Entergy

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Anthony J. Vitale
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NL-16-099

September 6, 2016

U.S. Nuclear Regulatory Commission
Document Control Desk
11545 Rockville Pike, TWFN-2 F1
Rockville, MD 20852-2738

SUBJECT: Licensee Event Report # 2015-008-01, "Automatic Reactor Trip Due to a Turbine-Generator Trip as a Result of a Fault on 345 kV Feeder W96 Tower Lines Caused by Pre-Existing Degraded Insulator"
Indian Point Unit No. 3
Docket No. 50-286
DPR-64

Reference: 1. Licensee Event Report # 2015-008-00, letter NL-16-011, dated February 11, 2016

Dear Sir or Madam:

Pursuant to 10 CFR 50.73(a)(1), Entergy Nuclear Operations Inc. (ENO) hereby provides Licensee Event Report (LER) 2015-008-01. The attached LER is a revision to an LER submitted by Reference 1, that identified an event where the reactor was automatically tripped, which is reportable under 10 CFR 50.73(a)(2)(iv)(A). As a result of the reactor trip, the Auxiliary Feedwater System was actuated, which is also reportable under 10 CFR 50.73(a)(2)(iv)(A). This condition was recorded in the Entergy Corrective Action Program as Condition Report CR-IP3-2015-05952. A failure analysis was performed and a root cause evaluation performed incorporating the failure analysis results and additional investigations. This LER revision incorporates the applicable changes provided in the revised cause evaluation.

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NRR

There are no new commitments identified in this letter. Should you have any questions regarding this submittal, please contact Mr. Robert Walpole, Manager, Regulatory Assurance at (914) 254-6710.

Sincerely,

AJV/cbr

cc: Mr. Daniel H. Dorman, Regional Administrator, NRC Region I
NRC Resident Inspector's Office, Indian Point Energy Center
Ms. Bridget Frymire, New York State Public Service Commission

NRC FORM 366 (01-2014) U.S. NUCLEAR REGULATORY COMMISSION

APPROVED BY OMB NO. 3150-0104 EXPIRES: 01/31/2017

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 Records and FOIA/Privacy Service 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-I0202, (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)

1. FACILITY NAME:	2. DOCKET NUMBER	3. PAGE
INDIAN POINT 3	05000-286	1 OF 5

4. TITLE: Automatic Reactor Trip Due to a Turbine-Generator Trip as a Result of a Fault on 345 kV Feeder W96 Tower Lines Caused by Pre-Existing Degraded Insulator

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
12	14	2015	2015	008 -	01	9	6	2016		05000
									FACILITY NAME	DOCKET NUMBER
										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

NAME	TELEPHONE NUMBER *(Include Area Code)*
Frank Bloise, Design Engineering-Electrical	(914) 254-6678

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

CAUSE	SYSTEM	COMPONENT	MANU-FACTURER	REPORTABLE TO EPIX	CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO EPIX
C	FK	INS	L246	Y					

14. SUPPLEMENTAL REPORT EXPECTED

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

15. EXPECTED SUBMISSION DATE

MONTH	DAY	YEAR

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

On December 14, 2015, an automatic reactor trip (RT) occurred due to a Turbine-Generator trip caused by a fault on 345 kV feeder W96 transmission tower IP3-4. All control rods fully inserted and all required safety systems functioned properly. The plant was stabilized in hot standby with decay heat being removed by the condenser. The auxiliary feedwater system actuated as expected due to steam generator low level from shrink effect. Inspections identified that an electrical fault damaged the 345 kV Transmission Tower line insulators. Direct cause of the RT was radial flashover of insulators on C phase of the 345 kV feeder W96 line at Transmission Tower IP3-4. The most likely cause is a pre-existing damaged insulator as a result of a prior flashover event that resulted in a repeat flashover due to environmental conditions. A single event with multiple flashovers associated with reduced insulation resistance due to a bird streamer is possible but less likely. Transmission Tower design does not have barriers to prevent avian perching on feeder towers. Corrective actions included inspection of Transmission Tower line insulators and ancillary hardware and replacement of damaged insulators and hardware. The preventive maintenance (PM) scope for the Unit 2 345 kV and 138 kV feeders was revised to include inspection and cleaning of Transmission Tower line insulators and hardware. An action request was generated to implement PM Template ENN-EP-G-004, Attachment 7.7 and Model Work Orders were revised and thermography and corona camera inspections performed. Bird guards will be installed on Entergy owned 345 kV and 138 kV Transmission Towers to preclude the effects of bird streaming. The event had no effect on public health and safety.

