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10 CFR 50.73

W3F1-2016-0033

April 28, 2016

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

Subject: Licensee Event Report (LER) 2015-004-02, Inoperability of the Emergency Feedwater Actuation System, Emergency Feedwater (EFW) System, and Atmospheric Dump Valves due to Improper Configuration of the EFW System Flow Control System
Waterford Steam Electric Station, Unit 3 (Waterford 3)
Docket No. 50-382
License No. NPF-38

Dear Sir or Madam:

In accordance with 10 CFR 50.73, Entergy is hereby submitting supplemental LER 2015-004-02 for an event that occurred on June 3, 2015.

It was determined that this condition is reportable pursuant to 10 CFR 50.73(a)(2)(i)(B), 10 CFR 50.73(a)(2)(v)(B), 10 CFR 50.73(a)(2)(vii) and 10 CFR 50.73(a)(2)(ix)(A). This revision updates corrective actions and provides the results of the Safety Significance Determination that was not complete when LER 2015-004-01 was submitted

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,

JPJ/MMZ

Attachments: 1. LER-2015-004-02

cc: Mr. Mark L. Dapas, Regional Administrator
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Attachment 1

to

W3F1-2016-0033

Licensee Event Report 2015-004-02

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 Page 2 for required number of digits/characters for each block)

1. FACILITY NAME	2. DOCKET NUMBER	3. PAGE
Waterford 3 Steam Electric Station	05000382	1 OF 7

4. TITLE

Inoperability of the Emergency Feedwater Actuation System, Emergency Feedwater (EFW) System, and Atmospheric Dump Valves due to Improper Configuration of the EFW System Flow Control System

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
06	03	2015	2015	- 004 -	02	04	28	2016	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)(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)
10. POWER LEVEL	☐ 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)
100	☐ 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

LICENSEE CONTACT	TELEPHONE NUMBER *(Include Area Code)*
John Jarrell	5047396685

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)*

On June 3, 2015, at 1707, following a manual reactor scram from 100% power, an Emergency Feedwater Actuation Signal (EFAS) was automatically actuated to both Steam Generators (SGs). Following flow initiation, the Emergency Feedwater (EFW) Backup Flow Control Valves (BFCVs) for both trains exhibited wide, frequent oscillations. Operators took manual control of both trains and stabilized flow. Both channels of EFAS flow control logic and both trains of EFW BFCVs were subsequently declared INOPERABLE and Technical Specifications (TS) 3.3.2.b and 3.7.1.2.d were entered, respectively. Analysis has determined that the identified valve cycling would have exceeded the assumed nitrogen consumption rate and, without operator intervention, would have exhausted the accumulators prior to the credited 10 hour analyzed mission time. The specified safety functions of both trains of EFW and both Atmospheric Dump Valves (ADVs) would not have been fulfilled. The cause of this event was that tuning of the flow control system was not adequate to cope with changes to system operating parameters. Compensatory measures have been put in place to station a dedicated operator to control the EFW BFCVs in manual following a reactor trip to establish and maintain the SG level in accordance with emergency operating procedures; system modification will follow.

NARRATIVE

INITIAL CONDITIONS

On June 3, 2015, Waterford 3 was in Mode 1 at approximately 100% power. There were no structures, components, or systems that were inoperable at the start of the event that contributed to the event.

The manual reactor [RCT] trip due to low SG levels is reported in LER 2015-005-01.

EVENT DESCRIPTION

At 1704 on June 3, 2015, Waterford 3 experienced a loss of the “A” Main Feedwater Pump. At 1705, the reactor was manually tripped when SG levels were continuing to lower. At 1707, an EFAS [JE] was automatically actuated to both SGs as SG level decreased. Flow initially stabilized at 250 gpm with the Primary Flow Control Valves (PFCVs) [FCV] providing flow and the BFCVs [FCV] closed. Both SG levels continued to decrease and the EFW [BA] control logic shifted the operation of the BFCVs to flow control mode to maintain flow to each SG. EFW flow stabilized and then SG levels began recovering. At 1709, the EFW AB pump [P] reached rated speed and EFW header discharge pressure increased. Shortly afterward, wide, frequent fluctuations in EFW flow were observed which was not in accordance with the expected system response.

Operations personnel observed that the controller [FIK] outputs for both BFCVs were oscillating frequently and widely. Both PFCVs operated correctly in automatic (the controller outputs remained steady and the valves remained in their fixed position). To prevent further oscillations, both BFCV controllers were taken to manual and then closed at 1715. The oscillations stopped concurrent with taking the valves to manual control. Operations personnel cycled both BFCVs in manual with no further flow oscillations noted. After confirming that they could control both BFCVs in manual, the operators closed the PFCVs. EFW flow to the SGs was controlled by operation of both BFCVs in manual for the remainder of the event, until EFW was secured.

