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Brian R. Sullivan
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JAFP-16-0047
March 23, 2016

United States Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D.C. 20555-0001

Subject: LER: 2016-001, System Actuations during Manual Scram in Response to Frazil Ice Blockage and Residual Transfer

James A. FitzPatrick Nuclear Power Plant
Docket No. 50-333
License No. DPR-59

Dear Sir or Madam:

This report is submitted in accordance with 10 CFR 50.73(a)(2)(iv)(A).

There are no new regulatory commitments contained in this report.

Questions concerning this report may be addressed to Mr. William Drews, Regulatory Assurance Manager, at (315) 349-6562.

Sincerely,

Brian R. Sullivan
Site Vice President

BRS/WD/mh

Enclosure: JAF LER 2016-001, System Actuations during Manual Scram in Response to Frazil Ice Blockage and Residual Transfer

cc: USNRC, Region I Administrator
USNRC, Project Manager
USNRC, Resident Inspector
INPO Records Center (ICES)

NRC FORM 366 (11-2015)

U.S. NUCLEAR REGULATORY COMMISSION

LICENSEE EVENT REPORT (LER)

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4. TITLE
System Actuations during Manual Scram in Response to Frazil Ice Blockage and Residual Transfer

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: N/A	DOCKET NUMBER: N/A
1	23	2016	2016	- 001 -	00	3	23	2016	FACILITY NAME: N/A	DOCKET NUMBER: N/A

9. OPERATING MODE: 1

10. POWER LEVEL: 89

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)(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)
☐ 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)
☐ 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)(2)(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)
Mr. William Drews, Regulatory Assurance Manager	315-349-6562

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
C	NN	BAF	N/A	N	B	EA	BKR	G080	N

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 January 23, 2016, James A. FitzPatrick Nuclear Power Plant (JAF) was ascending in power when screenwell water level started to lower. At 89 percent power, at 22:23, Operators began taking compensatory measures to reduce power and mitigate water level lowering. At 22:40, a manual scram was initiated.

The scram was complicated by a residual transfer that resulted in non-vital equipment trips. This event resulted in the manual actuation of the Reactor Protection System, High Pressure Coolant Injection, Reactor Core Isolation Cooling, Main Steam Isolation Valves and automatic actuation of Emergency Diesel Generators, Emergency Service Water, and containment isolations in multiple systems, reportable per 10 CFR 50.73(a)(2)(iv)(A).

The lowering screenwell water level was caused by frazil ice blockage at the intake structure. The frazil ice stopped affecting screenwell water level after the manual scram. Corrective actions include strengthening mitigating actions in response to frazil ice.

The residual transfer was caused by lubrication hardening in the lower control valve assembly of the 71PCB-10042 breaker. Corrective actions included replacing or reworking the lower control valve assembly.

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LICENSEE EVENT REPORT (LER) CONTINUATION SHEET	Estimated burden per response to comply with this mandatory collection request: 80 hours. Reported lessons learned are incorporated into the licensing process and fed back to industry. Send comments regarding burden estimate to the FOIA, Privacy and Information Collections Branch (T-5 F53), U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, or by internet e-mail to Infocollects.Resource@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.

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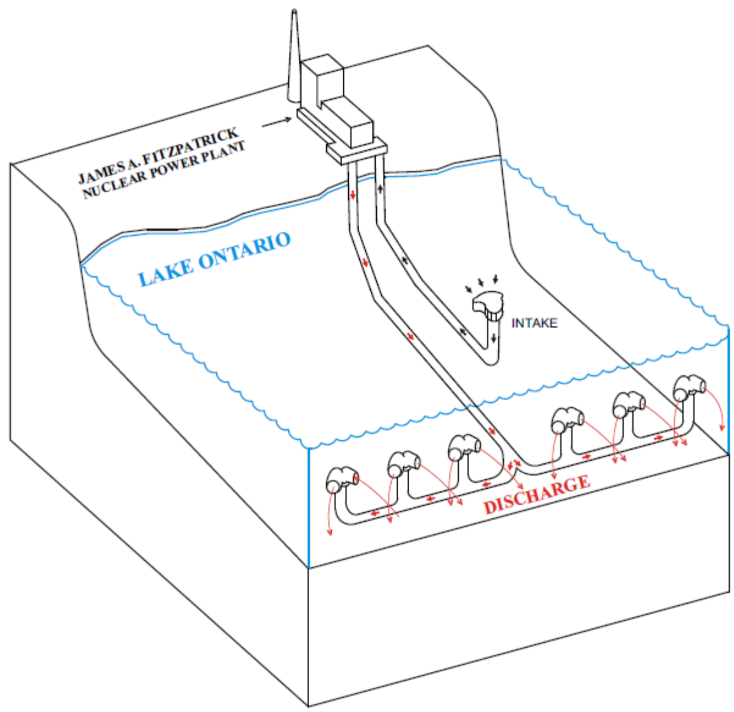
NARRATIVE