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

Note: The Energy Industry Identification System Codes are identified within the brackets {}.

DESCRIPTION OF EVENT

On December 14, 2015, an automatic reactor trip (RT) {JC} occurred at 19:06 hours, due to a Main Turbine {TA} Generator {TB} trip as a result of an electrical fault on 345 kV feeder W96 {FK} at Transmission Tower IP3-4 {TWR}. All control rods {AA} fully inserted and all required safety systems functioned properly. The plant was stabilized in hot standby with decay heat being removed by the condenser {SG}. There was no radiation release. The emergency diesel generators {EK} did not start as offsite power remained available. The auxiliary feedwater system {BA} actuated as expected due to steam generator {AB} low level from shrink effect. Inspections identified that an electrical fault damaged the 345 kV Transmission Tower line insulators {INS}. An investigation into the cause of the event and a post transient evaluation was initiated. The event was recorded in the Indian Point corrective action program (CAP) as Condition Report CR-IP3-2015-05952.

Prior to the RT the reactor was at 100 percent steady state power with no significant work in progress. 13.8 kV feeder 13W92 was out of service for scheduled maintenance for GT-2. The weather was moderate rain and fog in the area. At 19:06 hours, Control Room operators received a reactor trip due to a turbine trip. Turbine Trip First Out Annunciator was Generator Primary Lockout Relay. Cause of RT was due to a Main Generator trip due to the trip of the 86P (Lockout) and 86BU relays. All automatic systems functioned as designed and all control rods inserted automatically. At 20:01 hours, Control Room received a high vibration alarm due to high vibrations on the 33 reactor coolant pump at approximately 16 mils. Investigations determined that the trip was initiated by the 86P Lockout relay due to a phase to ground fault which actuated the Primary Phase Fault (50P) and Primary Ground Fault (50N) protective relays.

Several station employees observed the fault reporting that they saw an arc take place between the 345 kV Transmission Tower IP3-4 feeder W96 middle cross arm (B Phase) and the bottom cross arm (C Phase). No other arcing or faults were observed. Visual inspection of the W96 feeder Transmission Tower identified signs of multiple arc strikes on the W96 feeder Transmission Tower support arms and burning of the C Phase idler insulator. The C-phase idler insulator, the B-phase idler insulator, and the northernmost B-phase dead-end insulator were found damaged and replaced. Visual inspection of the remaining Transmission Towers on feeder W96 did not detect any indication of additional faults. During the Unit 3 refueling outage in March 2013, the insulators for feeder W96 were inspected and cleaned as required. The cleaning of 345 kV feeder line insulators is on a six year Preventive Maintenance (PM) Program schedule. The PM for these inspections are unit specific. The Unit 3 PM has specifics for inspecting the feeder insulators and hardware but the Unit 2 PM was more generic. Previous evaluations performed immediately after the event concluded the likely cause was a one-time event associated with reduced insulator properties from a bird streamer in combination with the environmental conditions at the time of the event. Streamers are long streams of excrement from large birds that are often expelled as a bird takes off from a perch. Streamers can impact reliability in several ways. If a streamer contacts an energized conductor, the electrical current may travel through the streamer back to the bird or pole/transmission tower. The result may be a bird electrocution, power outage, and/or line trip. More commonly, streamers may impact power reliability through the build-up of excrement on insulators. The contamination can compromise the integrity of an insulator resulting in power outages or line trips. Bird excrement contamination is greatest in areas where large birds frequently use structures such as transmission towers for nesting, roosting or perching. No bird carcasses were found in the vicinity of the transmission tower.

After the event the applicable insulators were removed and sent to the EPRI High Voltage Test Facility. A contracted vendor (LPI) assisted in performing an assessment of the failed insulators. LPI examined the failed insulators and several non-failed insulators and participated in insulator flashover testing at EPRI's test facility. The LPI Failure Analysis report concluded the evidence indicates the potential of two possible causes: 1) A single event with multiple flashovers that occurred on December 14, 2015 associated with likely reduced insulation resistance as a result of contamination from a bird streamer in combination with the environmental conditions of a wet heavy fog condition that were present at the time of the event, 2) A pre-existing damaged insulator as a result of a prior flashover event that resulted in a repeat flashover due to the environmental conditions of a wet heavy fog condition present at the time of the event. Causes of the pre-existing damaged insulators, based on the LPI report, would be low level energy events without operation of protective relays. The following applicable events were identified: 1) October 4, 2013, grid disturbance that resulted in flags dropping on 50P, 50BU, 50NP and 50NBU without relay operation, 2) March 13, 2014, grid disturbance resulting in flags dropping on 50NP and 50NBU without relay operation. This disturbance emanated from a fault on 38W33 line in Millwood west switchyard, 3) May 9, 2015, 31 Main Transformer experienced a fault with transformer failure and fire. The failure was associated with the A phase and the waveform data indicates current in the B and C phases for some period after fault initiation.