The EFW flow control logic [JB] and both BFCVs were declared INOPERABLE due to the FCV oscillation and actions per TS 3.3.2.b and 3.7.1.2.d were entered, respectively. The EFW system functioned adequately to fill the SGs and maintain the specified safety function (Reactor Coolant System Heat Removal).

This event and the manual reactor trip were immediately reportable (reference EN # 51116) under 10 CFR 50.72(b)(3)(iv)(A), Specified System Actuation, and 10 CFR 50.72(b)(2)(iv)(B), RPS Actuation (scram), respectively.

Investigation has revealed that the components comprising the EFW flow control system were not configured to appropriately respond to the changes observed in the system operating parameters. Both EFW BFCVs cycled more than assumed in the nitrogen accumulator [ACC] sizing calculation. The excessive cycling has the potential for exhausting the accumulators prior to their 10 hour analyzed mission time in the event of a loss of Instrument Air (IA) [LD]. These accumulators also supply backup nitrogen to the ADVs. Periodic testing to confirm the stability of the BFCVs in the automatic flow control mode has not been performed. It is therefore reasonable to assume that this condition has likely existed within three

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years of the time of discovery. It was concluded that the EFW FCVs and the ADVs [V] have been inoperable for the time in which the reactor operated in the modes requiring applicability during the three year time period leading up to this event.

SYSTEM DESCRIPTION

The safety function of the EFW system is to provide sufficient supply of cooling water to one or both SGs for the removal of decay heat from the Reactor Coolant System (RCS) [AB] in response to any event causing low SG level coincident with the absence of a low pressure trip. The EFW system supplies this demand via three EFW pumps through two supply paths. Both supply paths are supplied with redundant IA operated FCVs and isolation valves, all of which fail open on loss of air. The FCVs modulate EFW flow in response to SG level. These valves are designated as primary and backup. The FCVs change operating modes and setpoints based on changes in SG level indication. If IA is lost, backup positioning of the valves is provided utilizing nitrogen from dedicated accumulators (V and VIII) which are sized for a minimum of 10 hours operation.

The ADVs are used to remove reactor decay heat from the SG in the event of loss of condenser [COND] cooling. They are also credited with reducing RCS pressure during certain small break loss of coolant accident scenarios, but not actuated by any engineered safety feature actuation system signal. The valves are electro-pneumatically operated and are controlled automatically or manually. The valves are designed to fail closed on loss of IA. Each valve has a handwheel which can be operated locally to override the actuator spring. The nitrogen accumulators that supply backup nitrogen for the EFW valves also supply backup nitrogen to the ADVs.

Once the accumulators are depleted, manual local control is necessary, and analyzed in the design basis, to position the EFW BFCVs and the other valves fed by the accumulator (the PFCVs and the ADVs).

REPORTABLE OCCURRENCE

TS 3.3.2 requires that the EFAS control valve logic shall be OPERABLE in Modes 1, 2, and 3. Action b requires that with control valve logic inoperable, restore within 48 hours or be in HOT STANDBY within 6 hours, and in HOT SHUTDOWN within the following 6 hours. This also requires entry into TS 3.7.1.2 action d.

TS 3.7.1.2 requires that three EFW pumps and two flow paths shall be OPERABLE in Modes 1, 2, and 3. Action d requires that with the EFW system inoperable and able to deliver at least 100% flow to either SG, restore EFW to OPERABLE status within 72 hours or be in at least HOT STANDBY within the next 6 hours and in HOT SHUTDOWN within the following 6 hours.

TS 3.7.1.7 requires each ADV be OPERABLE in Modes 1, 2, 3, and 4. The condition of both ADVs inoperable for reasons other than the automatic actuation channels is not addressed by the ACTION statements; however, it is mentioned in the TS basis. For this condition, TS 3.0.3 is entered. TS 3.0.3 requires that when a Limiting Condition for Operation is not met, except as provided in the associated ACTION requirements, within 1 hour, action shall be initiated to place the unit in a MODE in which the specification does not apply by placing it, as applicable, in: (1) At least HOT STANDBY within the next 6 hours, (2) At least HOT SHUTDOWN within the following 6 hours, and (3) At least COLD SHUTDOWN within the subsequent 24 hours.

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During the event, the EFW flow control logic and both BFCVs were declared inoperable due to the observed erratic behavior and TS 3.3.2.b and TS 3.7.1.2.d were entered. This condition is reportable under 10 CFR 50.73(a)(2)(vii), Common Cause Inoperability of Independent Trains or Channels, because this resulted in both channels of the EFAS and all EFW control valves to become inoperable.

The following additional reportability criteria that were met are based on the conclusion that the EFW FCVs and the ADVs have been inoperable for the time in which the reactor operated in the modes requiring applicability during the three year time period leading up to this event.

