



**UNITED STATES
NUCLEAR REGULATORY COMMISSION**

REGION III
2443 WARRENVILLE ROAD, SUITE 210
LISLE, IL 60532-4352

June 16, 2011

Mr. Michael J. Pacilio
Senior Vice President, Exelon Generation Company, LLC
President and Chief Nuclear Officer (CNO), Exelon Nuclear
4300 Winfield Road
Warrenville, IL 60555

SUBJECT: BRAIDWOOD STATION, UNITS 1 AND 2; BYRON STATION, UNITS 1 AND 2,
NRC SPECIAL INSPECTION TEAM (SIT) REPORT 05000456/2011012;
05000457/2011012; 05000454/2011015; 05000455/2011015

Dear Mr. Pacilio:

On May 4, 2011, the U.S. Nuclear Regulatory Commission (NRC) completed a Special Inspection at your Braidwood Station, Units 1 and 2, and Byron Station, Units 1 and 2, to evaluate the facts and circumstances surrounding 1) the identification that voids in auxiliary feedwater (AF) alternate suction piping at Braidwood and Byron Stations could adversely affect the AF system and 2) loss of all main control room annunciator events at Braidwood Station Unit 2. Based on the risk and deterministic criteria specified in Management Directive 8.3, "NRC Incident Investigation Program," and due to the equipment performance issues that occurred, a Special Inspection was initiated in accordance with Inspection Procedure 93812, "Special Inspection." The basis for initiating the special inspection and the focus areas for review are detailed in the Special Inspection Charter (Attachment 2 of the enclosure).

The enclosed inspection report documents the inspection results, which were discussed at the exit meeting on May 4, 2011, with Mr. D. Enright, Mr. B. Adams, and other members of your staff. The determination that the inspection would be conducted was made on March 31, 2011, and on-site inspection commenced the same day.

The inspection examined activities conducted under your licenses as they relate to safety and compliance with the Commission's rules and regulations and with the conditions of your licenses. The inspectors reviewed selected procedures and records, observed activities, interviewed plant personnel, and evaluated the facts and circumstances surrounding the event, as well as the actions taken by your staff in response to the unexpected equipment conditions.

This report documents one self-revealed finding and two NRC-identified findings of very low safety significance affecting Braidwood. One of these findings was determined to involve a violation of NRC requirements. However, because of the very low safety significance and because the issue is entered into your corrective action program, the NRC is treating this issue as a non-cited violation (NCV) consistent with Section 2.3.2 of the NRC Enforcement Policy, dated September 30, 2010.

If you contest the subject or severity of this NCV, you should provide a response within 30 days of the date of this inspection report, with the basis for your denial, to the U.S. Nuclear Regulatory Commission, ATTN: Document Control Desk, Washington, DC 20555-0001, with a copy to the Regional Administrator, U.S. Nuclear Regulatory Commission - Region III, 2443 Warrenville Road, Suite 210, Lisle, IL 60532-4352; the Director, Office of Enforcement, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001; and the Resident Inspector Office at the Braidwood Station.

This report also documents one NRC-identified finding of very low safety significance affecting Byron. This finding was determined not to involve a violation of NRC requirements.

If you disagree with the cross-cutting aspect assigned to any finding in this report, you should provide a response within 30 days of the date of this inspection report, with the basis for your disagreement, to the Regional Administrator, Region III, and the NRC Senior Resident Inspector at the Braidwood Station and/or Byron Station, as applicable.

In accordance with 10 CFR 2.390 of the NRC's "Rules of Practice," a copy of this letter, its enclosure, and your response (if any) will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records System (PARS) component of NRC's document system (ADAMS). ADAMS is accessible from the NRC Website at <http://www.nrc.gov/reading-rm/adams.html> (the Public Electronic Reading Room).

Sincerely,

/RA/

Steven West, Director
Division of Reactor Projects

Docket Nos. 50-456; 50-457; 50-454; 50-455
License Nos. NPF-72; NPF-77; NPF-37; NPF-66

Enclosure: Inspection Report 05000456/2011012; 05000457/2011012;
05000454/2011015; 05000455/2011015
w/Attachments:
1. Supplemental Information
2. Special Inspection Team Charter
3. Timeline of Events for Auxiliary Feedwater Voids
4. Timeline of Events for Loss of Annunciators

cc w/encl: Distribution via ListServ

U.S. NUCLEAR REGULATORY COMMISSION

REGION III

Docket Nos: 50-456; 50-457
50-454; 50-455

License Nos: NPF-72; NPF-77
NPF-37; NPF-66

Report Nos: 05000456/2011012; 05000457/2011012
05000454/2011015; 05000455/2011015

Licensee: Exelon Generation Company, LLC

Facilities: Braidwood Station, Units 1 and 2
Byron Station, Units 1 and 2

Locations: Braceville, IL
Byron, IL

Dates: March 31, 2011 – May 4, 2011

Inspectors: A. Garmoe, Acting Project Engineer, Team Lead, DRP
S. Sheldon, Senior Engineering Inspector, DRS
C. Zoia, Senior License Examiner, DRS

Approved by: S. West, Director
Division of Reactor Projects

Enclosure

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SUMMARY OF FINDINGS

IR 05000456/2011012; 05000457/2011012; 05000454/2011015; 05000455/2011015; 3/31/2011 – 5/4/2011; Braidwood and Byron Stations, Units 1 & 2; Special Inspection.

This report covers an 8-day period (March 31 to April 11, 2011) of on-site inspection and in-office review through May 4, 2011. A three-person team composed of a project engineer and two regional inspectors conducted the inspection. Three Green findings affecting Braidwood Station were identified. One of the findings was considered a non-cited violation (NCV) of NRC regulations. One Green finding was identified affecting Byron Station. The finding was determined to not involve a violation of NRC regulations. The significance of most findings is indicated by their color (Green, White, Yellow, Red) using Inspection Manual Chapter (IMC) 0609, "Significance Determination Process" (SDP). Assigned cross-cutting aspects were determined using IMC 0310, "Components Within the Cross-Cutting Areas." Findings for which the SDP does not apply may be Green or be assigned a severity level after NRC management review. The NRC's program for overseeing the safe operation of commercial nuclear power reactors is described in NUREG-1649, "Reactor Oversight Process," Revision 4, dated December 2006.

A. NRC-Identified and Self-Revealed Findings

Cornerstone: Mitigating Systems

- Green. A finding of very low safety significance was identified at the Braidwood and Byron Stations by the inspectors when licensee personnel failed to adequately document and justify continued operability of the auxiliary feedwater (AF) system. Specifically, licensee evaluations of known voids in the AF alternate source suction piping did not provide an adequate technical basis to support operability of the AF pumps during a suction swap-over scenario. Subsequently, the licensee filled the voids and a Root Cause Evaluation (RCE) was initiated under Issue Report (IR) 1194196 (Braidwood) and IR 1194324 (Byron). The RCE was initiated to determine why prior opportunities for discovery of the inadequate void acceptance basis were missed and to develop associated corrective actions.

The inspectors determined the finding was more than minor because, if left uncorrected, the failure to recognize conditions that could render equipment inoperable had the potential to lead to a more significant safety concern. Because the finding was not a design deficiency, did not result in a loss of safety function, and did not screen as potentially risk-significant due to a seismic, flooding, or severe weather initiating event, the inspectors concluded that the finding was of very low safety significance (Green). This finding was associated with a cross-cutting aspect in the Decision-Making component of the Human Performance cross-cutting area because the licensee did not use conservative assumptions and did not verify the validity of underlying assumptions in their evaluations of the AF suction piping voids. (H.1(b)) (Section 40A5.1.7.b)

- Green. A finding of very low safety significance was self-revealed at Braidwood Station when licensee personnel failed to properly install portions of the annunciator system circuitry in accordance with design specifications. Specifically, wiring in the annunciator system clock circuitry (the portion of the circuitry that allows annunciators to change status) was incorrectly installed, which resulted in an unexpected loss of all Braidwood Unit 2 control room annunciators on March 24, 2011. The licensee entered the issue

into the corrective action program (CAP) as IR 1192465, corrected the wiring to provide the intended function, and revised procedures used to energize and de-energize the system.

The finding was determined to be more than minor because it was associated with the Equipment Performance attribute of the Mitigating Systems cornerstone and affected the cornerstone objective of ensuring the availability, reliability, and capability of systems that respond to initiating events to prevent undesirable consequences. Specifically, annunciator system redundancy was adversely affected and when the annunciator panels were de-energized, the ability of operators to identify and respond to abnormal plant conditions was degraded. Because the finding was not a design deficiency, did not result in a loss of safety function, and did not screen as potentially risk significant due to a seismic, flooding, or severe weather initiating event, the inspectors concluded that the finding was of very low safety significance (Green). The inspectors did not identify a cross-cutting aspect associated with this finding because it was not indicative of current performance. (Section 4OA5.2.3.b)

Cornerstone: Emergency Preparedness

- Green. The inspectors identified a finding of very low safety significance (Green) and an associated non-cited violation of 10 CFR 50.54(q) at Braidwood Station after licensee personnel failed to promptly declare a Notice of Unusual Event in accordance with the Braidwood Emergency Plan. Specifically, on March 24, 2011, contrary to the Braidwood Station Radiological Emergency Plan Annex, the licensee did not declare Emergency Action Level (EAL) MU6 (Unusual Event) within 15 minutes of indications of a loss of greater than 75 percent of Unit 2 main control room annunciators. Corrective actions included implementation of Standing Order 11-007; additional training; and procedures revisions, which were all intended to clarify the function of the annunciator test push buttons in determining whether a loss of annunciators has occurred.

The finding was more than minor because it was associated with the Emergency Response Organization Performance attribute of the Emergency Preparedness cornerstone, and affected the cornerstone objective of implementing adequate measures to protect the health and safety of the public in the event of a radiological emergency. Using the emergency preparedness significance determination process, Sheet 2, "Actual Event Implementation Problem," the inspectors determined the finding was of very low safety significance (Green) because the licensee failed to implement a risk significant planning standard (10 CFR 50.47(b)(4)) during an actual Notice of Unusual Event. This finding was associated with a cross-cutting aspect in the Resources component of the Human Performance cross-cutting area because the licensee did not ensure that procedures were accurate and adequate to assure nuclear safety. Specifically, when provided with sufficient evidence that the annunciators were not properly responding, licensee personnel delayed implementation of the Emergency Plan until further information was obtained. This was due to inaccurate and conflicting procedures and a lack of knowledge of the annunciator system. (H.2(c)) (Section 4OA5.2.5.b)

B. Licensee-Identified Violations

None.

REPORT DETAILS

Auxiliary Feedwater Voiding Event Summary

On January 31, 2011, NRC inspectors at Byron questioned the acceptability of voids in portions of essential service water (SX) supply piping to the AF pumps. Similar questions were asked by NRC inspectors at Braidwood on February 4, 2011. The purpose of the voided piping was to prevent SX water intrusion into the steam generators through valve leak-by, which would have an adverse chemical effect since SX water is not chemically treated to the same standards as condensate storage tank (CST) water.

The NRC questions were entered into the licensee's corrective action program as Issue Report (IR) 1172938 at Byron and IR 1173517 at Braidwood. Both IRs concluded that the AF systems were operable with the voids present. The Byron licensee used previously installed vent valves in the voided piping areas to fill and vent the voided areas on February 15, which eliminated current operability questions. Braidwood did not have vent valves installed and did not initially fill the voided piping areas. Braidwood Operability Evaluation (OpEval) 11-003, Rev. 0, dated February 15, was generated and concluded the AF system was operable with the voids present. The 1A AF train at Braidwood was vacuum filled on February 26, but was not verified water solid through ultrasonic testing. A modification to install vent valves on the 2B AF train was completed and the piping filled, vented, and verified water solid on March 25. Similar actions were accomplished for the 1B AF train on March 26.