Background

James A. FitzPatrick's (JAF) Ultimate Heat Sink [EIIS designation: BS] is Lake Ontario. Water from Lake Ontario is transported via a water intake structure. The intake structure is an underwater concrete structure on the lakebed. Lake water enters the intake structure, travels through the intake tunnel, and enters the intake bay. The intake bay is located inside the screen house building. The enclosed intake bay area is also called the screenwell.



Located in the screenwell area, downstream of trash racks and rotating screens, are three Circulating Water pumps [KE], three Normal Service Water (NSW) pumps [KG], two Emergency Service Water (ESW) pumps [BI], four Residual Heat Removal Service Water (RHRSW) pumps [BI] and two Fire pumps [KP]. One Fire pump is upstream of the trash racks. The Circulating Water pumps supply cooling to the main condenser and are each operated at 133,000 gpm. NSW pumps are each rated at 17,800 gpm and supply cooling to plant loads during normal operating conditions. ESW pumps supply cooling to safety-related loads during both normal and accident conditions and are rated at 3,700 gpm each. RHRSW pumps, rated at 4,000 gpm each, supply cooling to the RHR heat exchangers.

Intake / screenwell water level is normally slightly lower than lake level due to flow head losses (generally at about 244 feet elevation depending on seasonal changes). The screenwell level is monitored in the control room and on Operator rounds. The NSW, ESW, and RHRSW pumps require a minimum water elevation at 235 feet elevation for safe operation. The Circulating Water and the Fire pumps require a minimum water elevation of 239 feet 6 inches for safe operation.

Frazil ice is a natural phenomenon in lakes and water ways, including Lake Ontario, when water freezes into loosely formed needle-like crystals. Surface water becomes supercooled when it loses heat rapidly to cold air without freezing. Turbulence, caused by winds, can mix the supercooled water throughout a body of water. The supercooled water encourages the formation of small ice crystals (frazil ice). Ice generally floats, but due to frazil ice's small size relative to current speeds, it can be carried to the bottom very easily. Frazil ice is more likely to occur when air temperatures decrease below freezing and when there is little ice cover on the lake, no cloud cover, winds are present, and the sun has set. Frazil ice has a negative impact on plant operations when it adheres to the intake structure. Supercooled water can reduce the intake structure surface temperatures below freezing then ice forms directly on the surface or frazil ice slush could drift into the structure and adhere to it. Since the intake structure actively draws in water it may draw in frazil ice. The intake structure entrance includes rack bars to screen large debris, consisting of 88 metal bars. These metal bars would normally be an optimal surface for frazil ice accumulation; however, deicing heaters are located in each.

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Alternating Current (AC) power is provided to JAF continuously by one of three sources. During normal power operations, a portion of the power created by the Main Generator [EL] becomes the Normal Service power source. In the event the main generator is not available offsite power circuits are available to supply plant loads. Finally, Emergency Diesel Generators (EDG) [EK] are available on standby as the emergency power source. The AC power supply system is designed with transfer power schemes to maintain power to Engineered Safeguards systems.

The fast transfer scheme triggers multiple electrical breakers in such a way that all electrical loads remain at power and in-phase. Alternatively, if the fast transfer was unsuccessful or the nature of the disturbance will not allow a fast transfer, an automatic residual transfer takes place. Residual transfer scheme is delayed until the voltage on the affected bus has decayed to approximately 25 percent of normal; this permits reenergizing the motors even though reserve and supply voltages may be out of phase.

Event Description

On January 23, 2016, JAF was ascending in power after a planned downpower to perform maintenance when screenwell water level began to decrease. The initial water level in the screenwell was 243.8 feet.

At 21:45, screenwell water level began to gradually decrease at a rate of about 1/4 inch per minute. At that time, Operators were commencing with power ascension to a reactor power level of 89 percent.

At 22:17, the screenwell water level low alarm was received at 242 feet, and an Operator was sent to verify local indications.

At 22:20, AOP-56, Intake Water Level Trouble.

At 22:23, Reactor Water Recirculating pump speed was reduced to lower reactor power and one of three Circulating Water pumps was secured.

