Entergy Operations, Inc.
17265 River Road
Killona, LA 70057-3093
Tel 504 739 6685
Fax 504 739 6698
jjarrel@entergy.com

John P. Jarrell III
Manager, Regulatory Assurance
Waterford 3

10 CFR 50.73

W3F1-2018-0034

June 27, 2018

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

Subject: Licensee Event Report (LER) 2017-002-01
Automatic Reactor Scram due to the Failure of Fast Dead Bus Transfer Relays to Automatically Transfer Station Loads to Off-Site Power on a Main Generator Trip
Waterford Steam Electric Station, Unit 3 (Waterford 3)
License No. NPF-38
Docket No. 50-382

Dear Sir or Madam:

Pursuant to 10 CFR 50.73, Entergy is hereby submitting supplemental LER 2017-002-01 for an event that occurred at Waterford 3 on July 17, 2017.

This supplement provides updates to the results of the Root Cause Evaluation and Safety Significance Determination that was not complete when LER 2017-002-00 was submitted. This revision also updates the reporting criteria for which the condition was reportable.

This report contains no new commitments. Please contact John P. Jarrell, Regulatory Assurance Manager, at (504) 739-6685 if you have questions regarding this information.

Sincerely,

John Jarrell
Regulatory Assurance Manager

JPJ/MMZ

Attachment: LER 2017-002-01

cc: Mr. Kriss Kennedy, Regional Administrator
U.S. NRC, Region IV
RidsRgn4MailCenter@nrc.gov

U.S. NRC Project Manager for Waterford 3
April.Pulvirenti@nrc.gov

U.S. NRC Senior Resident Inspector for Waterford 3
Frances.Ramirez@nrc.gov
Chris.Speer@nrc.gov

Attachment

to

W3F1-2018-0034

Licensee Event Report 2017-002-01

(5 pages)

NRC FORM 366 (06-2016) U.S. NUCLEAR REGULATORY COMMISSION

APPROVED BY OMB: NO. 3150-0104 EXPIRES: 10/31/2018

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
Waterford Steam Electric Station, Unit 3	05000382	1 OF 5

4. TITLE

Automatic Reactor Scram due to the Failure of Fast Dead Bus Transfer Relays to Automatically Transfer Station Loads to Off-Site Power on a Main Generator Trip

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
07	17	2017	2017	- 002 -	01	06	27	2018	FACILITY NAME	DOCKET NUMBER

9. OPERATING MODE	11. THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: *(Check all that apply)*			
1	☐ 20.2201(b)	☐ 20.2203(a)(3)(i)	☐ 50.73(a)(2)(ii)(A)	☐ 50.73(a)(2)(viii)(A)
	☐ 20.2201(d)	☐ 20.2203(a)(3)(ii)	☐ 50.73(a)(2)(ii)(B)	☐ 50.73(a)(2)(viii)(B)
	☐ 20.2203(a)(1)	☐ 20.2203(a)(4)	☐ 50.73(a)(2)(iii)	☐ 50.73(a)(2)(ix)(A)
	☐ 20.2203(a)(2)(i)	☐ 50.36(c)(1)(i)(A)	☒ 50.73(a)(2)(iv)(A)	☐ 50.73(a)(2)(x)
10. POWER LEVEL	☐ 20.2203(a)(2)(ii)	☐ 50.36(c)(1)(ii)(A)	☐ 50.73(a)(2)(v)(A)	☐ 73.71(a)(4)
	☐ 20.2203(a)(2)(iii)	☐ 50.36(c)(2)	☐ 50.73(a)(2)(v)(B)	☐ 73.71(a)(5)
	☐ 20.2203(a)(2)(iv)	☐ 50.46(a)(3)(ii)	☐ 50.73(a)(2)(v)(C)	☐ 73.77(a)(1)
100	☐ 20.2203(a)(2)(v)	☐ 50.73(a)(2)(i)(A)	☐ 50.73(a)(2)(v)(D)	☐ 73.77(a)(2)(i)
	☐ 20.2203(a)(2)(vi)	☒ 50.73(a)(2)(i)(B)	☒ 50.73(a)(2)(vii)	☐ 73.77(a)(5)(ii)
		☐ 50.73(a)(2)(i)(C)	☐ OTHER Specify in Abstract below or in NRC Form 366A	