On March 29, the licensee received preliminary analysis results for Braidwood from a contractor, which concluded that the void fraction at the 2A and 2B AF pump suction did not meet industry acceptance criteria under certain suction swap-over scenarios. As a result, Braidwood declared the 1A and 2A AF trains inoperable since the 1A AF train had not been verified water solid and the modification for the 2A AF train had not been completed. Vent valves were subsequently installed in the 2A and 1A AF trains and both trains were filled, vented, verified water solid, and declared operable on March 30 and March 31, respectively. Event Notification (EN) 46707 for Braidwood and EN 46708 for Byron were submitted to the NRC on March 30, 2011, in accordance with 10 CFR 50.72(b)(3)(ii)(B).

Loss of Annunciators Event Summary

On March 24, 2011, Braidwood Station Unit 2 submitted Event Notification 46694 for entry into Emergency Action Level (EAL) MU6 (Notice of Unusual Event), "Unplanned loss of most or all safety system annunciation or indication in the control room for greater than 15 minutes." During a planned maintenance activity on the Unit 2 main control room alarm cabinets, it was identified that all Unit 2 safety system annunciators were unavailable.

On March 30, 2011, Braidwood Station Unit 2 submitted Event Notification 46712 for the discovery of an after-the-fact emergency condition (Notice of Unusual Event). During a review of the March 24, 2011, event, it was identified that a previous unknown loss of annunciators had occurred on August 10, 2010, from 10:24 a.m. to 11:36 a.m. on Unit 2. This condition occurred during planned maintenance on annunciator cabinet 2PA19J power supply capacitors.

Inspection Scope

A Special Inspection was initiated following the NRC's review of the deterministic and conditional risk criteria specified in Management Directive 8.3, "NRC Incident Investigation Program." The inspection was conducted in accordance with NRC Inspection Procedure

(IP) 93812, "Special Inspection." The Special Inspection Charter, dated April 4, 2011, is included as Attachment 2. The team reviewed technical and design documents, procedures, maintenance records, corrective action documents, interviewed station personnel, gathered information from the plant computers and event recorders with alarm printouts, and performed physical walkdowns of plant equipment. A list of specific documents reviewed is provided in Attachment 1.

4OA5 Other Activities - Special Inspection (93812)

As detailed in the Special Inspection Charter (Attachment 2), the following items were reviewed and associated results obtained.

1. UNANALYZED CONDITION ASSOCIATED WITH AUXILIARY FEEDWATER SYSTEM

.1 Develop a time line for the unanalyzed condition

a. Inspection Scope

The inspectors reviewed the sequence of events at Braidwood and Byron, including licensee evaluations of the condition, responses to questions raised by inspectors, and any prior opportunities to identify that the basis for accepting the voids was not sufficient.

A detailed sequence of the events surrounding the AF system alternate suction voids for Braidwood and Byron is included as Attachment 3.

b. Findings and Observations

The inspectors identified prior opportunities to identify the insufficient basis for void acceptability. Additional information regarding the inspectors' evaluation of these prior opportunities is included in Section 4OA5.1.7 of this report.

.2 Review information relied upon by Braidwood and Byron to support initial design acceptance and determine whether the acceptance review was adequate

a. Inspection Scope

The inspectors reviewed design and licensing documentation to determine the circumstances surrounding the acceptance of the AF system design and interfaces with the SX system. Vendor system description documentation dating to the time of construction indicated that the AF and SX systems at Braidwood and Byron were designed to include a voided section in the SX supply piping to the AF system. The purpose of this voided section was to prevent SX water from leaking by valve seats and into the steam generators, which would have an adverse effect on steam generator water chemistry. The inspectors were unable to determine details about initial design review or acceptance of the voids by the licensee, but concluded that the inclusion of voids in the SX supply piping to the AF system was known to the licensee at the time of construction.

b. Findings and Observations

(Unresolved Item) Design of Auxiliary Feedwater System Included Voids in Safety-Related Alternate Suction Flowpaths

This Unresolved Item (URI) is applicable to Braidwood Station, Units 1 and 2, and Byron Station, Units 1 and 2.

Introduction: A URI was identified by the inspectors during the review of voided sections of AF alternate suction piping affecting all AF trains at Braidwood and Byron. Specifically, the inspectors questioned the acceptability of the voids and the potential impact on the AF systems, and an adequate technical justification from the licensee was not readily available.

Description:

Background

The AF system provides decay heat removal by cooling the steam generators following a reactor shutdown. The normal supply of water to the AF system is from the nonsafety-related condensate storage tank (CST), which contains chemically treated water. In the event the CST becomes empty or damaged, the alternate water source is the safety-related SX system, which provides lake water at Braidwood and river water at Byron.

The design of the AF systems at Braidwood and Byron included a section of SX supply to AF piping that was maintained voided between two valves with a partially open drain. The purpose of this configuration was to prevent SX water intrusion into the steam generators through valve leak-by, which would have an adverse chemical effect since SX water is not chemically treated to the same standards as CST water.

Byron Discussion

On January 31, 2011, NRC inspectors at Byron questioned the existence of voided sections of piping in the SX supply to the AF system.

At Byron, the NRC questions were entered into the CAP as IR 1172938. In response to the question identified in the subject IR, the Byron licensee concluded that the AF system was operable with the voids present based on a 1993 Byron Engineering letter addressed to the Braidwood and Byron Station Managers. This letter documented that the AF pumps would not be adversely affected by the ingestion of the assumed voids through the pumps following a swap-over from the CST to the SX water supply. As a basis for this conclusion, the letter referenced a 1987 telephone conversation with the pump vendor and a Duke Engineering Services letter, neither of which were attached to the Byron Engineering letter.

The inspectors at Byron questioned whether this conclusion was valid since no formal documentation supporting the conclusion was included with the 1993 Byron Engineering letter.

Despite an exhaustive effort at Byron, neither a record of the telephone conversation with the pump vendor or a copy of the Duke Engineering Services letter that provided the basis for the conclusion in the Byron Engineering letter could be found.

At Byron, in the absence of formal documentation supporting the conclusion that the AF pumps would not be adversely impacted by the ingestion of the voids following a swap-over from the CST to the SX water supply, previously installed vent valves in the voided piping sections were used to fill the voids in all four AF trains on Unit 1 and Unit 2 on February 15, which eliminated current operability questions.

Event Notification (EN) 446708 for Byron was submitted to the NRC on March 30, 2011, in accordance with 10 CFR 50.72(b)(3)(ii)(B).

Braidwood Discussion

Based on the questions raised by NRC inspectors at Byron, similar questions were asked by NRC inspectors at Braidwood on February 4, 2011.

At Braidwood, the NRC questions were entered into the CAP as IR 1173517. In response to the questions identified in the subject IR, the Braidwood licensee also concluded that the AF system was operable with the voids present based on the 1993 Byron Engineering letter addressed to the Braidwood and Byron Station Managers.

The inspectors at Braidwood also questioned whether this conclusion was valid since no formal documentation supporting the conclusion was included with the 1993 Byron Engineering letter to the Braidwood Station Manager.

Despite an exhaustive effort at Braidwood, neither a record of the telephone conversation with the pump vendor or a copy of the Duke Engineering Services letter that provided the basis for the conclusion in the Byron Engineering letter could be found.

However, Braidwood was unable to fill the voided piping sections because the sections of piping containing the voids did not have vent valves installed as was the case at Byron. Instead, Braidwood generated Operability Evaluation 11-003, dated February 15, which concluded the AF system was operable with the voids present. This conclusion was based largely upon the 1993 Byron Engineering letter to the Braidwood Station Manager. In the absence of vendor documentation, Braidwood formally requested a more detailed analysis of the acceptability of the voided sections of piping from a vendor on March 23.

In the absence of installed vent valves in the voided piping sections, Braidwood attempted to vacuum fill the piping sections for all four AF trains to remove the voids. This was completed on February 26, but was only successful for the 1A AF train due to excessive leakage past the isolation valves used to establish the void. However, the 1A AF piping was not ultrasonically tested to verify that it was water solid.

Braidwood subsequently developed engineering change packages for all four AF trains to add vent valves to facilitate filling the voided piping sections. The 2B AF train vent valve installation was completed and the piping filled, vented, and verified water solid on March 25. A similar vent valve installation, followed by a fill, vent, and water solid verification, was accomplished for the 1B AF train on March 26.

Preliminary information was received from the vendor for the 2B AF train at Braidwood on March 29 and for both Braidwood Unit 2 AF trains on April 5, which concluded that the void fraction at the 2A and 2B AF pump suction did not meet industry acceptance criteria. As a result, Braidwood declared the 1A and 2A AF trains inoperable since the 1A AF train had not been verified water solid and the vent valve modification to the 2A AF train had not been completed and the piping had not been filled. Vent valves were subsequently installed on the 2A and 1A AF trains at Braidwood, and both trains were filled, vented, verified water solid, and declared operable on March 30, and March 31, respectively.

Event Notification 46707 for Braidwood was submitted to the NRC on March 30, 2011, in accordance with 10 CFR 50.72(b)(3)(ii)(B).

Vendor analyses for the remaining 1A and 1B Braidwood AF trains and all four Byron AF trains were provided on April 15. The analyses concluded that the void fraction at the pump suction for the 1A AF trains at Braidwood and Byron was within industry acceptance criteria limits. The void fraction at the pump suction for the 1B, 2A, and 2B AF trains at Braidwood and Byron did not meet acceptance criteria limits. After the vendor analyses were received, Braidwood and Byron elected to contract a second vendor to perform full-scale testing of the impact of the AF void configurations at a testing facility.

The inspectors reviewed the vendor analyses and discussed a number of questions and concerns with licensee personnel. A large number of simplifying assumptions were used in the vendor analyses, and there were limitations in the accuracy of computer modeling of multi-phase flow and voiding. As a result, the inspectors concluded that useful information could be gained from the full-scale testing planned by Braidwood and Byron. At the conclusion of the inspection, NRC inspectors were following development of the full-scale testing plan. This issue is an Unresolved Item pending NRC review of the full-scale testing and results. (**URI 05000456/2011012-01; 05000457/2011012-01; 05000454/2011015-01; 05000455/2011015-01, Design of Auxiliary Feedwater System Included Voids in Safety-Related Alternate Suction Flowpaths**)

.3 Review recent vendor-developed calculations and assess the conclusion that operability could no longer be supported

a. Inspection Scope

The inspectors reviewed vendor-developed hydraulic analyses of the potential impact of the voided sections of SX to AF supply piping on the AF pumps for Braidwood and Byron.

b. Findings and Observations

Preliminary results from the first analysis were received at Braidwood for the 2B AF train on March 29 and for both Braidwood Unit 2 trains on April 5. This analysis concluded that the void fraction at the Braidwood 2A and 2B AF pump suction did not meet industry acceptance criteria. As a result, the licensee concluded that 2A and 2B AF trains at Braidwood were inoperable with the designed void in the SX to AF supply piping. The inspectors also reviewed a second analysis, which addressed Braidwood Unit 1 and Byron Units 1 and 2 that was provided to Braidwood and Byron on April 15.