This condition is reportable under 10 CFR 50.73(a)(2)(i)(B), Operation or Condition Prohibited by Technical Specifications, because the potential condition has existed for longer than the allowed outage time of TS 3.3.2 action b (15), TS 3.7.1.2 action d, and 3.7.1.7 actions per 3.0.3.

This condition is also reportable under 10 CFR 50.73(a)(2)(v)(B), Event or Condition that Could Have Prevented Fulfillment of a Safety Function, and 10 CFR 50.73(a)(2)(ix)(A), Single Cause that Could Have Prevented Fulfillment of the Safety Functions of Trains or Channels in Different Systems, because the potential condition could have prevented the fulfillment of the safety function of both trains of the EFW system, both channels of the EFAS, and both ADVs.

CAUSAL FACTORS

A root cause evaluation was completed for this condition.

The direct cause of this condition was an instability in the control system setup of the EFW BFCVs that occurred when the valves were operating in the flow control mode. This resulted in the continuous cycling of the EFW BFCVs.

The root cause of this event was that the components comprising the EFW flow control system were not configured to appropriately respond to the changes observed in the system operating parameters. Improper configuration of the following attributes (all tied to system gain) collectively resulted in the observed unstable behavior: controller proportional gain and reset interval, valve trim (linear), valve stroke time, and volume booster setup. With the gain improperly selected, a perturbation in EFW flow caused a feedback effect that set up a varying output signal to the FCVs.

One contributing cause of this event was that there is no periodic testing that confirms the stability of the BFCVs in the automatic flow control mode. No startup test exists where the system was allowed to shift the BFCVs to the flow control mode and control in this mode. Calibration checks of the flow control loops and actuator are periodically performed; however, these tests do not provide sufficient intrusiveness to determine instabilities in system operation in all modes.

A second contributing cause of this event is that previous corrective actions were ineffective at determining the cause of the EFW flow instabilities and confirming the oscillations were corrected. EFW flow oscillations of similar magnitude and frequency were observed following a plant trip on January 21, 2013. There were missed opportunities noted in response to this event that may have led to earlier discovery of the causes.

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EXTENT OF CONDITION

Other safety-related FCVs were identified. Since the BFCVs operate in multiple modes, each mode was considered in the extent of condition.

The possibility of flow oscillations in the manual mode was eliminated by direct observation of flow with the BFCVs in manual mode. EFW flow was varied over a wide range of conditions and flow was stable. The probability of oscillations in level control mode is considered low. Level is a slowly changing variable and is not expected to produce oscillations. Observation of level control mode was made during previous events and no oscillations were noted.

The PFCVs were considered as similar items, since they also control EFW flow and could be a source of oscillations. The probability of oscillations is considered low because the primary EFW valves do not have a flow control mode, and their observation in manual was directly observed. Level control mode is also considered low risk for the same reasons given for the BFCVs.

In extending the extent of condition beyond the EFW system, it was determined that systems where two valves operate in parallel to control flow would be of particular concern.

A review was conducted of major plant systems with operations input for similar applications. The review identified main feed regulating valves and startup feed regulating valves as a similar application. This application is considered low risk because the system is normally in flow control mode and the performance of the feed regulating valves is continuously monitored. This behavior is not currently observed in the system.

CORRECTIVE ACTIONS

Operations has issued a standing order to implement a manual compensatory action for this condition. This requires that an additional operator to be stationed to operate the BFCVs in manual following a reactor trip to establish and maintain the SG water level in accordance with emergency procedures. This manual action is required to protect the associated nitrogen accumulators from depletion due to the excessive cycling of the BFCVs during an EFW actuation. Crediting the established compensatory measures, the EFW and ADVs are capable of performing their specified safety functions for the evaluated mission times. This will remain in effect until the condition is resolved.

An operability evaluation was completed by engineering personnel providing analysis supporting continued operation of the EFW system with the BFCVs in the manual closed position and specifying manual operator action to control the EFW BFCVs in manual upon an EFAS actuation.

A walkdown of the EFW piping adjacent to the BFCVs was conducted to confirm that no collateral damage to the equipment occurred as a result of this condition. No damage was noted.

Additional corrective actions:

(1) Develop a modification to the EFW system that ensures control stability is maintained under all expected operating conditions (in progress).

(2) Develop requirements for periodic testing of the EFW BFCVs (in progress).

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(3) Perform a comprehensive design review of the EFW control logic for the PFCVs and BFCVs (complete).

(4) Perform a review of air operated control valves to determine if control system instabilities currently exist with the valves in automatic (complete).

(5) Perform a review of surveillance testing of air operated FCVs to determine if the current surveillances are adequate to detect changes in system or component parameter that could lead to unstable operation in the automatic mode (complete).

(6) Perform a review of significant condition reports (category A and B) associated with the EFW system to ensure that if multiple condition reports were closed to another condition report, all conditions were adequately corrected (complete).