12. LICENSEE CONTACT FOR THIS LER

LICENSEE CONTACT	TELEPHONE NUMBER *(Include Area Code)*
John Jarrell - Manager, Regulatory Assurance	(504) 739-6685

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
D	EA	RLY	S440	Y					

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)*

On July 17, 2017, at 1606 CDT, Waterford 3 experienced an automatic reactor scram due to a loss of forced circulation, which was the result of a loss of off-site power to the safety and non-safety electrical busses. Prior to the scram, plant operators manually tripped the main turbine and generator due to overheating of the isophase bus duct due to the failure of a shunt assembly connection in the duct to Main Transformer 'B'. The automatic electrical bus transfer did not occur due to relay failures in the fast dead bus transfer system. Both 'A' and 'B' Emergency Diesel Generators started and loaded as designed to re-energize the 'A' and 'B' safety busses. The loss of off-site power caused a loss of both Main Feedwater pumps, resulting in an automatic actuation of the Emergency Feedwater system.

The Root Cause of this event was the design change procedure used for modifications to the fast dead bus transfer circuitry did not include guidance to detect the susceptibility of the relays to DC coil inductive kick. The faulty relays in the fast bus transfer circuit were replaced prior to plant startup.

An Unusual Event was declared at 1617 CDT due to loss of off-site power to safety buses for >15 minutes.

All required safety-related equipment responded as expected during this event.

1. FACILITY NAME	2. DOCKET NUMBER	3. LER NUMBER		
		YEAR	SEQUENTIAL NUMBER	REV NO.
Waterford Steam Electric Station, Unit 3	05000382	2017	- 002 -	01

NARRATIVE

EVENT DESCRIPTION

A. Plant Status

At the time of this event Waterford 3 was operating at 100% reactor power. The site was experiencing a severe thunderstorm. No structures, systems or components were out of service that contributed to this event.

B. Event Chronology

On July 17, 2017, at approximately 1555 CDT, Waterford 3 control room operators received indications of an electrical grid spike. The control room received several control panel alarms related to the Waterford 3 switching station [FK] and operators were dispatched to investigate the electrical components in the transformer yard [EL]. During this investigation field operators reported that the Isophase Bus duct to Main Transformer 'B' [MT] was glowing orange and arcing and sparks were observed.

At 1606 CDT, control room operators manually tripped the main turbine [TA] to de-energize Main Transformer 'B'. When the main turbine was tripped the main generator [TB] automatically tripped and Reactor Power Cutback [JD] initiated as designed. The transfer of electrical busses did not occur as expected and the site experienced a loss of off-site power to the safety and non-safety electrical busses [SWGR]. This loss of off-site power resulted in a loss of all four Reactor Coolant Pumps (RCP) [P] which then resulted in an automatic reactor scram [JC] on loss of forced circulation. Both emergency diesel generators (EDG) [DG] started and loaded to provide power to both safety busses. The automatic actuation of the reactor protection system [JC], reactor scram, and the automatic start of both EDG's, are reportable conditions pursuant to 10 CFR 50.73(a)(2)(iv)(A).

At 1617 CDT the Shift Manager declared an Unusual Event for a loss of off-site power for >15 minutes (EN# 52863).

Due to the loss of power both Main Feedwater Pumps [SK] tripped resulting in levels in both Steam Generators [SG] lowering to the initiation setpoint of Emergency Feedwater (EFW) [BA] at the time of the automatic scram. At 1630 CDT, when reactor coolant system cold leg temperature lowered to 530 degrees Fahrenheit, plant operators took manual control of EFW to control Steam Generator levels as required in site Emergency Operating procedures. The automatic actuation of the EFW system is a reportable condition pursuant to 10 CFR 50.73(a)(2)(iv)(A).