Visual inspections of insulators showed no build-up of pollutants or dirt on the insulators. Build-up of marine, agricultural, or industrial pollution, or bird droppings on the insulator disks, coupled with appropriate moisture, can create a coating that could compromise the insulation properties and result in a phase to earth flashover across the insulator string. If an electrical fault was caused by a bird streamer, the fault normally initiates on the energized hardware and jumps vertically towards the grounded tower. The fault appears to flash across the air gap and does not follow an insulator creepage path as has been observed on pollution faults. The visual inspection of the W96 line insulator disks supports this type of fault evolution. A review of the Disturbance Monitoring data shows that the neutral current peaked at 21.4 kAmps. This fault current is sufficient to actuate protective relays. Visual inspections were performed on Lightning Arrestors {LAR} to ensure proper grounding. No broken or damaged grounding cables were observed.

The Unit 3 High Voltage Electrical Distribution System consists of the following subsystems: 1) 22kV system, 2) 345kV system, and 3) 138kV and 13.8kV system. The Unit 3 Main Generator supplies electrical power at 22kV through isolated phase bus to the two Main Transformers (MT). The MTs increase the voltage of the generator output to 345kV which is transmitted to the Buchanan Substation South Ring Bus via feeder W96. The Buchanan Substation contains two 345kV Ring Buses (North and South) and a 138kv bus. The South Ring Bus is normally supplied by Unit 3 and the North Ring Bus by Unit 2. The South Ring Bus consists of four 345kV breakers, numbered 1, 3, 5 and 6. Breakers 1 and 3 are the Unit 3 Main Generator output breakers.

An Extent of Condition (EOC) review was performed. The conditions present at Tower IP3-4 are present on all 345 kV W96 towers. Inspections have not been performed since March 2013. Corona camera inspections have never been performed. A visual inspection of insulators and ancillary hardware on the remaining Transmission Towers for feeder W96 (Unit 3) did not identify any indication of additional faults or damage. Insulators and ancillary hardware on 345 kV feeder W95 (Unit 2) and 138 kV feeders 95331 Transmission Towers were inspected and cleaned through the PM Program during the March 2016 outage. No known damage has been identified on those towers insulators. The EOC review is bounded for only those insulators installed on 138 kV and 345 kV towers as they are the only towers which carry high voltage lines. The 13.8 kV lines are carried on wooden poles and pose no risk of exposure to bird streaming.

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

Medium risk assigned to faults on phases A, B, C of Unit 3 345 kV feeder W96. Insulators on other 345 kV W96 towers could be damaged. Conditions present at Tower IP3-4 are present on all 345 kV W96 towers. Inspections have not been performed since March 2013. Corona camera inspections have never been performed. Medium risk assigned to faults on phases A, B, C of feeder W95 and 138 kV Transmission lines 95331 and 95332. Low risk for components on feeder W95 and Transmission line 95331 as lines have been inspected in 2R22. Engineering concluded there is a low frequency and probability of occurrence since this event is the first documented event of its kind in the operating history of the site. Additional transmission operating experience (OE) re: bird streaming was identified during the initial investigation following the plant trip based on discussions with Consolidated Edison personnel and Entergy Transmission Group. Based on their OE Consolidated Edison is scheduled to install bird guards on their transmission towers to preclude the effects of bird streaming.

The Cause of Event

The direct cause of the RT was a 345 kV electrical disturbance (fault) on feeder W96 at Transmission Tower IP3-4. The RT was initiated by the main generator lockout protective relay (86P) due to a phase-to-ground fault on the 345 kV W96 feeder lines which actuated the primary phase fault (50P) and primary ground fault (50N) protective relays. The trip of the 86P relay tripped (opened) the Main Generator output breakers 1 and 3 and generator exciter (field breaker) which initiated the trip of the turbine and reactor. Direct cause of the RT was radial flashover of insulators on C phase of the 345 kV feeder W96 line at Transmission Tower IP3-4.

