event.

While inoperable for planned maintenance on August 31, 2006 the train-A EDG experienced a voltage regulator diode failure light indication during a test run. However, the EDG satisfied the Technical Specification requirements for voltage and frequency. The generator voltage attained its nominal value in less than ten seconds following starting of the engine, and voltage was maintained during operation of the EDG. EDG-A was capable of carrying full load during and after the time that the diode failure light was on. Data obtained during the test run showed that one SCR was providing the required power contribution to the generator field, one SCR was providing a partial contribution, and one SCR was not providing any contribution to the generator field. The difference between the SCR power contributions was the reason the diode failure light was lit. Based on test data and vendor information, only one SCR is required to maintain generator voltage at full load. Therefore, EDG-A was functional and capable of carrying full load and fulfilling the safety function of the on-site emergency power system.

During this event, the Supplemental Emergency Power System (SEPS) was available and capable of carrying its design bases emergency loads. Additionally, all three offsite lines and associated on-site transformers were available to power the emergency buses. Based on the functional capability of EDG-A, the PRA risk assessment for the event determined that the incremental core damage probability (ICDP) was 6.88E-07.

IV. Corrective Actions

The corrective actions for this event include:

1. Replace the T-5 transformer on the EDG-A with a transformer of the new design.

2. Perform periodic monitoring of the voltage regulator circuitry including measurement of the flyback diode circuit voltage drop.

3. Perform an instrumented run of EDG-A to confirm flyback circuit low resistance and adjust the resistance if necessary to establish the desired flyback circuit voltage drop.

4. Complete investigation into why the flyback diode connection resistance increase occurred.

5. Revise the Corrective Action Program to:

   - Require repeat event reviews for critical component failures in Maintenance Rule risk significant systems to determine if evaluations and corrective actions for previous events addressed all possible causes. Revise the definition of and increase the timeframe for repeat event reviews.

   - Provide guidance on intermittent problems for which the cause cannot be determined to report to the Condition Report Oversight Group (CROG) the inability to find the root cause, actions to be taken to identify the cause, and an evaluation of the risk associated with a repeat event.

   - Require an action be assigned for apparent cause and root cause evaluations to report to CROG the results of offsite testing performed for Maintenance Rule risk significant system equipment failures.

Similar Events

The emergency diesel generators have previously experienced voltage regulator failures; however, none of these events resulted in a plant shutdown or reportable event.

NRC FORM 366B
(1-2001)

U.S. NUCLEAR REGULATORY COMMISSION

LICENSEE EVENT REPORT (LER)

FAILURE CONTINUATION

FACILITY NAME (1)	DOCKET (2)	LER NUMBER (6)			PAGE (3)
		YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	
Seabrook Station	0500-0443	2006	- 006	- 01	6 OF 6

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

CAUSE	SYSTEM	COMPONENT	MANU-FACTURER	REPORTABLE TO EPIX	CAUSE	SYSTEM	COMPONENT	MANU-FATURER	REPORTABLE TO EPIX
X	EK	CONTR	B093	N					