At 1831 CDT off-site power was restored to the 'A' train non-safety electrical busses.
At 1844 CDT off-site power was restored the 'A' train safety electrical bus.
At 1854 CDT EDG 'A' was secured and returned to standby, operating for two (2) hours and 47 minutes.
At 1944 CDT off-site power was restored to the 'B' train non-safety electrical busses.
At 2001 CDT off-site power was restored to the 'B' train safety electrical bus.
At 2015 CDT EDG 'B' was secured and returned to standby, operating for four (4) hours and eight (8) minutes.
At 2056 CDT the Shift Manager exited the Emergency Plan and secured from the Unusual Event.
At 0116 CDT on July 18, 2017, control room operators started the Auxiliary Feedwater Pump and commenced feeding both SG's from the condensate system.
At 0128 CDT on July 18, 2017, the emergency feedwater actuation signal was reset. EFW pumps 'A', 'B', and 'AB' were secured, operating for nine (9) hours and 21 minutes.

C. Event Causes

Isophase Bus Duct Overheating:

The direct cause of the Isophase Bus Duct overheating is the failure of a shunt assembly connection to the Phase B bus duct.

The most likely apparent causes are: (1) a grid transient recorded on July 17, 2017, produced a dynamic response between the isophase bus and the bus duct that resulted in the separation of the shunt assembly connection, and; (2)

NARRATIVE

degraded connections between the laminated shunt assemblies and the bus duct resulted in formation of gaps between the contact surfaces. Electrical arcing across these gaps over time eroded the contact surfaces which increased resistance and weakened the connection.

Failure of Fast Dead Bus Transfer:

The direct cause of the failure of the fast dead bus transfer was the Struthers Dunn (S-D) 237 Series Direct Current (DC) Time Delay on Dropout (TDDO) relays [62] installed in the fast dead bus transfer circuitry instantaneously timed out when they were exposed to DC coil inductive kick, which prevented automatic transfer of the safety and non-safety electrical busses from the Unit Auxiliary Transformers [XFMR] to the Startup Transformers [XFMR].

The Root Cause of this event was design change procedures in effect during the development of the 1997 and 2017 modifications to the fast dead bus transfer circuitry did not include guidance that electronic devices have a greater susceptibility to DC coil inductive kick than electro-mechanical devices and did not require identification of critical characteristics for non-quality related plant changes.

The Contributing Cause of this event was the post-modification testing performed following change of the relays from Allen Bradley to Struthers Dunn did not exercise the fast dead bus transfer timing circuitry. This contributed to this condition by delaying detection of relay failure.

The inadequate design of the fast bus transfer relays resulted in a common cause inoperability of both trains of off-site power. This condition is reportable pursuant to 10 CFR 50.73(a)(2)(vii).

CORRECTIVE ACTIONS

A. Isophase Bus Overheating:

Completed corrective actions include:

a. The Main Transformer 'B', Phase 'B' isolated phase bus duct was repaired by cutting out the damaged duct sections and welding in new aluminum material. All laminated shunt assemblies were replaced using new bolting hardware.
b. The Main Transformer 'B' Phase 'A' and 'C' laminated shunt assemblies were removed, cleaned and re-installed with new bolting hardware.
c. Performed a complete inspection and torque check for all laminated shunt assemblies to identify any other degraded bolted connections and adjusted torque as needed.
d. Revise preventive maintenance strategy for isophase bus based on EPRI and industry recommendations to include shunt assembly torque checks, regular bus inspections, thermography scans, and corona scans.
e. Revise the site procedure for inspection of the isophase busses and ducting based on engineering input.

B. Failure of Fast Dead Bus Transfer:

Completed corrective actions include:

a. The installation of a suppression diode in parallel with fast bus transfer relay. (Corrective Action to Prevent Recurrence)
b. The Struthers-Dunn relays were removed from service and replaced with Allen Bradley relays.
c. Entergy Nuclear Fleet has adopted the Standard Design Process in accordance with IP-ENG-0001, Revision 0, Standard Design Process.
d. Fast Dead Bus Transfer engineering change test procedure was developed during troubleshooting and was performed following re-installation of the Allen Bradley relays and the installation of flyback diodes.
e. Verify that all Allen-Bradley 700RTC relays installed in the plant are immune to the effects of inductive kick. If any Allen-Bradley relays are discovered to not be immune to the effects of Inductive kick, generate additional actions to correct the lack of immunity.