This analysis concluded that the void fraction at the AF pump suction for six of the eight total AF trains did not meet industry acceptance criteria. Only the 1A AF trains at Braidwood and Byron did not exceed the industry void fraction acceptance criteria. The inspectors noted that the analyses were conducted using RELAP5 models for each AF train at Braidwood and Byron. As of the end of this inspection, the NRC had not accepted or endorsed any software package, including RELAP5, for the application of modeling void transport.

.4 Review the adequacy of the modifications at Braidwood to install high point vents and fill the voided piping and review why these high point vents were previously installed at Byron, but not Braidwood

a. Inspection Scope

The inspectors reviewed Engineering Changes (ECs) 383301, 383302, 383303, and 383304 detailing the installation of vent valves in the voided section of SX supply to AF suction piping at Braidwood.

b. Findings and Observations

Because Braidwood did not have installed vent valves in the voided piping sections, engineering changes (ECs) were developed at Braidwood to add vent valves to fill the voided piping sections.

As part of the ECs to add vent valves at Braidwood, the licensee revised the piping structural analyses, and the inspectors reviewed those calculations. The inspectors determined that vent valves were previously installed at Byron as an operational convenience to allow for more rapid draining of the voided space between the SX supply to AF suction motor-operated valves following routine valve stroking surveillances. Braidwood previously evaluated this modification and elected not to install similar vent valves.

.5 Review the 50.72 reports generated by Braidwood and Byron and determine whether these reports were timely and accurate

a. Inspection Scope

The inspectors reviewed the ENs made by Braidwood (EN 46707) and Byron (EN 46708). The inspectors reviewed the ENs to determine whether they were submitted in a timely manner, provided technically accurate information, and were reported under the appropriate sections of 10 CFR Part 50.72.

b. Findings and Observations

No issues were identified with the ENs that were submitted.

.6 Determine whether other issues that have been reported as required by 10 CFR 50.72 have similarities to the reported unanalyzed condition for the AF system and assess these similarities to determine if any common causes or themes exist

a. Inspection Scope

The inspectors reviewed all ENs submitted by Braidwood and Byron over the previous 5 years to determine whether similarities or common themes existed between the circumstances surrounding prior Event Reports and the SX supply to AF suction void issue.

b. Findings and Observations

Event Notifications 46415 (Braidwood) and 46416 (Byron), dated November 12, 2010, reported an unanalyzed condition associated with the operation of the component cooling water (CC) system. Specifically, a design flaw in the CC system was identified that resulted in the inability to use the standby CC train as an operable spare train when another train was out of service. In addition, the licensee identified that inaccurate information was provided to the NRC in a 1987 License Amendment Request (LAR) to extend the Technical Specification (TS) allowed outage time for a CC train.

The inspectors reviewed the root cause evaluation for the CC issue and noted multiple missed opportunities to identify the error in the amendment request. The missed opportunities were generally attributed to a lack of questioning attitude and technical rigor. The system design basis was not investigated to a depth necessary to identify and correct technical deficiencies. The inspectors noted that the lack of a questioning attitude was a common theme in the CC and SX/AF unanalyzed conditions.

.7 Review and assess the Braidwood and Byron evaluation of this issue

a. Inspection Scope

The inspectors reviewed the Braidwood and Byron evaluations of the AF system in response to industry operating experience regarding gas accumulation in safety systems that was issued in January 2008. The Byron evaluation was documented in ECs 376806 and 379027 and the Braidwood evaluation was documented in IR 728092. The inspectors also reviewed IRs 1172398 (Byron) and 1173517 (Braidwood), which were written in response to NRC questions about void acceptability in January and February 2011. Braidwood Operability Evaluation 11-003, which formally documented the licensee's position on AF pump operability following NRC questioning, was also reviewed.

The inspectors also reviewed the communications between Braidwood and Byron following NRC questioning of the acceptability of the voids. As part of this review, the inspectors evaluated whether the licensees' actions following identification were conservative, appropriate, and properly prioritized.

b. Findings and Observations

The inspectors' review of communications between Braidwood and Byron revealed limited and inconsistent communications, especially once the voids at Byron were filled. Despite having nearly identical AF system configurations, the evaluations in response

to the January 2008 industry operating experience on gas voids in safety systems came to different conclusions on whether the SX supply to AF suction voids should be filled. Also, while both evaluations referenced the 1993 Byron letter, the Byron evaluation raised some questions about the basis for accepting the void whereas the Braidwood evaluation accepted the basis in the 1993 Byron letter without question. In addition, discussions with plant personnel indicated that once the Byron voids were filled, communications about the voids between the two sites decreased substantially. The inspectors concluded that communications between the engineering departments at Braidwood and Byron was less formalized and frequent than expected, given the similarities between the sites.

The inspectors at Byron initially questioned acceptability of the SX supply to AF suction voids on January 31, 2011. The issue was first entered into the CAP (IR 1172938) on February 9. Byron ultimately addressed the unanalyzed condition when the SX supply to AF suction voids in all four trains were filled on February 15. Overall, the inspectors concluded that filling the voided portions of AF suction piping was a prudent action that eliminated questions about operability in the current condition. However, the inspectors noted weaknesses in the licensee's initial response to the void acceptability questions by waiting 9 days to enter the issue into the CAP and 2 weeks before filling the voided portions of piping.

The inspectors at Braidwood initially questioned acceptability of the SX supply to AF suction voids on February 4, 2011. The issue was first entered into the CAP (IR 1173517) on February 10. Braidwood completed Operability Evaluation 11-003, Rev. 0, on February 15, which concluded that the voids would have no adverse affect on AF system operability. Because vent valves were not installed at the void locations, the licensee attempted a vacuum fill of the four voids on February 26, which was only successful for one of the four AF trains. A formal contract was issued to a vendor for an analysis of the potential void impact on March 23. Braidwood ultimately addressed the unanalyzed condition when all four SX supply to AF suction voids were filled by March 31. Overall, the inspectors concluded that the response to the issue at Braidwood was not conservative in nature. After the issue was initially raised by inspectors, the licensee waited 6 days to enter inspector concerns about void acceptability into the CAP, 3 weeks before the first attempt to fill the void, and nearly 2 months before the unanalyzed condition was fully addressed. While the timing of the licensee's response was affected by the conclusion in OpEval 11-003, Rev. 0, that the AF system remained operable, this OpEval justified operability by relying on the same inadequate technical basis that had been questioned by inspectors and was not ultimately supported by vendor analyses.

Failure to Adequately Document and Justify the Continued Operability of the Auxiliary Feedwater System

This finding is applicable to Braidwood Station, Units 1 and 2 and Byron Station, Units 1 and 2.

Introduction: A finding of very low safety significance (Green) was identified at the Braidwood and Byron Stations by the inspectors when licensee personnel failed to adequately document and justify continued operability of the AF system. Specifically, licensee evaluations of known voids in the AF alternate source suction piping did not

provide an adequate technical basis to support operability of the AF pumps during a suction swap-over scenario.

Description: On January 31, 2011, NRC inspectors at Byron questioned the existence of voided portions of piping in the SX supply to the AF system. Similar questions were asked by NRC inspectors at Braidwood on February 4, 2011. The AF system provides decay heat removal by cooling the steam generators following a reactor shutdown. The normal supply of water to the AF system is from the nonsafety-related CST, which contains chemically treated water. In the event the CST becomes empty or damaged, the water source automatically swaps to the safety-related SX system, which provides lake or river water. A voided section of piping, between two valves with a partially open drain, was maintained in the SX piping near the AF pump suction. The purpose was to prevent SX water intrusion into the steam generators through valve leak-by, which would have an adverse chemical effect since SX water is not chemically treated to the same standards as CST water. This voided section was maintained in both AF trains at all four Byron and Braidwood Units.

In response to NRC questions, the licensee provided a letter, dated May 28, 1993, from Byron engineering personnel to the Byron and Braidwood Station Managers as a basis for accepting the existence of the voids. The letter stated that Byron Engineering had reviewed a Duke Engineering Services letter, dated May 14, 1993, and concluded that it did not apply to Byron or Braidwood. However, the licensee could not locate the Duke letter and did not know what it contained. The Byron letter also referenced a 1987 telephone conversation with a vendor representative, in which the vendor concluded that no failure of the AF pump was expected if 1.5 cubic feet of air at 80 psig passed through the pump. However, this statement could not be verified and no calculations or analyses were located to support the conclusion.

The licensee initiated IR 1172938 at Byron and IR 1173517 at Braidwood to document the response to NRC questions about acceptability of the voids. Both IRs used the Byron 1993 letter as a basis to conclude that the voids had been evaluated and the AF systems were operable. Specifically, IR 1172938 included the statement, "*The evaluation contained in the CHRON letter remains as the basis for acceptability of the existing void,*" and IR 1173517 included the statement, "*Based on the related discussion between Byron and Braidwood personnel regarding this issue, at this time there are no operability concerns. The corresponding Byron IR is 1172398.*"

Byron elected to fill and vent the voided portions of piping, which was completed on February 15, 2011, and eliminated current operability questions. Braidwood did not fill the voided piping and generated OpEval 11-003, Rev. 0, on February 15, 2011, to formally document the operability conclusion. The basis for operability in OpEval 11-003 was again the 1993 Byron letter, despite acknowledgement in the OpEval that the related documentation could not be located. OpEval 11-003, Rev. 0, included the statements, "*This configuration has been previously evaluated by the AF pump vendor [vendor name redacted] as acceptable for pump operation during swapover from the normal CST water source to the SX system as documented in engineering letter CHRON 120086 dated May 28, 1993,*" and, "*We currently meet the definition of reasonable expectation in that this issue was brought up before and resolved to the satisfaction of those involved, including senior management at both Byron and Braidwood stations.*"

The licensee contracted a vendor to perform a computer model analysis of the voided piping sections to obtain information to support the conclusion of OpEval 11-003 and the licensee's past operability review. Results of the vendor analysis were provided to the licensee on April 5, 2011, and concluded that void fraction at the Braidwood 2A and 2B AF pump suction did not meet industry acceptance criteria. As a result, the licensee declared the unfilled trains at Braidwood (the 1A train had not been verified water solid following vacuum fill and the 2A train had not yet been filled) inoperable. Braidwood OpEval 11-003 was updated to Revision 1, which concluded that the AF systems were not operable with the voids present. Event Notification (EN) 46707 for Braidwood and EN 46708 for Byron were submitted on March 30, 2011, in accordance with 10 CFR 50.72(b)(3)(ii)(B), which required an 8-hour event notification for unanalyzed conditions that significantly degrade plant safety. During a review of the circumstances surrounding the issue, the inspectors noted that the licensee had a prior opportunity to determine that AF operability could not be supported based on the existing evaluation of the voids. Specifically, industry operating experience that had been issued in January 2008 discussed gas intrusion in safety-related systems. The AF system at Byron was evaluated in ECs 376806 and 379027. The Byron ECs included the statement, *"Conversations with the pump vendor indicate this void may not be qualifiable. Therefore, Operating will have to alter the practice of leaving this segment void,"* and recommended filling the voids. However, the voids were not filled and operability concerns were not raised. The Braidwood AF system was evaluated in IR 728092, which included the statement, *"There is an existing document (Chron #120086) that evaluates the void size left between the 1/2AF006A/B and 1/2AF017A/B sections. This documentation makes it acceptable to leave this piping void."* The Braidwood evaluation concluded that the voids were acceptable and raised no operability concerns.

At the end of this inspection, a Root Cause Evaluation (RCE) was initiated under IR 1194196 (Braidwood) and IR 1194324 (Byron) to determine why prior opportunities for discovery of the inadequate void acceptance basis were missed and to develop associated corrective actions.