At 22:28, power reached 68% and screenwell water level reached 240.7 feet. Screenwell water level recovered up to 241.5 feet.

At 22:31, screenwell water level began to decrease again.

At 22:39, water level decreased to 240 feet.

At 22:40, a manual scram was initiated. All control rods successfully inserted. The Main Turbine [TA] / Generator [TB] was manually tripped.

The fast transfer scheme failed and a residual transfer occurred automatically, as designed, and several plant systems automatically tripped or started:

- Reactor Water Recirculation pumps [AD] tripped
- Remaining Circulating Water pumps, Feedwater [SJ], Condensate [SD], and Condensate Booster pumps tripped
- Reactor Building Cooling [CC] and Turbine Building Cooling [KB] tripped
- Air System [LD] tripped
- EDG and ESW automatically started

Main Steam Isolation Valves (MSIV) were manually closed and Safety Relief Valves (SR/V) [SB], High Pressure Coolant Injection (HPCI) [BJ], and Reactor Core Isolation Cooling (RCIC) [BN] were manually actuated to maintain vessel inventory and pressure. ESW was used as the cooling water source for equipment. This event was reported to the NRC by ENS 51680.

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Event Analysis

Frazil Ice

This event was a severe case of frazil ice which caused significant blockage, reducing the amount of water that flows into the screenwell, and effectively reducing the ability of the Ultimate Heat Sink to remove heat. The most likely location for frazil ice accumulation is the bar racks or the concrete surfaces at the intake structure.

Currently, there isn't a way to directly observe the formation of frazil ice in the lake until it has already begun to degrade screenwell water level. Meteorological and lake conditions are monitored by Chemistry personnel for susceptibility of frazil ice and, if conditions warrant it, Operators are alerted to the possibility. On the day of this event, frazil ice susceptibility was addressed during shift turnover.

The intake structure rack bars are heated to maintain their surface temperature above freezing. If surfaces are above 32 degrees no matter how slightly, ice cannot adhere to the surface. However, the concrete surfaces of the intake structure itself are not heated and may provide a location for frazil ice accumulation and growth. Ice build-up can still occur on the bars if the amount of supercooling exceeds the thermal margin provided by the deicing heaters. The deicing heaters are not adequately sized to prevent frazil ice formation under extreme supercooling conditions, although they will minimize frazil ice formation most of the time. Maintenance and surveillance history of deicing heaters demonstrate that they were Operable during this event.

In response to lowering screenwell water level, procedure AOP-56, Intake Water Level Trouble, initiates reductions in plant power and demand for the cooling water supply. Operators responded by reducing reactor power and removing a Circulating Water pump.

Prior to this event, tempering was being used to control intake bay water temperature to 37 degrees Fahrenheit. Warm discharge water can be added to intake bay by raising the tempering gate. In effect, a portion of water drawn by pumps will come from the discharge flow rather than the intake structure. A higher water temperature correlates with a higher tempering flow and a lower intake velocity. A lower velocity at the intake structure would allow more time for the ice to float to the surface instead of being drawn into the intake structure. If frazil ice blockage cannot be prevented, the rate of formation can be mitigated by reducing the intake flow rate. To be successful, these actions to reduce flow rate need initiated as soon as possible.

Residual Transfer

Unrelated to frazil ice, during this event, the fast transfer scheme failed to occur when a fast transfer blocking relay performed a timing function. If the fast transfer doesn't happen within a short time after a Main Generator trip, the fast transfer is blocked and a residual transfer is automatically initiated.

Investigations performed after this event identified that indications from the line circuit breaker 71PCB-10042, required for fast transfer, did not occur as expected. The indications from 71PCB-10042 breaker were delayed due to the lower control valves actuating slowly. This caused the breaker failure logic to actuate. This logic in turn (appropriately per design) prevented the fast transfer from occurring. Slow breaker operation is attributed to degraded lubrication in the lower control valves of 71PCB-10042. Degraded lubrication is caused by lubrication hardening, due to a lack of maintenance, along with cold weather and infrequent operation.

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System Actuations

RPS was actuated by a manual scram, resulting in all control rods inserting successfully.

During the residual transfer, non-class 1E loads were shed and 4.16 kV class 1E buses transferred to standby power source. The EDG started on undervoltage, as designed, all breakers for 4.16 kV motor were tripped and the load sequencer was reset. The EDG started but did not load onto the bus because off-site power was maintained.