NARRATIVE

f. Review and verify the existing EMC qualifications of currently installed Allen-Bradley 700RTC relays to ensure that they are appropriate for their operating environment. If any Allen Bradley relays are discovered to not be appropriate for their operating environment, generate additional corrective actions to correct the deficiency.

g. Anchor surge suppression/flyback diodes into design basis drawings and the Fast Dead Bus Transfer circuit Control Wiring Diagrams to ensure they are not removed if the Fast Dead Bus Transfer circuit is modified. (Corrective Action to Prevent Recurrence)

SAFETY EVALUATION

The Struthers-Dunn relays were installed in the fast dead bus transfer circuit in May of 2017, and were required to be functional on June 2, 2017, at 1902, when the main generator was paralleled to the grid and loads were transferred to the Unit Auxiliary Transformers at the conclusion of Refueling Outage 21. Both trains of the offsite transmission network have been inoperable from that time until the time of the generator trip on July 17, 2017. Action 'e' of TS 3.8.1.1 requires restoration of one of the inoperable offsite A.C. circuits to OPERABLE status within 24 hours or be in at least HOT STANDBY within the next 6 hours. Because of this, Waterford 3 was not in compliance of TS 3.8.1.1 for 45 days.

The non-compliance with Technical Specifications is a reportable condition pursuant to 10 CFR 50.73(a)(2)(i)(B).

Technical Specification (TS) 3.8.1.1 requires two physically independent circuits between the off-site transmission network and the on-site Class 1E distribution system to be operable. The operability of the electrical distribution systems during operation ensures that sufficient power will be available to supply the safety-related equipment required for (1) the safe shutdown of the facility, and (2) the mitigation and control of accident conditions within the facility. The minimum specified independent and redundant A.C. and D.C. power sources and distribution systems satisfy the requirements of General Design Criterion 17 of Appendix A to10 CFR Part 50. The fast dead bus transfer system is required to be functional per the Waterford 3 UFSAR to support the operability of off-site power. Both 'A' and 'B' Emergency Diesel Generators were available started and loaded as designed re-energizing the 'A' and 'B' safety busses ensuring sufficient power was available to supply safety-related equipment. Therefore, the onsite electrical distribution system was capable of performing its safety function.

Both trains of off-site electrical distribution were inoperable because the fast dead bus transfer function was not available; however, this function is not needed to restore offsite power. Without automatic transfer available, operators can perform the transfer manually from the control room as part of standard post trip actions. With manual operator action, offsite power was still capable of providing power to the safety-related 4.16kV electrical busses.

A Probabilistic Risk Assessment was performed by Entergy to determine the safety significance of the finding. The performance deficiency results in an Incremental Core Damage Probability (ICDP) of 5.17E-07/yr. This is considered a low risk impact, being reasonably below the Green-White threshold of 1.0E-06/yr in the NRC Significance Determination Process. The vendor performed analysis also addressed credit for FLEX implementation procedures and equipment.

PREVIOUS OCCURRENCES

CR-WF3-2015-3566: Failure of 'B' Fast Dead Bus Transfer during Plant Scram on June 3, 2015. (Reported under LER 2015-005-00 and 2015 005-01.)

Directly following a manual plant scram on June 3, 2015, due to a secondary system malfunction, a loss of off-site power occurred on the 'B' Train due to the failure of the fast dead bus transfer relays on the 'B' train. The Apparent Cause of this event was determined to be Unknown Equipment Cause (FEUU). A contributing cause was that the 1997 Plant Change was due to a Design Change That Was Not Adequate (FE18) because a latent design deficiency did not take into account the observed failure mode where a two coil design allowed one coil to fail preventing the fast dead bus transfer function (timed contacts) without actuating the contacts for the alarm circuit.

From this event, all fast dead bus transfer relays were replaced with new Allen -Bradley relays. Preventative Maintenance strategies were revised to replace the relays on a three (3) year frequency.

LICENSEE EVENT REPORT (LER) CONTINUATION SHEET

(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. LER NUMBER		
		YEAR	SEQUENTIAL NUMBER	REV NO.
Waterford Steam Electric Station, Unit 3	05000382	2017	- 002 -	01

NARRATIVE

The corrective actions from this earlier event did not correct the issue and prevent recurrence because the nature of the relay failure was not determined conclusively. Corrective actions were assigned from the apparent cause without a solid understanding of the causal factors for the respective failure.