Analysis: The inspectors determined that the failure to adequately document and justify the continued operability of the AF systems at Braidwood and Byron was a performance deficiency. Specifically, when evaluating the impact of voids in portions of the AF suction piping, the Braidwood and Byron licensee repeatedly relied on a Byron 1993 letter that contained insufficient justification to support AF operability with voids present. The inspectors determined that the finding was more than minor because, if left uncorrected, the failure to recognize conditions that could render equipment inoperable has the potential to lead to a more significant safety concern.

The underlying technical issue was being evaluated separately, as discussed in Section 4OA5.1.2.b of this inspection report. The inspectors conducted a Phase 1 SDP Screening of the inadequate evaluations of the AF voids at Braidwood and Byron, in accordance with Inspection Manual Chapter (IMC) 0609, Attachment 4. Using Table 2, the inspectors determined the finding affected the Mitigating Systems cornerstone. Because the finding was not a design deficiency; did not result in a loss of safety function; and did not screen as potentially risk significant due to a seismic, flooding, or severe weather initiating event, the inspectors concluded that the finding was of very low safety significance (Green). This finding was associated with a cross-cutting aspect in the Decision-Making component of the Human Performance cross-cutting area (H.1(b))

because the licensee did not use conservative assumptions and did not verify the validity of underlying assumptions in their evaluations of the AF suction piping voids. Specifically, the supporting information for the Byron 1993 letter documenting void acceptability could not be located, but the letter was used as a basis for void acceptance and AF system operability.

Enforcement: This finding does not involve enforcement action because no regulatory requirement violation was identified. Because this finding does not involve a violation and has very low safety significance, it is identified as **FIN 05000456/2011012-02; 05000457/2011012-02; 05000454/2011015-02; 05000455/2011015-02, Failure to Adequately Document and Justify Continued Operability of the Auxiliary Feedwater System.**

2. NOTICE OF UNUSUAL EVENT ASSOCIATED WITH LOSS OF ANNUNCIATORS

.1 Construct a timeline for the loss of annunciator events at Braidwood

a. Inspection Scope

The inspectors reviewed the sequence of events surrounding the loss of all main control room annunciators at Braidwood Unit 2 on March 24, 2011, and August 10, 2010, including operator actions, plant conditions, circumstances surrounding the maintenance activity, any prior instances of a potential loss of control room annunciators, and extent of condition at Byron.

A detailed sequence of events for the August 10, 2010, and March 24, 2011, Loss of Annunciator Events is included as Attachment 4.

b. Findings and Observations

The inspectors identified the following occasions where prior maintenance on the annunciator system de-energized the 2PA19JV4 panel, which most likely resulted in the loss of annunciators.

June 11, 2002: Unit 1 annunciators were likely unavailable from 11:50 a.m. to 1:50 p.m.

June 19, 2002: Unit 2 annunciators were likely unavailable from 9:24 a.m. to 1:27 p.m.

July 22, 2002: Unit 1 annunciators were likely unavailable from 9:57 a.m. to 11:03 a.m.

February 19, 2003: Unit 1 annunciators were likely unavailable from 9:24 a.m. to 10:54 a.m.

The June 11, 2002, event was the first performance of a new periodic maintenance task and the operators received unexpected responses from the annunciator system. Operators suspended the activity due to a lack of confidence in the guidance provided by BwOP AN-10, "1PA19J Annunciator Cabinets Power Supply Energization/De-energization," and unfamiliarity with the situation. The licensee initiated IR 00111478, and BwOP AN-10 was revised prior to the next attempt.

.2 Review and assess the licensee's evaluation of the March 24, 2011, and August 10, 2010, loss of Braidwood Unit 2 control room annunciators

a. Inspection Scope

The inspectors reviewed corrective action documents related to the loss of annunciator events to determine whether the circumstances were accurately described. A root cause evaluation was ongoing at the conclusion of the inspection. The inspectors reviewed the root cause evaluation plan and determined whether the scope of investigation and composition of the team were appropriate.

b. Findings and Observations

No issues were identified with the root cause evaluation plan or scope and composition of the team.

3. Independently review plant data and records to evaluate the licensee's assessment of the loss of annunciator events and corrective actions

a. Inspection Scope

The inspectors reviewed the technical design of the annunciator systems at Braidwood and Byron. The annunciator system for each unit consisted of three sections of annunciator logic circuits that were powered independently. For the logic circuits to function properly, a clock signal was required, which drives the change in status of the annunciators (i.e., allows an annunciator to change between lit, not lit, and flashing.) This clock signal was provided by either primary or backup clock cards that were powered by separate sections of the annunciator system. The intended system design was for the primary clock card to provide the clock signal with an automatic switch to the backup clock card if the primary clock card failed. There was no automatic switch in the other direction. An alarm would be generated if either clock card failed or if the system was operating on the backup clock card.

The licensee determined that a wiring error in Braidwood Units 1 and 2 caused the annunciator clock failure alarm to operate opposite to the design. The alarm would be received when the circuit was in the intended configuration with the primary clock card providing the clock signal, and would clear when the backup clock card was providing the clock signal. As a result, Braidwood Units 1 and 2 had likely been operating on the backup clock card for the life of the plant. The loss of annunciators occurred when power was removed from the backup clock circuit while the backup clock card was providing the required clock signal. Since this removed the clock signal, the annunciator system logic was unable to change the state of the annunciators; each annunciator was frozen in its current condition of lit, not lit, or flashing.

The inspectors reviewed the licensee's assessment that the cause of the loss of annunciators was the result of a wiring error. In addition, the licensee identified a design drawing error for Braidwood Unit 1. The annunciator systems at Byron Units 1 and 2 were wired to operate correctly. The inspectors determined that the licensee's conclusions were appropriate.

b. Findings and Observations

Incorrect Installation of Annunciator System Wiring

This finding is applicable to Braidwood Station, Units 1 and 2.

Introduction: A finding of very low safety significance was self-revealed when licensee personnel failed to properly install portions of the annunciator system circuitry in accordance with the design specifications. Specifically, wiring in the annunciator system clock circuitry (the portion of the annunciator system circuitry that allowed annunciators to change status) was incorrectly installed, which resulted in an unexpected loss of all Braidwood Unit 2 control room annunciators on March 24, 2011.

Description: On March 24, 2011, licensee personnel commenced planned maintenance on the Braidwood Unit 2 main control room annunciators. This maintenance activity was expected to result in the loss of approximately one-third of all annunciators. In order to perform the maintenance activity the licensee removed power from 2PA19JV4, which provided power to the backup clock circuit for the annunciators. The clock circuit had been unknowingly operating on the backup, rather than the primary, power supply. As a result, the removal of power to the backup power supply caused a loss of the annunciator clock circuit and the annunciators lost the ability to change state; each annunciator was frozen in its current condition of lit, not lit, or flashing. This was subsequently identified by main control room operators and the licensee declared a Notice of Unusual Event (EN 46712) per their Emergency Action Level (EAL) scheme. The licensee suspended the maintenance activity and restored power to the backup clock circuit to return the annunciator system to service.

The licensee investigated the event and identified a wiring error in the clock fail circuit, such that the wiring was not installed in accordance with the applicable design specification (Design Specification F-2818/L-2828.) If installed correctly, an annunciator would be lit when the system was being supplied by the backup clock circuit rather than the primary clock circuit, or if a clock circuit card failed. However, as installed, the system would have generated an annunciator system alarm only when the system was being powered by the primary clock circuit and both clock circuit cards were operational. The alarm would clear when the system was being supplied by the backup clock circuit. The licensee's investigation also found that the primary clock circuit had not been reset following prior maintenance, thus it was unable to provide power. As a result, the annunciator clock circuitry was unknowingly powered through the backup rather than primary clock circuitry. When power was removed from the backup clock circuit via 2PA19JV4 the entire clock circuit lost power, which prevented the annunciators from changing state.

The licensee entered the issue into the CAP as IR 1192465, corrected the wiring to provide the intended function, and revised procedures used to energize and de-energize the system.

Analysis: The inspectors determined that failure to properly install the Unit 1 and Unit 2 annunciator clock alarm circuitry in accordance with Design Specification F-2818/L-2828 was a performance deficiency. Design Specification F-2818/L-2828 cited Institute of Electrical and Electronics Engineers (IEEE) 336-1971, "Installation, Inspection, and Testing Requirements for Instrumentation and Electric Equipment

During the Construction of Nuclear Power Generating Stations,” as a required standard. The IEEE standard required electrical testing “to ascertain proper phasing and functioning of equipment, including indicating meters, recorders, transducers, targets and lamps, annunciators and alarms, controls, interlocks, protective relays and breakers.” The finding was determined to be more than minor because it was associated with the Equipment Performance attribute of the Mitigating Systems cornerstone and affected the cornerstone objective of ensuring the availability, reliability, and capability of systems that respond to initiating events to prevent undesirable consequences. Specifically, annunciator system redundancy was adversely affected and when the annunciator panels were de-energized, the ability of operators to identify and respond to abnormal plant conditions was degraded.

The inspectors determined the finding could be evaluated using the SDP in accordance with IMC 0609, “Significance Determination Process,” Attachment 4, “Phase 1 - Initial Screening and Characterization of Findings,” Table 4a, for the Mitigating Systems cornerstone. Because the finding was not a design deficiency, did not result in a loss of safety function, and did not screen as potentially risk significant due to a seismic, flooding, or severe weather initiating event, the inspectors concluded that the finding was of very low safety significance (Green). The inspectors did not identify a cross-cutting aspect associated with this finding because it was not indicative of current performance. The wiring installation error most likely occurred during the time of initial construction.

Enforcement: This finding does not involve enforcement action because no regulatory requirement violation was identified. Because this finding does not involve a violation and has very low safety significance, it is identified as **FIN 05000456/2011012-03; 05000457/2011012-03, Incorrect Installation of Annunciator System Wiring.**

4. Review and assess the licensee’s repair activities to restore the main control room annunciator systems

a. Inspection Scope

The inspectors reviewed the licensee’s corrective actions and repair activities.

b. Findings and Observations

The licensee reconfigured the clock alarm circuit wiring such that the system would operate as designed and reset the circuit. The licensee also initiated procedure changes to include a requirement to reset the system to the primary clock card following maintenance that affects power to the primary clock card. The licensee verified correct clock circuit operation through testing and thermography inspections. The inspectors concluded that the repair activities appropriately restored the design to function as originally intended, with the primary clock card providing the clock signal and an alarm signaling when the system is powered from the backup clock card.

5. Evaluate and assess the impact of the March 24, 2011, and August 10, 2010, loss of annunciator events

a. Inspection Scope

The inspectors reviewed the circumstances surrounding the Braidwood Unit 2 loss of annunciator events on August 10, 2010, and March 24, 2011, including operator response to the events, implementation of the Emergency Plan, and the impact on the ability of operators to respond to plant events.

b. Findings and Observations

Untimely Declaration of a Notice of Unusual Event

This finding is applicable to Braidwood Station, Unit 2.

Introduction: The inspectors identified a finding of very low safety significance (Green) and an associated non-cited violation of 10 CFR 50.54(q) when licensee personnel failed to promptly declare a Notice of Unusual Event in accordance with the Braidwood Emergency Plan. Specifically, on March 24, 2011, contrary to the Braidwood Station Radiological Emergency Plan Annex, the licensee did not declare EAL MU6 (Notice of Unusual Event) within 15 minutes of indications of a loss of greater than 75 percent of Unit 2 main control room safety system annunciators.

