



**UNITED STATES  
NUCLEAR REGULATORY COMMISSION**

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

August 11, 2015

EA-15-064

Mr. Bryan C. Hanson  
Senior VP, Exelon Generation Company, LLC  
President and CNO, Exelon Nuclear  
4300 Winfield Road  
Warrenville, IL 60555

**SUBJECT: FINAL SIGNIFICANCE DETERMINATION OF A WHITE FINDING WITH  
ASSESSMENT FOLLOWUP AND NOTICE OF VIOLATION; NRC INSPECTION  
REPORT NO. 05000461/2015009; CLINTON POWER STATION**

Dear Mr. Hanson:

This letter provides you the final significance determination of the preliminary White finding discussed in Inspection Report (IR) 05000461/2015001, dated May 13, 2015 (ML15134A224). The finding involved the failure of the Division 3 shutdown service (SX) water pump to perform its intended safety function.

At your request, a Regulatory Conference was held on June 25, 2015, to discuss your views on this issue. A copy of the handout you provided at that meeting was entered into the U.S. Nuclear Regulatory Commission's (NRC's) Agencywide Documents Access and Management System (ADAMS) under Accession Number ML15173A381. Enclosure 1 to this letter is a summary of the Regulatory Conference. During the meeting, your staff described your reassessment of the cause of the pump failure and the corrective actions taken to resolve it. You also discussed the significance evaluation of the finding and discussed the recovery credit you believed should be considered for the issue. You provided the results of additional analysis performed to support your conclusion that the shaft sleeve hard-face material application was deficient leading to failure of the bushing. Since you believe the application technique was below the level of design detail reasonably expected to be provided in a procurement specification, your contention was that the cause of the failure was not reasonably within your ability to foresee and correct. Further, since the issue of concern was beyond your ability to prevent, you contend there was no performance deficiency as determined using the guidance in Inspection Manual Chapter 0612, Appendix B, "Issue Screening," and therefore, there was no finding.

After considering the information developed during the inspection, the information provided at the regulatory conference and the supplemental information submitted on July 6, 2015, the NRC has concluded that a finding does exist and is appropriately characterized as White, a finding of low-to-moderate risk significance.

The NRC determined that the failure to review the suitability of application of materials, parts, equipment and processes that are essential to the safety-related functions of structures, systems, and components was a performance deficiency within your ability to foresee and correct. Specifically, the failure to review the suitability of application of the design for the replacement Division 3 SX pump and ensure the pump internals would not degrade under expected operating conditions is a violation of Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, Appendix B, Criterion III, "Design Control," as cited in the attached Notice of Violation (Notice) found in Enclosure 2. The circumstances surrounding the violation were described in detail in the subject inspection report and additional considerations are included in the Regulatory Conference summary notes attached to this document. In accordance with the NRC Enforcement Policy, the Notice is considered an escalated enforcement action because it is associated with a White finding. No cross-cutting aspect was assigned since the performance deficiency associated with this finding occurred more than 3-years ago; therefore, it did not reflect current licensee performance.

The NRC has concluded that the information regarding the reason for the violation, the corrective actions taken and planned to correct the violation and prevent recurrence, and the date when full compliance will be achieved is already adequately addressed on the docket as reflected in the inspectors' summary of the corrective action document included in IR 05000461/2015001. Therefore, you are not required to respond to this letter unless the description therein does not accurately reflect your corrective actions or your position.

As a result of our review of Clinton's performance, including this White finding, we have assessed Clinton Power Station to be in the Regulatory Response column of the NRC's Action Matrix, effective the first quarter of 2015. Therefore, we plan to conduct a supplemental inspection using Inspection Procedure 95001, "Inspection for One or Two White Inputs in a Strategic Performance Area," when your staff has notified us of your readiness for this inspection. This inspection procedure is conducted to provide assurance that the root cause and contributing cause of risk significant performance issues are understood, the extent of condition and the extent of cause are identified, and the corrective actions are sufficient to prevent recurrence.

You have 30 calendar days from the date of this letter to appeal the staff's determination of significance for the identified White finding. Such appeals will be considered to have merit only if they meet the criteria given in Inspection Manual Chapter (IMC) 0609, Attachment 2. An appeal must be sent in writing to the Regional Administrator, Region III 2443 Warrenville Road, Suite 210, Lisle, Illinois 60532.

In accordance with 10 CFR 2.390 of the NRC's "Rules of Practice," a copy of this letter, its enclosures, and your response if you choose to provide one, will be made available

B. Hanson

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electronically for public inspection in the NRC Public Document Room or from the NRC's ADAMS, accessible from the NRC Web site at <http://www.nrc.gov/reading-rm/adams.html>. To the extent possible, your response should not include any personal privacy, proprietary, or safeguards information so that it can be made available to the Public without redaction.