(7) Complete safety significance determination (complete).

SAFETY SIGNIFICANCE

The actual consequence was that EFW flow did not stabilize at 400 gpm as designed following an EFAS. Despite this behavior, the required EFW flow was provided to both SGs in automatic control and SG level was recovering. There were no other actual consequences to general safety of the public, nuclear safety, industrial safety or radiological safety for this event. Though both channels of the EFAS and both trains of EFW BFCVs were declared inoperable at the same time, both trains of the EFW system remained available to perform their required safety functions during all required accident conditions.

The potential consequences to general safety of the public, nuclear safety, industrial safety and radiological safety of this event if response actions were delayed were none. If operations personnel had not responded to take manual control, the observed oscillations would have continued until SG wide range level had recovered to 81%. At this level, the BFCVs would have switched to level control mode.

The potential consequence to the general safety of the public, nuclear safety, industrial safety or radiological safety of this event if the IA was lost is that the nitrogen accumulators providing the backup supply to the FCVs and ADVs could be depleted by sustained oscillations. Once the accumulators are depleted, manual local control is necessary to position valves supplied by the accumulator.

The Waterford-3 Probabilistic Risk Analysis (PRA) was used to determine the risk significance of this event by calculating the change in Core Damage Frequency (CDF). The resulting change in CDF is an increased probability of 2.2E-7/yr. Based on PRA analysis, the risk is considered Low.

PREVIOUS OCCURRENCES

Plant operating history was reviewed for other possible plant transients in which an EFAS occurred and water was injected into the SGs. Three previous EFAS actuations (1998, 2005, & 2013) have been identified.

January 21, 2013 (LER 2013-001-00, Condition Report CR-WF3-2013-0451): A plant trip on Low SG Level occurred following the inadvertent closure of the SG 1 feedwater regulating valve. EFAS was actuated for SG 1 only. SG 2 levels remained above the EFAS actuation setpoint. All three EFW pumps

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started and the BFCV and the PFCV initially went to the full open position due to SG wide range indication dropping. When SG level recovered, the BFCV should have shifted to flow control mode to maintain EFW total flow at the setpoint. EFW flow was instead observed to widely fluctuate. These oscillations exhibited a similar frequency and amplitude to the oscillations observed during the most recent June 3, 2015 event. The condition report documents that the PFCV position remained steady during this period. The BFCV remained in the automatic mode of operation during the entire 13 minute period in which oscillations were occurring. The oscillations remained relatively constant in amplitude and frequency until SG level reached the level control mode setpoint at which the valve shifted modes and the oscillations stopped. Subsequent troubleshooting revealed that the positioner for the BFCV had been degraded by a loose screw within its pneumatic operating mechanism resulting in a shift in the positioner's calibration. The apparent cause of the oscillations observed was attributed to the degraded positioner.

November 11, 2005 (LER 2005-005-00, CR-WF3-2005-4598): A plant trip and loss of main feedwater occurred due to a loss of circulating water. EFAS was initiated to both SGs, all three EFW pumps started, and the BFCVs for both SGs opened. The PFCVs failed to open due to a rapid, short duration downward spike in wide range level and a vulnerability inherent to the design of the EFW control logic. The BFCVs were observed to control flow during this event at the intended rate with no oscillations in flow observed. Since the PFCVs were closed in this event rather than at their fixed position, the BFCVs operated farther off their closed seat in order to maintain the flow setpoint. Operating the BFCVs closer to mid-stroke position placed the valves in a more favorable position to control flow. It is believed that operating the BFCVs in this manner prevented flow oscillations from occurring.

July 16, 1998 (LER 1998-014-00, CR-WF3-1998-0948): A loss of main feedwater occurred resulting in a plant trip and EFW actuation. EFAS was initiated for both SGs, all three EFW pumps started, and both the PFCVs and BFCVs for both SGs opened. The BFCVs were observed to operate in flow control mode at the setpoint without any oscillations present. The PFCVs operated as designed at their fixed position. This event is significant because it provides evidence that the flow control system for the BFCVs previously exhibited stable operation, even with the PFCVs opened at a fixed setpoint. The differences between this event and the event that occurred on June 3, 2015 were: 1) The speed setpoint for EFW AB pump had been increased after the 1998 EFAS actuation; and 2) The event started with the EFW BFCVs full open. This may have prevented initial overshoot of the system since the valves were closer to the setpoint. One anomaly was noted during this event. One BFCV went to the full open position when the valve switched from flow control mode to level control mode. This was caused by the failure of a relay card in the process analog control system. This failure is unrelated to the oscillations observed on June 3, 2015.

ADDITIONAL INFORMATION

Energy industry identification system (EIIS) codes and component function identifiers are identified in the text with brackets [ ].