Description: At 9:52 a.m. on March 24, 2011, planned maintenance commenced on the Braidwood Unit 2 control room annunciator system that was expected to result in the loss of approximately one-third of the control room annunciators. A fuse was removed in panel 2PA19JV7 to remove alternating current (AC) power from 2PA19JV3/V4 to allow for the maintenance activity to occur. When the fuse was removed, annunciator 1-4-A7 'ANNUNCIATOR POWER SUPPLY TROUBLE' re-flashed, as expected; however, the operators' attempt to acknowledge the alarm was unsuccessful. The operating crew discussed this abnormal response and at 9:57 a.m. attempted to test all Unit 2 annunciators using the TEST pushbuttons on each section of the control board. No response was received from any of the TEST pushbuttons.

The crew then attempted to induce an alarm. The first attempt was made by changing the selector switch position for the condensate pumps on panel 2PM05J. When the expected alarm was not received, the operators noted that this annunciator had been flagged as one expected to be made inoperable by the planned maintenance. The crew then attempted to cause a PROCESS CABINET DOORS OPEN alarm by opening the doors to panels 2PA01J and 2PA02J at 10:06 a.m., however, the expected alarm was not received. At this time, the Shift Manager (SM) declared all the annunciators unavailable. At 10:07 a.m., the SM directed the Electrical Maintenance Department (EMD) to immediately suspend the maintenance activity and restore the Unit 2 annunciator system. The SM declared Unusual Event MU6 at 10:18 a.m., after it was determined that all Unit 2 annunciators would be unavailable for greater than 15 minutes.

The Radiological Emergency Plan Annex for Braidwood Station, Revision 27, defined Unusual Event MU6 as an unplanned loss of most (greater than 75 percent) safety system annunciators for greater than 15 minutes. A note in EAL MU6 stated,

“The Emergency Director should declare the event as soon as it is determined the condition has exceeded, or will likely exceed the applicable time.” The inspectors concluded that sufficient information was available at 9:57 a.m. to conclude that the annunciators were not responding. As a result, the licensee failed to meet the time requirements of the Braidwood Emergency Plan because the Notice of Unusual Event declaration was not made until 10:18 a.m. (greater than 15 minutes from 9:57 a.m.).

This issue was entered into the licensee’s CAP as IR 1191669 and IR 1199930. Corrective actions included implementation of Standing Order 11-007; clarifying the function of the annunciator test pushbuttons in determining whether a loss of annunciators had occurred; training to reinforce standards in determining whether a loss of annunciators had occurred; and revisions to procedures 1/2 BwOS AN-1a, “Loss of Annunciators,” and 1/2 BwOA-ELEC-7, “Loss of Annunciators,” to clarify information about the test push buttons.

Analysis: The inspectors determined that the failure to classify an EAL within the required timeframe was a performance deficiency. Traditional enforcement did not apply because the issue did not have actual safety consequences or the potential for impacting the NRC’s regulatory function, and was not the result of any willful violation of NRC requirements or licensee procedures. The finding was more than minor because it was associated with the Emergency Response Organization Performance attribute of the Emergency Preparedness cornerstone, and adversely affected the cornerstone objective of implementing adequate measures to protect the health and safety of the public in the event of a radiological emergency. Delays in activation and notification of emergency conditions could adversely affect the health and safety of the public.

The inspectors determined the finding was associated with an actual event implementation problem, and assessed the significance using IMC 0609, Appendix B, “Emergency Preparedness Significance Determination Process.” Using the Emergency Preparedness SDP, Sheet 2, “Actual Event Implementation Problem,” the inspectors determined the finding was of very low safety significance (Green) because the licensee failed to implement a risk significant planning standard (10 CFR 50.47(b)(4)) during an actual Notice of Unusual Event.

This finding was associated with a cross-cutting aspect in the Resources component of the Human Performance cross-cutting area because the licensee did not ensure that procedures were accurate and adequate to assure nuclear safety. Specifically, when provided with evidence that the annunciators were not properly responding, licensee personnel delayed implementation of the Emergency Plan until further information was provided due to inaccurate and conflicting procedures, and a lack of knowledge of the annunciator system. Specifically, after one annunciator failed to acknowledge and all annunciators failed to respond to the TEST pushbuttons, the licensee attempted to induce additional annunciators for 9 minutes before implementing the Emergency Plan. (H.2(c))

Enforcement: Title 10 CFR 50.54(q) requires that licensees follow and maintain their emergency plans. The Radiological Emergency Plan Annex for Braidwood Station, Section 3, states, in part, “The Emergency Director should declare the event as soon as it is determined the condition has exceeded, or will likely exceed, the applicable time.” In addition, Exelon Procedure EP-AA-111, “Emergency Classification and Protective Action Recommendations,” step 4.1 states, “Once indication of an abnormal condition is

available, classification declaration must be made within 15 minutes.” Contrary to the above, on March 24, 2011, a Notice of Unusual Event was not classified within 15 minutes of indications of a loss of all control room annunciators. Specifically, when a loss of all Unit 2 control room annunciators occurred, conditions were met for classification of EAL MU6 in accordance with EP-AA-1001, Radiological Emergency Plan Annex for Braidwood Station; however, the EAL was not classified until 21 minutes after the confirming indication was received. This issue was entered into the licensee’s CAP as IR 1191669 and IR 1199930. Corrective actions included implementation of Standing Order 11-007; clarifying the function of the annunciator test push buttons in determining whether a loss of annunciators had occurred; training to reinforce standards in determining whether a loss of annunciators had occurred; and revisions to procedures 1/2 BwOS An-1a, “Loss of Annunciators,” and 1/2 BwOA-ELEC-7, “Loss of Annunciators,” to clarify information about the test push buttons. Because this violation was of very low safety significance and has been entered into the CAP as IR 1199930, it is being treated as a non-cited violation consistent with Section 2.3.2 of the NRC Enforcement Policy. **(NCV 05000457/2011012-04, Untimely Declaration of a Notice of Unusual Event)**

6. Starting from the time when a vulnerability to a loss of annunciator event began, identify and assess any missed opportunities to identify subsequent loss of annunciator events

a. Inspection Scope

The inspectors reviewed the conclusion that a wiring error combined with maintenance practices led to the loss of annunciator events and agreed with the conclusions. Based on that information, the inspectors reviewed historical documents to determine when the wiring error occurred and when certain maintenance practices were implemented. The inspectors then reviewed whether there were historical opportunities to previously identify the vulnerability to loss of annunciators.

b. Findings and Observations

The inspectors identified four missed opportunities to identify that the clock circuit was not functioning as designed.

- A maintenance evolution on June 11, 2002, resulted in unexpected annunciator system responses. The operators stopped the activity, entered the issue in the CAP, and implemented procedure revisions to BwOP-AN-10.
- On September 16, 2002, and again on September 17, 2002, following inverter replacements, maintenance technicians troubleshooting clock card failure alarms replaced the primary clock card, which cleared the alarm. With the alarms clear and positive indication of both clock cards functioning, the technicians assumed the system was operating correctly.
- On August 6, 2010, maintenance technicians replaced the primary clock card in Unit 2 during troubleshooting of the annunciator system. After resetting the system, the clock failure alarm was received. The technicians reseated the primary clock card, which cleared the alarm since it caused the system to transfer to the backup clock. With the alarms clear and positive indication of both clock cards functioning, the technicians assumed the system was operating correctly.

After a review of the circumstances surrounding each missed opportunity, the inspectors concluded that, since the system was indicating normal operation despite being wired incorrectly, it was not reasonable to expect the licensee to have identified the wiring error previously.

7. Perform an extent of condition review for the annunciator system and assess the results

a. Inspection Scope

The inspectors reviewed the licensee's extent of condition activities and performed independent extent of condition inspections at Braidwood Unit 1 and both Byron Units.

b. Findings and Observations

The licensee determined that the Braidwood Unit 1 wiring was also improperly installed and initiated IR 01192556. Corrective actions for the Unit 2 wiring were also completed on Unit 1. The wiring errors did not exist in either Byron Unit. The inspectors also reviewed other licensee records associated with the annunciator systems to determine the impact of other annunciator system issues. The inspectors did not identify any additional issues with the annunciator systems.

8. Evaluate operations and maintenance department interface during annunciator maintenance and assess whether interface issues contributed to the loss of annunciator events

a. Inspection Scope

The inspectors evaluated the interfaces between maintenance and operations personnel in the planning and execution of annunciator maintenance activities, including development of work documentation, pre-job briefings, and during conduct of the work.

b. Findings and Observations

The inspectors concluded that the interface between the departments was appropriate and did not contribute to the loss of annunciator events or issues with timely implementation of the Emergency Plan.

9. Evaluate the licensee's procedures and processes for annunciator maintenance and determine whether these procedures and processes are adequate

a. Inspection Scope

The inspectors reviewed maintenance and operations procedures associated with annunciator maintenance activities.

b. Findings and Observations

The licensee's maintenance procedures for inverter replacement controlled the removal and replacement of inverters through work orders. The procedures that removed and restored power to the annunciator cabinets were operations procedures. These procedures did not include a step to reset the clock circuit. With the errant indication showing that the system was functioning as designed, the licensee did not have an

indication that there was a problem with the system and was not aware of the need to revise the procedures.

As a corrective action, the licensee initiated procedure changes to include the requirement to reset the system to the primary clock after restoring power to the primary clock card. With the wiring corrections in place, an annunciator should indicate the need to reset the circuit. This annunciator should clear once the circuit is reset.

10. Evaluate and assess whether Byron has had similar loss of annunciator events and whether Byron is vulnerable to similar events

a. Inspection Scope

The inspectors walked down the Byron circuitry to verify that it was correctly installed.

b. Findings and Observations

Byron did not have the same wiring problem and was therefore not susceptible to the same issue.

3. ADDITIONAL INSPECTION REQUIREMENTS

1. Determine whether the two issues that are the subject of this Special Inspection at Braidwood and Byron have any common themes

a. Inspection Scope

The inspectors reviewed their observations and conclusions for each of the Charter items discussed in Sections 4OA5.1 and 4OA5.2 of this inspection report to determine whether there were common behavioral or cultural aspects that contributed to each issue.

b. Findings and Observations

The inspectors identified two common themes that were apparent in both the auxiliary feedwater alternate suction voids and the loss of control room annunciator issues.

First, the inspectors determined that non-conservative assumptions were apparent in aspects of both issues. The licensee repeatedly relied on the conclusions in the 1993 Byron letter in their evaluations of the AF alternate suction voids without challenging the information, which resulted in missed opportunities to identify that those conclusions could not be supported by available information. In addition, following the inability to acknowledge a flashing annunciator and failure of all annunciators to respond to any of the test pushbuttons, the licensee elected to continue troubleshooting the alarms rather than entering the emergency plan at that point. Taking a more conservative approach in the response to both issues could have resulted in quicker identification of AF operability questions and more timely emergency plan activation and annunciator restoration.

The inspectors also determined that a lack of technical rigor was apparent in aspects of both issues. The numerous evaluations of AF alternate suction voids were accepted and approved with very little technical basis for the conclusions and an incorrect

understanding of the annunciator system operation impacted the licensee's response to the loss of annunciators on March 24, 2011. More rigor in the evaluations of the AF alternate suction voids and in the operator training related to the annunciator system could have resulted in earlier identification of AF operability questions and more timely entry into the emergency plan and restoration of annunciators.

No regulatory issues were identified as a result of this review.

4OA6 Management Meetings

1. Exit Meeting Summary

On May 4, 2011, the inspectors presented the inspection results to Mr. D. Enright, Mr. B. Adams, and other members of the licensee staff. The licensee acknowledged the issues presented. The inspectors confirmed that proprietary information reviewed as part of this inspection was returned to the licensee.