Based on the data and engineering judgment the most likely cause is a pre-existing degraded insulator condition. Multiple flashovers associated with bird streamers are possible but less likely. The C-phase idler insulator on Tower 4 likely sustained previous flashover damage. The extent of the damage was a thin layer of metal on the surface of the insulator bell. This condition created a location of high electrical stress concentration making the insulator string more susceptible to flashover. The decreased dielectric properties of the air as a result of rain and fog, combined with the degraded insulator string, resulted in a radial flashover between the tower and the 345 kV C-phase. Root cause 1 (RC1) is the PM template of ENN-EP-G-004, Attachment 7.7 was not implemented for corona camera inspections on the W96 line and components. These inspections are designed to detect unacceptable wear of high voltage insulators. This RC1 resulted in the condition by not identifying the degraded insulator prior to the flashover event. RC2 is that current design of the Transmission Towers does not preclude birds from roosting (no physical barriers) in areas where bird streaming could compromise insulator effectiveness.

Corrective Actions

The following are some of the corrective actions that have been or will be performed under the Corrective Action Program (CAP) to address the causes of this event.

- The 345 kV and 138 kV Transmission Tower line insulators and ancillary hardware were inspected and damaged insulators and hardware were replaced. The C Phase idler insulators, B Phase idler insulators, and the northernmost B Phase dead-end insulators were replaced.
- A failure analysis and testing of the 345 kV insulators was performed and evaluated to determine the cause of failure.
- An action request was generated to implement PM Template ENN-EP-G-004, Attachment 7.7 and Model Work Orders were revised and thermography and corona camera inspections performed for both units 345 kV W95, and W96 conductors and insulators, 138 kV feeder 95331 and 95332 conductors and insulators.

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

- The preventive maintenance (PM) scope for the Unit 2 345 kV and 138 kV feeders was revised to clearly specify the inspection and cleaning of Transmission Tower line insulators and ancillary hardware.
- Bird guards will be installed on Entergy owned 345 kV and 138 kV Transmission Towers to preclude the effects of bird streaming.

Event Analysis

The event is reportable under 10CFR50.73(a)(2)(iv)(A). The licensee shall report any event or condition that resulted in manual or automatic actuation of any of the systems listed under 10CFR50.73(a)(2)(iv)(B). Systems to which the requirements of 10CFR50.73(a)(2)(iv)(A) apply for this event include the Reactor Protection System (RPS) including RT and AFWS actuation. This event meets the reporting criteria because an automatic RT was initiated at 19:06 hours, on December 14, 2015, and the AFWS actuated as a result of the RT. On December 14, 2015, at 19:49 hours, a notification was made in accordance with 10 CFR 50.72: a 4-hour non-emergency notification for an actuation of the reactor protection system while critical under 10 CFR 50.72(b)(2)(iv)(B), and an 8-hour notification under 10CFR50.72(b)(3)(iv)(A) for a valid actuation of the AFW System (Event Log #51606). As all primary safety systems functioned properly there was no safety system functional failure reportable under 10CFR50.73(a)(2)(v).

Past Similar Events

A review was performed of previous Licensee Event Reports (LERs) in the past three years reporting a RT as a result of a high voltage feeder fault. Two LERs were identified that reported a RT as a result of 345 kV (HV) RT. LER-2015-005 reported a RT on June 15, 2015, due to a failure of south ring bus breaker 5 while the main generator output breaker 1 was opened for the removal of a Mylar balloon on feeder W97 outside a substation.

This event was judged not to be similar as it was not related to feeder insulator damage and had a different cause. LER-2012-004 reported a RT on October 29, 2012 as a result of a fault on 345 kV feeders W97 and W98. The fault was caused by damage to feeder tower line insulators from the effects of super storm Sandy.

Safety Significance

This event had no effect on the health and safety of the public.
There were no actual safety consequences for the event because the event was an uncomplicated reactor trip with no other transients or accidents. Required primary safety systems performed as designed when the RT was initiated. The AFWS actuation was an expected reaction as a result of low SG water level due to SG void fraction (shrink), which occurs after a RT and main steam back pressure as a result of the rapid reduction of steam flow due to turbine control valve closure.

There were no significant potential safety consequences of this event. The RPS is designed to actuate a RT for any anticipated combination of plant conditions. This event was bounded by the analyzed event described in FSAR Section 14.1.8 (Loss of External Electrical Load). All components in the RCS were designed to withstand the effects of cyclic loads due to reactor system temperature and pressure changes. For this event, rod control was in automatic and all rods inserted upon initiation of a RT. The AFWS actuated and provided required FW flow to the SGs. RCS pressure remained below the set point for pressurizer PORV or code safety valve operation and above the set point for automatic safety injection actuation. Following the RT, the plant was stabilized in hot standby