This event resulted in the actuation of RPS, HPCI, RCIC, ESW, MSIV, EDG, and containment isolations in multiple systems; reportable per 10 CFR 50.73(a)(2)(iv)(A).

Cause

The root cause of the event is a design vulnerability of the intake structure to frazil ice accumulation. Frazil ice accumulation on the intake structure restricted the flowrate to the screenwell, resulting in a lowering water level and Operators inserted a manual scram.

The apparent cause of the residual transfer is lubrication hardening in the lower control valve assembly of the 71PCB-10042 breaker due to age. This apparent cause resulted in this condition by slowing down the opening time outside the allowed time for the 71PCB-10042 breaker, and causing the residual transfer logic to actuate.

Similar Events

Internal

There have been a total of four previously recorded frazil ice events at JAF:

Date	Min screenwell level (feet elevation)	Duration* (hours)	Consequence	Reference
02/25/93	236 - 237	2	Manual Scram	DER-93-0252
02/15/04	241.2	4	Downpower	CR-JAF-2004-00685
03/03/06	243.1	5	Downpower	CR-JAF-2006-00951
02/07/10	242.7	8	Downpower	CR-JAF-2010-00588
01/23/16	239.5	1	Manual Scram	CR-JAF-2016-00243

* Approximate duration between the initial screenwell level to minimum level rounded to nearest hour.

On February 16, 2004, the Main Generator was manually tripped to take the plant offline to perform maintenance when an unexpected residual transfer occurred. The apparent cause was a delayed opening of 71PCB-10042 due to aging and cold weather (CR-JAF-2004-00709).

External

Frazil ice is a known industry issue for power plants in colder climates that use bodies of water as their Ultimate Heat Sink. Operating experience has been summarized in INPO document SOER 07-2, Intake Cooling Water Blockage.

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FAILED COMPONENT IDENTIFICATION:

Breaker Manufacturer:	General Electric
Manufacturer Model Number:	ATB-362-7
NPRDS Manufacturer Code:	G080
NPRDS Component Code:	BKR
FitzPatrick Component ID:	71PCB-10042

Corrective Actions

Frazil ice accumulation was a temporary condition which dissipated several hours after it began. Frazil ice mitigation strategies have proven useful at delaying its onset under slower acting events. Corrective actions due to this event include strengthening Operator awareness and prolonging the onset of frazil ice:

- New alarm point EPIC-A-2957, high change rate of screenwell water level during potential frazil ice.
- Enhance OP-4, Circulating Water System. Increase intake bay water temperature tempering to a range of 47 to 52 degrees Fahrenheit. Reduce power to 75% when notified by Nine Mile Point plant if they have indication of intake icing. Include guidance for monitoring meteorological conditions. If frazil ice potential is very high then tempering is increased to 65 degrees Fahrenheit.
- Enhance AOP-56, Intake Water Level Trouble. Provide instructions to increase tempering flow during frazil ice events and the use of EPIC-A-2957.

Corrective actions for the residual transfer included: all three lower control valves for the 71PCB-10042 breaker were rebuilt or replaced.

Safety Significance

There was no actual radiological or nuclear safety consequence during this event.

During plant power operations, when Circulating Water pumps are operating, intake velocity may be high enough to draw in large masses of ice and block the intake opening. Even if a manual scram is not initiated, the resulting lowered intake water level will automatically trip the Circulating Water pumps and cause an automatic scram. This automatic scram occurs prior to screenwell water level lowering below what is needed to run RHRSW and ESW cooling. The total flow needed for RHRSW and ESW cooling (30,000 gpm) is relatively low and it is unlikely that the intake structure will be completely blocked. However, assuming complete intake blockage, the screenwell has built-in provisions that make it possible for the flow in the intake and discharge tunnels to be reversed.

During plant shutdown conditions, when the Circulating Water pumps are not normally operating, the intake velocity is so low that significant frazil ice is not drawn into the intake structure. Under these conditions, the heat generated by the rack bar heaters is sufficient to prevent frazil ice from adhering to them. Additionally, the residence time for the water in the intake tunnel is significantly increased allowing the water to absorb more heat from the ground/earth and melt any ice particles that may have passed the intake structure.

Even though several non-vital systems tripped, a residual transfer is designed to maintain power to Engineered Safeguards systems.

References

- Condition Report: CR-JAF-2016-00243, Root Cause for Manual Scram due to Frazil Ice
- Condition Report: CR-JAF-2016-00244, Apparent Cause for Residual Transfer
- Procedure: AOP-56, Intake Water Level Trouble