ATTACHMENTS:

1. SUPPLEMENTAL INFORMATION
2. SPECIAL INSPECTION CHARTER
3. EVENT TIMELINE – BRAIDWOOD/BYRON AUXILIARY FEEDWATER ALTERNATE SUCTION PIPING VOIDS
4. EVENT TIMELINE – BRAIDWOOD UNIT 2 LOSS OF ANNUNCIATOR EVENTS

SUPPLEMENTAL INFORMATION

KEY POINTS OF CONTACT

Licensee

D. Enright, Site Vice President, Braidwood
M. Kanavos, Plant Manager, Braidwood
B. Adams, Plant Manager, Byron
A. Ferko, Engineering Director, Braidwood
E. Hernandez, Engineering Director, Byron
M. Marchionda-Palmer, Operations Director, Braidwood
D. Benyak, Director of Licensing, Exelon Cantera
P. Simpson, Licensing Manager, Exelon Cantera
P. Boyle, Maintenance Director, Braidwood
C. VanDenburgh, Regulatory Assurance Manager, Braidwood
D. Gudger, Regulatory Assurance Manager, Byron
D. Lesnick, Emergency Preparedness Manager, Braidwood
S. Swanson, Nuclear Oversight Manager, Byron
R. Radulovich, Nuclear Oversight Manager, Braidwood

Nuclear Regulatory Commission

E. Duncan, Chief, Reactor Projects Branch 3

LIST OF ITEMS OPENED, CLOSED AND DISCUSSED

Opened

05000456/2011012-01; 05000457/2011012-01; 05000454/2011015-01; 05000455/2011015-01	URI	Design of Auxiliary Feedwater System Included Voids in Safety-Related Alternate Suction Flowpaths (Section 4OA5.1.2.b)
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Opened and Closed

05000456/2011012-02; 05000457/2011012-02; 05000454/2011015-02; 05000455/2011015-02	FIN	Failure to Adequately Document and Justify Continued Operability of the Auxiliary Feedwater System (Section 4OA5.1.7.b)
05000456/2011012-03; 05000457/2011012-03	FIN	Incorrect Installation of Annunciator System Wiring (Section 4OA5.2.3.b)
05000457/2011012-04	NCV	Untimely Declaration of a Notice of Unusual Event (Section 4OA5.2.5.b)

LIST OF DOCUMENTS REVIEWED

The following is a partial list of documents reviewed during the inspection. Inclusion on this list does not imply that the NRC inspector reviewed the documents in their entirety, but rather that selected sections or portions of the documents were evaluated as part of the overall inspection effort. Inclusion of a document on this list does not imply NRC acceptance of the document or any part of it, unless this is stated in the body of the inspection report.

CALCULATIONS

<u>Number</u>	<u>Description or Title</u>	<u>Date</u>
BRW-03-0122-M	Evaluation of CST Technical Specification at Braidwood Station	10/24/03
BYR04-043	Documentation of Adequate NPSH for AF Pumps When Supplied from CSTs	5/13/05
FAI/11-364	Braidwood Unit 2 Train A and B Auxiliary Feedwater Air Intrusion Analysis	4/6/11
MAD 91-0121	Cooling Tower Flows for UHS Analysis	10/4/91
PSA-B-97-14	Evaluation of New CST Technical Specification Levels for Byron and Braidwood Stations	12/17/97
SX1-89, Revision 1	Available NPSH for AF Pump When Supplied from SX System	11/30/04

CORRECTIVE ACTION DOCUMENTS REVIEWED DURING THE INSPECTION

<u>Number</u>	<u>Description or Title</u>	<u>Date</u>
IR 00321153	SER 2-05, Gas Intrusion in Safety Systems	4/5/05
IR 00635104	IN 2007-18 Entrainment of Gas/Debris in Aux Feed Systems	5/30/07
IR 00728092	SER 2-05 Gas Accumulation Review Perform System Evaluation	10/30/08
IR 00736911	SER 2-05 Rev1 Gas Intrusion in Safety Systems	2/15/08
IR 01005649	SER 2-05 Gas Accumulation Follow Up Actions	12/15/09
IR 01088474	Potential Design Vulnerability on Aux. Feedwater System	7/7/10
IR 01115119	Concern with Operability Determination	9/20/10
IR 01172938	Voided SX to AF Suction Piping (Byron)	2/9/11
IR 01173517	AF Voided Section of SX to AF Piping – AF Pump Suction	2/10/11
IR 01176071	NRC Question Regarding Op Eval of Aux Feed Pump Suction	2/16/11
IR 01176378	UT Results in Small Void Detected in 2A & 2B SX to AF Piping	2/17/11
IR 01180553	Unable to Perform BwOP AF-3 on 3 of 4 Trains	2/26/11
IR 01191669	Unexpected Impact of C/O on U-2 Annunciators – 2PA19J-V4	3/24/11
IR 01192080	Plant Impact of BwOP AN-11	3/25/11
IR 01192465	Wiring Discrepancy in Annunciator CAB 2PA19J-V7	3/25/11
IR 01192556	1PA19J Clock Failure Not Wired Properly	3/26/11
IR 01194196	2A AF Pump Suction Void	3/29/11
IR 01194814	Extent of Condition Review Identified Previous Loss of U2 AN	3/30/11
IR 01194822	Braidwood Annunciator Lessons Learn	4/1/11

CORRECTIVE ACTION DOCUMENTS REVIEWED DURING THE INSPECTION

<u>Number</u>	<u>Description or Title</u>	<u>Date</u>
IR 01197017	Missed Opportunity for Earlier ID of Void Issue	4/3/11
IR 01197032	Extent of Condition Review for Braidwood Loss of Annunciator Event	4/3/11
IR 01199866	Unit 1 Train A & B AF Pumps Suction from SX UT's Indicate Voids	4/8/11
IR 01199930	NRC Disagrees with UE Declaration Time	4/8/11

DRAWINGS

<u>Number</u>	<u>Description or Title</u>	<u>Revision</u>
300-B50090	Outline of Auxiliary Feedwater Pump	4
M-37	Diagram of Auxiliary Feedwater Unit 1	BG
1A-AF-11	Auxiliary Feedwater System Auxiliary Building	9/20/83
2A-AF-31	Auxiliary Feedwater	
M-122	Diagram of Auxiliary Feedwater	AX
AF-11	Aux. Feedwater Large Bore Isometric	15
AF-31	Auxiliary Feedwater Isometric	8
M-37	Diagram of Auxiliary Feedwater	AY
500-B50090	Pump Assembly	5/30/79
M-122	Diagram of Auxiliary Feedwater	BA
1	Contract # 101537 General Elevation 45'-0" DIA X 55'-0" (New HT) Aluminum CRT 2CD01T	4
20E-1-4132G	Annunciator Logic Cabinet 2PA19J Part 7	F
20E-2-4030	Schematic Diagram Annunciator System Functional Diagram	D

ENGINEERING DOCUMENTS

<u>Number</u>	<u>Description or Title</u>	<u>Date/Rev</u>
BRW-S-2011-30	50.59 Screening Form: EC 383301, EC 383302, EC 383303, EC 383304 (Revs. 0)	
DCP 9500320	Install Vent Lines on the Piping Between the 1AF006A(B) and 1AF017A(B) Valves	5/31/96
DCP 9500321	Install Vent Lines on the Piping Between the 2AF006A(B) and 2AF017A(B) Valves	5/31/96
EC 376806	SER 2-05 Revision 1 AF System Evaluation	7/14/10
EC 379027	SER 02-05 Eval for Voids in AF System	7/1/10
EC 381435	Op Eval 10-004, Potential Motor-Driven AF Pump Design Vulnerability	1/11/11
EC 383229	Fill Empty Pipe Between 1AF006A and 1AF017A, Close Drain Valve 1AF018A, and Throttle Open Vent Valve 1AF030A	2/14/11

ENGINEERING DOCUMENTS

<u>Number</u>	<u>Description or Title</u>	<u>Date/Rev</u>
EC 383239	Fill Empty Pipe Between 1AF006B and 1AF017B, Close Drain Valve 1AF018B, and Throttle Open Vent Valve 1AF030B	2/14/11
EC 383240	Fill Empty Pipe Between 2AF006A and 2AF017A, Close Drain Valve 2AF018A, and Throttle Open Vent Valve 2AF030A	2/14/11
EC 383241	Fill Empty Pipe Between 2AF006B and 2AF017B, Close Drain Valve 2AF018B, and Throttle Open Vent Valve 2AF030B	2/14/11
EC 383301	Install Vent Valves in Pipe 2AF03AA-6 Between Valves 2AF006A & 2AF017A	3/3/11
EC 383302	Install Vent Valves in Pipe 2AF03AB-6 Between Valves 2AF006B & 2AF017B	3/9/11
EC 383303	Install Vent Valves in Pipe 1AF03AB-6 Between Valves 1AF006B & 2AF017B	3/22/11
EC 383304	Install Vent Valves in Pipe 1AF03AA-6 Between Valves 1AF006A & 1AF017A	0
EC 383308	Op Eval 11-003, Small Voids in 2A & 2B SX to AF Suction Piping	2/21/11
EC 383328	Vacuum Filling the Pipe Segment Between the Two SX Crosstie Valves to the AF Pumps	2/28/11
EC 383807	Revise Drawing 20E-1-4132G to Reflect Correct Wiring	0
Engineering Study 3N71SN	Potential Design Vulnerability on Auxiliary Feedwater System (Ability of AF Pump Motors to Survive Four Sequential Starts)	10/7/10
OpEval 011-003	Voided Section of SX to AF Piping – AF Pump Suction	0, 1

MISCELLANEOUS

<u>Number</u>	<u>Description or Title</u>	<u>Date or Revision</u>
CHRON # 0120086	Memo: K.W. Passmore to G.K. Swartz and K.L. Kofron; Potential Air Entrapment within the Auxiliary Feedwater System SX Suction Lines	5/28/93
F-2818/L-2818	Annunciator System Design Specification	3/10/76
I1-AN-XL-01	PWR Initial License Training – Annunciators	2a
L-0504	Instructor Manual BETA Isolator/Annunciator	Apr. 1979
N / A	AF Pump Vendor Manual	
N / A	Engineering Communication Matrix	
N / A	Operator Logs: 6/11/02, 6/19/02, 7/22/02, 2/19/03, 8/10/10, 3/23/11, 3/24/11	
N / A	Sequence of Events Recorder Data: 6/11/02, 6/19/02, 7/22/02, 2/19/03, 8/10/10, 3/24/11	

MISCELLANEOUS

<u>Number</u>	<u>Description or Title</u>	<u>Date or Revision</u>
RS-08-050	Letter AmerGen to NRC: Three Month Response to Generic Letter 2008-01	4/11/08
RS-08-131	Letter AmerGen to NRC: Nine-Month Response to Generic Letter 2008-01	10/14/08
RS-09-161	Letter Exelon to NRC: Response to Request for Additional Information Regarding Generic Letter 2008-01	11/30/09
SDD-AF-01-BB	Byron/Braidwood Stations Units 1 and 2 System Design Description for Auxiliary Feedwater (AF)	12/5/86
Training Course NPGPWRs	Braidwood/Byron ESPT PWR Systems Indoctrination, Rev 6	6/1/09
Westinghouse Letter	Ability of 50DHP350 1200 Ampere Breakers to Operate for Four Rapid Close Cycles	2/9/11
Plant Health Issue #121123	Plant Health Report: Add Vent Valves Between AF006 and AF017 (4 Total)	7/12/06

PROCEDURES

<u>Number</u>	<u>Description or Title</u>	<u>Revision</u>
1BwOA ELEC-7	Loss of Annunciators	1
2BwOS AN-1a	Loss of Annunciators	2
BwAR 1-4-A7	Annunciator Response Procedure 1-4-A7	7, 8
BwAR 2-4-A7	Annunciator Response Procedure 2-4-A7	3, 4
BwOP AF-3	Filling and Venting the Auxiliary Feedwater System	25
BwOP AN-10	1PA19J Annunciator Cabinets Power Supply Energization/De-energization	6
BwOP AN-11	2PA19J Annunciator Cabinets Power Supply Energization/De-energization	1, 2, 3, 4, 5
OP-AA-108-115, Att. 1	Operability Evaluation	9, 10
CC-AA-309-1001	Guidelines for Preparation and Processing of Design Analyses	0, 2
CC-AA-102	Design Input and Configuration Change Impact Screening	20
EP-AA-1001	Radiological Emergency Plan Annex for Braidwood Station	27
EP-AA-111	Emergency Classification and Protective Action Recommendations	16
LS-AA-125-1001	Root Cause Investigation	7, 8

ROOT CAUSE EVALUATIONS

<u>Number</u>	<u>Description or Title</u>	<u>Date or Revision</u>
IR 1139610 (Byron) / IT 1139618 (Braidwood)	Root Cause Investigation: Inadequate License Amendment Request (LAR) Submittal for Component Cooling (CC), Cause Indeterminate	0
IR 1191669	Root Cause Investigation Charter: Unexpected Impact of C/O on U-2 Annunciators – 2PA19J-V4	0
IR 1194196 (Braidwood) / IR 1194324 (Byron)	Root Cause Investigation Charter: Current and past AF system operability challenged due to inadequate design analysis to support successful AF suction switchover to Essential Service Water (SX)	0

WORK DOCUMENTS

<u>Number</u>	<u>Description or Title</u>	<u>Date or Revision</u>
WO 00974368	2PA19J Replace Power Supply Electrolytic Capacitors	8/10/10
WO 01072115-01	2PA19J-V2, V4 & V6 Replace 1K12 Inverters	3/22/11
WO 01072115-05	2PA19J-V2, V4 & V6 Replace 1K12 Inverters	3/24/11
WO 01072115-07	2PA19J-V2, V4 & V6 Replace 1K12 Inverters	3/23/11
WO 01247533	U2 Annunciator System Input Isolator Operability Check	2/23/11
WO 01338406	FNE Troubleshoot 1PM05J Audible Alarm	9/14/10
WO 01410167	Install TCCP on 1AF018A & 030A per EC 383229	2/15/11
WO 01410258	OP Install TCCP on 1AF018B & 030B per EC 383239	2/15/11
WO 01410260	OP Install TCCP on 2AF018A & 030A per EC 383240	2/15/11
WO 01410262	OP Install TCCP on 2AF018B & 030B per EC 383241	2/15/11
WO 01421647	Unexpected Impact of C/O on U2 Annunciators	4/4/11
WO 01422142	1PA19J Clock Failure Not Wired Properly	4/4/11

LIST OF ACRONYMS USED

AC	Alternating Current
ADAMS	Agencywide Document Access Management System
AF	Auxiliary Feedwater
CAP	Corrective Action Program
CC	Component Cooling Water
CFR	Code of Federal Regulations
C/O	Clearance Order
CST	Condensate Storage Tank
DC	Direct Current
EAL	Emergency Action Level
EC	Engineering Change
EMD	Electrical Maintenance Department
EN	Event Notification
FIN	Finding
IEEE	Institute of Electrical and Electronics Engineers
IMC	Inspection Manual Chapter
IP	Inspection Procedure
IR	Inspection Report
IR	Issue Report
LAR	License Amendment Request
NCV	Non-Cited Violation
NPSH	Net Positive Suction Head
NRC	U.S. Nuclear Regulatory Commission
OpEval	Operability Evaluation
PARS	Publicly Available Records System
psig	Pounds Per Square Inch Gauge
RCE	Root Cause Evaluation
SDP	Significance Determination Process
SM	Shift Manager
SX	Essential Service Water
TS	Technical Specification
URI	Unresolved Item
WO	Work Order



**UNITED STATES
NUCLEAR REGULATORY COMMISSION**

REGION III
2443 WARRENVILLE ROAD, SUITE 210
LISLE, IL 60532-4352

April 4, 2011

MEMORANDUM TO: Alex Garmoe, Acting Project Engineer
Branch 6
Division of Reactor Projects

FROM: Steven West, Director */RA by S. Reynolds for/*
Division of Reactor Projects

SUBJECT: SPECIAL INSPECTION CHARTER FOR BRAIDWOOD STATION
AND BYRON STATION POTENTIAL VOIDING IN AUXILIARY
FEEDWATER ALTERNATE SUCTION LINE AND BRAIDWOOD
STATION LOSS OF CONTROL ROOM ANNUNCIATOR EVENTS
ON MARCH 24, 2011 AND AUGUST 10, 2010

Two issues at Braidwood and Byron were recently identified and are the subject of a Special Inspection that you have been identified to lead. A short discussion of these events follows.

Unanalyzed Condition Associated With Auxiliary Feedwater System

As discussed in EN 46707 and EN 46708 for Braidwood and Byron Stations, respectively, on March 30, 2011, both licensees reported a potentially unanalyzed condition pursuant to 50.72(b)(3)(ii)(B) associated with their auxiliary feedwater (AF) system. This issue was most recently identified during a walkdown of the AF system in February 2011, by the Byron resident inspector who observed that the essential service water (SX) inlet piping to the AF pump suction was by design voided between two suction isolation valves. This configuration facilitated identification of valve seat leakage to preclude an adverse impact on steam generator water chemistry. The licensee initially completed an operability determination and concluded that the system was operable. Nonetheless, Byron filled the voided pipes and performed a past operability determination. However, due to the lack of high point vent lines, Braidwood could not fill the lines until vents were installed. Braidwood also contracted a vendor to perform a detailed analysis to evaluate the issue. Subsequently, Braidwood implemented modifications to install high point vents and filled the piping between the suction isolation valves on the 1B and 2B AF trains during the week of March 14, 2011. On March 30, 2011, Braidwood received preliminary information from the vendor that the air void fraction in the piping under certain design basis accident scenarios (tornado, earthquake, etc.) might exceed the operability limit. As a result, Braidwood declared the 1A and 2A AF trains inoperable on March 30. On March 31, 2011, Braidwood completed the installation of high point vents on the 1A and 2A AF trains, filled the piping, and declared the trains operable. This condition appears to have existed since initial startup of the plant.

CONTACT: Eric Duncan, DRP
630-829-9620

Notice of Unusual Event Associated With Loss of Annunciators

As discussed in EN 46712 for Braidwood, the licensee declared a Notice of Unusual Event at 10:18 a.m. on March 24, 2011, due to the loss of all Unit 2 main control room annunciators. At the time of the event, the utility was performing planned maintenance on the Unit 2 annunciator system. This maintenance activity was not expected to result in the loss of all Unit 2 annunciators. The loss of annunciators occurred at 9:51 a.m. The annunciators were restored and the Unusual Event was terminated at 10:47 a.m. There was no impact on any plant equipment and the reactor remained at 100 percent power. The utility implemented increased monitoring of available plant indications throughout the event. The situation posed no threat to public health and safety. An extent of condition review was performed for both Units of Braidwood Station. During this review it was identified that a previous unknown loss of annunciators had occurred on August 10, 2010 from 10:24 a.m. to 11:36 a.m. on Unit 2. The licensee did not declare a Notice of Unusual Event at that time.

The sequence of events and the root and contributing causes for both of these issues are being investigated by the licensee.

Based on the deterministic and risk-based criteria in Management Directive 8.3, a Special Inspection at Braidwood and Byron commenced on March 31, 2011. The Special Inspection Team, which is being led by you, will include Stu Sheldon and Chuck Zoia. Other members may be assigned as specific needs are identified.

The special inspection will determine the sequence of events, and will evaluate the facts, circumstances, and the licensee's actions surrounding both of these issues. The Special Inspection Charter for you and your team is enclosed.

Enclosure: As Stated

cc w/encl: See next page

Memo to A. Garmoe from S. West dated April 4, 2011

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BRAIDWOOD/BYRON SPECIAL INSPECTION CHARTER

This Special Inspection Team is chartered to assess the circumstances surrounding the identification of an unanalyzed condition on March 30, 2011, associated with the auxiliary feedwater (AF) systems at Braidwood Unit 1 and Unit 2, and Byron Unit 1 and Unit 2; and multiple unplanned losses of Unit 2 control room annunciators on August 10, 2010, and March 24, 2011 at Braidwood Unit 2. The Special Inspection will be conducted in accordance with Inspection Procedure 93812, "Special Inspection." The special inspection will include, but not be limited to, the items listed below. This charter may be revised based on the results and findings of the inspection.

Auxiliary Feedwater Issue

1. Develop a timeline for both Braidwood and Byron associated with the identification and resolution of the reported unanalyzed condition, including prior opportunities for identification.
2. Review information relied upon by Braidwood and Byron to support initial design acceptance and determine whether the acceptance review was adequate.
3. Review recent vendor-developed calculations used as an input to operability and assess the licensees' conclusion that operability could no longer be supported.
4. Review the adequacy of the modifications at Braidwood to install high point vents and fill the voided piping to address the reported unanalyzed condition and review why these high point vents were previously installed at Byron, but not Braidwood.
5. Review the 50.72 reports generated by Braidwood and Byron and determine whether these reports were timely and accurate.
6. Determine whether other issues that have been reported as required by 10 CFR 50.72, such as design inadequacies in the component cooling water system at Braidwood and Byron, have similarities to the reported unanalyzed condition for the AF system and assess these similarities to determine if any common causes or themes exist.
7. Review and assess the Braidwood and Byron evaluation of this issue. Include communications between and within Braidwood and Byron following the recent identification of the potential unanalyzed condition by the Byron Resident Inspector; and whether the prioritization and implementation of efforts to address the potential unanalyzed condition at both sites reflected a conservative decision-making approach to safety.

Annunciator Issue

1. Construct a time line for the loss of annunciator events at Braidwood, including information such as plant conditions and special circumstances, and include a brief explanation of the cause(s). Include any instance(s) in which the control room annunciator system could have been rendered non-functional and unavailable without the knowledge of the control room operators.
2. Review and assess the licensee's evaluation of the March 24, 2011, and August 10, 2010, loss of Unit 2 control room annunciators.

3. Independently review plant data and records to evaluate the licensee's assessment of the loss of annunciator events and corrective actions.
4. Review and assess the licensee's repair activities to restore the main control room annunciator systems.
5. Evaluate and assess the impact of the March 24, 2011, and August 10, 2010, loss of annunciator events and any other similar loss of annunciator events on the ability of operators to respond to plant events.
6. Starting from the time when a vulnerability to a loss of annunciator event began, identify and assess any missed opportunities to identify subsequent loss of annunciator events.
7. Perform an extent of condition review for the annunciator system and assess the results. Include a sampling of any known control room annunciator issues, plant impact evaluation, and plans to restore compliance.
8. Evaluate operations and maintenance department interface during annunciator maintenance and assess whether interface issues contributed to the loss of annunciator events.
9. Evaluate the licensee's procedures and processes for annunciator maintenance that could cause the unplanned loss of a large number of annunciators and determine whether these procedures and processes are adequate.
10. Evaluate and assess whether Byron has had similar loss of annunciator events and whether Byron is vulnerable to similar events.

Note: Items 1 thru 9 apply only to Braidwood Station.

Additional Inspection Requirements

1. Determine whether the two issues that are the subject of this Special Inspection at Braidwood and Byron have any common themes. Themes that should be considered include, but are not limited to, conservative decision-making and organizational communications.
2. Determine if there is any lesson learned from this Special Inspection.

Charter Approval

 /RA/

E. Duncan, Chief, Branch 3, DRP

 /RA by S. Reynolds for/

S. West, Director, Division of Reactor

Event Timeline

Braidwood/Byron Auxiliary Feedwater Alternate Suction Piping Voids

- 8/27/1987 AF pump vendor provided information via telephone memorandum that the AF pumps would not fail or lose net positive suction head if 1.5 cubic feet of air at 80 psig was passed through the pumps. No calculations or documentation of the analysis was available.
- 5/14/1993 Duke Engineering Services letter with unknown content was sent between unknown parties.
- 5/28/1993 Letter (CHRON 120086) was sent from Byron Engineering Support to Byron and Braidwood Station managers (Subject: "Potential Air Entrapment within the Auxiliary Feedwater System SX Suction Lines") documenting that Byron Engineering had reviewed the 5/14/1993 Duke Engineering Services letter and determined that it did not apply to Byron and Braidwood. This memo also reiterated the position in the 1987 telephone call that 1.5 cubic feet of air at 80 psig will not cause pump failure.
- 1997-1999 Byron installed vent valves on voided sections of piping to accelerate draining of piping following quarterly valve strokes. Braidwood subsequently evaluated this modification and elected not to install similar vents.
- 1/9/2008 Industry Operating Experience was issued to identify continuing industry problems with gas intrusion events.
- 12/15/2009 Braidwood evaluation of AF system per January 2008 industry operating experience documented in IR 728092 – the void in the SX suction piping was evaluated as acceptable based on the CHRON letter from May 28, 1993.
- 6/28/2010 Byron evaluation of the AF system alternate suction voids per January 2008 industry operating experience (EC 379027) completed and commented that additional actions are required to address the voids.
- 7/12/2010 Byron evaluation of the overall AF system per January 2008 industry operating experience was approved (EC 376806). The evaluation referenced Byron EC 379027, which recommended filling the intentionally voided areas in the AF system alternate suction. However, operability as a result of the void was not questioned and the licensee referenced the conclusions in the 1993 CHRON letter.
- 1/31/2011 Byron NRC resident inspectors questioned licensee on acceptability of the AF alternate suction piping void.
- 2/4/2011 Braidwood NRC resident inspectors questioned licensee on acceptability of the AF alternate suction piping void.
- 2/9/2011 Byron initiated IR 1172938 based on NRC concerns.
- 2/10/2011 Braidwood initiated IR 1173517 based on discussions with NRC and Byron staff.

- 2/14/2011 Braidwood and Cantera personnel began discussions with a contractor regarding performance of a formal void analysis.
- 2/15/2011 Byron initiated temporary changes to fill the AF alternate suction voids for all four AF trains using previously installed fill and vent capability. Unit 1 piping was verified water solid and Unit 2 piping had small voids.
- Braidwood completed Operability Evaluation 11-003, Rev. 0, which was largely based on the CHRON letter from May 28, 1993. The OpEval concluded that the AF system was operable.
- 2/17/2011 Braidwood solicited four modification packages from a contractor to install vent valves in the AF alternate suction voided areas of piping.
- 2/18/2011 Braidwood received the proposal from the vendor for vent valve installation.
- 2/21/2011 Initial proposal for performing the void analysis was received from the contractor.
- Byron completed an operability evaluation to address the small voids in Byron Unit 2 AF alternate suction piping following the fill and vent. The OpEval concluded that the voids were small enough to not be of concern.
- 2/23/2011 Braidwood Design Engineering completed a technical evaluation (EC 383328) to support the vacuum fill of voided pipe sections.
- Braidwood Operations completed procedure changes to allow for vacuum fill.
- 2/24/2011 Braidwood, Byron, and Cantera provided comments to the contractor regarding the void analysis proposal.
- 2/26/2011 Braidwood 1A AF train was successfully vacuum filled, but not verified water solid through ultrasonic testing. The other three AF trains were unable to be vacuum filled due to excessive valve seat leakage.
- 3/4/2011 Byron completed a search that had been ongoing to locate the additional information discussed in the CHRON letter, but was unable to find anything.
- 3/15/2011 Formal revised proposal for the void analysis was received from the contractor.
- 3/21/2011 Exelon gave the contractor verbal authorization to begin the void analysis.
- 3/23/2011 Formal contract was issued for the contractor's void analysis.
- 3/25/2011 The contractor provided initial information to Exelon that the void analysis results for AF suction swap while the pump is running showed void fraction that did not meet industry acceptance criteria.
- Exelon raised technical questions about the analysis methodology and results with the contractor, including potential errors in the modeling of the plant.

- Braidwood 2B AF train venting modification was installed and piping was verified water solid.
- 3/26/2011 Braidwood 1B AF train venting modification was installed and piping was verified water solid.
- 3/28/2011 Cantera had additional discussions with the contractor about correcting the modeling errors.
- 3/29/2011 The contractor provided information from an updated analysis for the Braidwood 2B AF train, which indicated that void fraction at the pump suction did not meet industry acceptance criteria.
- Braidwood initiated IR 1194196.
- Braidwood 1A and 2A AF trains were declared inoperable.
- 3/30/2011 Braidwood and Byron submitted Event Notifications to the NRC.
- Braidwood 2A AF train venting modification was installed and the piping was verified water solid.
- Braidwood initiated actions to determine the impact of the AF alternate suction voids on the AF pumps by beginning procurement of a replica pump and contracting development of a test plan.
- 3/31/2011 Braidwood 1A AF train venting modification was installed and piping was verified water solid.
- 4/1/2011 Braidwood and Byron Root Cause Evaluation team initiated with final approval in early May.
- 4/5/2011 Final report of void analysis from the contractor was provided for Braidwood 2B AF train.
- 4/15/2011 Final report of void analysis from the contractor was received for the remaining Braidwood and Byron AF trains.

Event Timeline

Braidwood Unit 2 Loss of Annunciator Events

August 10, 2010

- 10:23 a.m. DC power to crossover power supply in 2PA19JV4 failed due to operators removing supply fuses in 2PA19JV7 to perform planned maintenance.
- 10:24 a.m. AC power to crossover power supply in 2PA19JV4 failed due to operators removing supply fuses in 2PA19JV7 to perform planned maintenance.
- 11:36 a.m. AC power to crossover power supply in 2PA19JV4 was operable due to operators re-installing supply fuses in 2PA19JV7.
- 11:36 a.m. DC power to crossover power supply in 2PA19JV4 was operable due to operators re-installing supply fuses in 2PA19JV7.

The annunciators were determined to be unavailable from 10:24 a.m. to 11:36 a.m. on August 10, 2010.

March 24, 2011

- 9:51 a.m. DC power to crossover power supply in 2PA19JV4 failed due to operators removing supply fuses in 2PA19JV7 to perform planned maintenance.
- 9:52 a.m. AC power to crossover power supply in 2PA19JV4 failed due to operators removing supply fuses in 2PA19JV7 to perform planned maintenance. Operators attempted to acknowledge the expected annunciator associated with the de-energized power supply, but received no response.
- 9:57 a.m. Reactor Operator attempted to test all Unit 2 annunciators with the control room test pushbuttons. No response was received.
- 10:02 a.m. Operators placed the condensate/condensate booster pump selector switch to an abnormal position to induce an annunciator for the switch being in the wrong position. No response was received.
- 10:06 a.m. Operators opened cabinet doors to 2PA01J and 2PA02J in order to induce an annunciator. No response was received.
- 10:07 a.m. Shift Manager directed maintenance personnel to restore annunciators.
- 10:18 a.m. Shift Manager declared a Notification of Unusual Event per Emergency Action Level (EAL) MU6, "Unplanned Loss of Unit 2 Annunciators."
- 10:24 a.m. State and local officials notification of EAL entry was completed.
- 10:30 a.m. AC power to crossover power supply in 2PA19JV4 was operable due to operators re-installing power supply fuses in 2PA19JV7.

- 10:33 a.m. DC power to crossover power supply in 2PA19JV4 was operable due to operators re-installing power supply fuses in 2PA19JV7.
- 10:36 a.m. NRC notification of EAL entry was completed.
- 10:43 a.m. Operators confirmed operation of Unit 2 annunciators by placing the condensate/condensate booster pump selector switch to an abnormal position in order to induce an annunciator for the switch being in the wrong position. The expected response was received.
- 10:47 a.m. Shift Manager terminated NOUE declaration.
- 11:13 a.m. State and locals notification of EAL termination was completed.
- 11:17 a.m. NRC notification of EAL termination was completed.
- 11:22 a.m. NRC Senior Resident Inspector notification of EAL termination was completed.

The loss of all Unit 2 annunciators occurred when power was removed from 2PA19JV4, which powered the backup annunciator clock circuit that was providing a required signal to the Unit 2 annunciators. The primary clock circuit had not been reset following prior maintenance that de-energized the crossover power supply in 2PA19JV6. Thus, the primary clock circuit was unavailable to provide the required clock signal. Without a clock signal, the annunciators would not change state.

If you contest the subject or severity of this NCV, you should provide a response within 30 days of the date of this inspection report, with the basis for your denial, to the U.S. Nuclear Regulatory Commission, ATTN: Document Control Desk, Washington, DC 20555-0001, with a copy to the Regional Administrator, U.S. Nuclear Regulatory Commission - Region III, 2443 Warrenville Road, Suite 210, Lisle, IL 60532-4352; the Director, Office of Enforcement, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001; and the Resident Inspector Office at the Braidwood Station.

This report also documents one NRC-identified finding of very low safety significance affecting Byron. This finding was determined not to involve a violation of NRC requirements.

If you disagree with the cross-cutting aspect assigned to any finding in this report, you should provide a response within 30 days of the date of this inspection report, with the basis for your disagreement, to the Regional Administrator, Region III, and the NRC Senior Resident Inspector at the Braidwood Station and/or Byron Station, as applicable.

In accordance with 10 CFR 2.390 of the NRC's "Rules of Practice," a copy of this letter, its enclosure, and your response (if any) will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records System (PARS) component of NRC's document system (ADAMS). ADAMS is accessible from the NRC Website at <http://www.nrc.gov/reading-rm/adams.html> (the Public Electronic Reading Room).

Sincerely,

/RA/

Steven West, Director
Division of Reactor Projects

Docket Nos. 50-456; 50-457; 50-454; 50-455
License Nos. NPF-72; NPF-77; NPF-37; NPF-66

Enclosure: Inspection Report 05000456/2011012; 05000457/2011012;
05000454/2011015; 05000455/2011015

w/Attachments:

1. Supplemental Information
2. Special Inspection Team Charter
3. Timeline of Events for Auxiliary Feedwater Voids
4. Timeline of Events for Loss of Annunciators

cc w/encl: Distribution via ListServ

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Letter to M. Pacilio from S. West dated June 16, 2011.

SUBJECT: BRAIDWOOD STATION, UNITS 1 AND 2; BYRON STATION, UNITS 1 AND 2,
NRC SPECIAL INSPECTION TEAM (SIT) REPORT 05000456/2011012;
05000457/2011012; 05000454/2011015; 05000455/2011015

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