Sincerely,

*/RA/*

Cynthia D. Pederson  
Regional Administrator

Docket No. 50-461  
License No. NPF-62

Enclosures:

1. Summary of Regulatory Conference
2. Notice of Violation

cc: Distribution via LISTSERV®

NRC RESPONSE TO INFORMATION  
PROVIDED BY EXELON GENERATION COMPANY, LLC AT THE JUNE 25, 2015  
REGULATORY CONFERENCE IN LISLE, IL

SUMMARY OF INFORMATION PROVIDED BY EXELON

At the Regulatory Conference, Exelon representatives of the Clinton Power Station provided information in a slideshow format (ML15173A381) that was gathered through additional analysis of the failed Division 3 shutdown service water (SX) pump. During the introductory remarks, Exelon stated that they would present the results of additional analysis to support a revised causal evaluation stating that the shaft sleeve hard-face material application was deficient and led to failure of the bushing and the application technique of the hard-facing was below the level of design detail reasonably expected to be provided in a procurement specification. Exelon concluded that the cause of the failure was not reasonably within the licensee's ability to foresee and correct and the issue of concern was beyond their ability to prevent; therefore, it was not a performance deficiency.

To support the causal evaluation performed after the pump failed, Exelon initially had the pump vendor and its contractor analyze the failed pump components. The analyses performed included metallurgical examinations, visual examinations and hardness tests. Following the NRC issuing the preliminary White finding, the licensee had Exelon PowerLabs perform an analysis and contracted a second vendor to review the results of the accumulated analysis. In addition, this second vendor performed calculations to support an alternate causal determination. Exelon presented bulleted conclusions based on analysis performed by these vendors to support the following conclusions:

- Analysis performed by Exelon PowerLabs on the failed assembly and other shaft bushings determined that the cause identified in the original causal evaluation was not correct in that silt and mud blockage of the cooling channels was not the likely cause of the bushing failure.
- Further analysis and examination of the other bushings determined that the hard-face application was inadequate and hard-face delamination was the most likely cause of the bushing failure.

These conclusions were supported by Scanning Electron Microscopy analysis of the material in the parts shipped to PowerLabs in that the silicon previously identified in the cooling channels and assumed to be mud/silt from the cooling lake was determined to be in a concentration similar to the same substance in the hard-face alloy. The analysis performed did not identify any other expected minerals (i.e. calcium or silicon rich sediment) that indicated environmental mud or silt was present.

Exelon stated that analysis of bushing loads, flow rates, temperatures, and stresses led them to conclude that temperatures produced in a water starved bushing would be within the capabilities of the material. The original pump manufacturer indicated that the sleeve hard-facing was applied by a third party vendor. The vendor that the pump manufacturer used in the application of the overlay noted that the sleeves were liquid penetrant (PT) examined after overlay application and rough grinding. The pump manufacturer indicated the only records available were the material tracking reports for the sleeve, the manufacturing drawings, the design change records, and the bill of material for the pump, including sleeves and bushings.

In the supplemental information Exelon provided the pump manufacturer's statement describing the application process. The hard-facing was oxy-acetylene weld applied in 2 passes, not spray and fused. Approved oxy-acetylene weld procedures were used by the sleeve manufacturer. The sleeve was post-weld stress relieved and PT examined with approved procedures by the vendor. The pump manufacturer concluded that the original position (i.e., mud and silt blocking the cooling channels as the most likely cause of failure) remained valid and did not believe that a design defect was responsible for the 2014 pump failure. Again, the documentation of weld procedures and PT results were not provided to the pump manufacturer. Exelon assumed that the presence of cracks or defects during the PT would cause reject of the part.

Additionally, Exelon identified that the hard-face material thickness applied to the sleeve was thicker at 95 mils than usual spray on applications and put forth the premise that if the thicker material was not applied correctly, this misapplication could result in cracking or delamination of the hard-facing material and was therefore the cause of the hard-face failure and the most likely cause of the pump failure.

For the risk significance determination, Exelon reiterated information from its risk evaluation discussed in NRC Inspection Report 05000461/2015001. During the Regulatory Conference, Exelon stated that influential factors affecting risk were recovery of the Division 3 SX pump (suction bell not critical, mechanics demonstrated shaft movement); unavailability of the pump coinciding with summer operation (no major system outages/higher equipment availabilities); and reduced likelihood of plant and switchyard-centered loss of offsite power events during the summer. In response to NRC questions, Exelon stated that no formal human reliability analysis was performed for recovery of the pump and stated they agreed with the results of the risk portion of the Significance Determination Process conducted by the NRC.

In supplemental information provided on July 6, 2015, in response to open questions during the Regulatory Conference, Exelon provided additional information regarding calculations and models used to support the station's conclusions.

## NRC RESPONSE

The licensee's initial investigation found what appeared to be mud and silt in each of the pump sections with an increasing amount present in the lower sections of the pump during disassembly. The licensee sent the pump components to the pump manufacturer and their contractor. The material was then sent to PowerLabs for additional analysis. During the failure analysis and subsequent transfers, parts were cleaned (i.e., bead blasting was referenced) and paired components were not tracked together making additional analysis results questionable. The NRC technical reviewers determined that while the mud and silt probably did not cause the hard-face failure, it likely contributed to the pump failure.

The NRC personnel asked several questions during the Regulatory Conference about the analysis used to support the licensee's conclusion that the application process for the hard-face material was the most likely cause of the failure. While the licensee postulated misapplication of the hard-facing, the pump manufacturer's conclusions seemed to refute Exelon's assertion. While the Exelon calculation concluded that the expected temperature rise for a bushing with no cooling would not rise to a temperature sufficient to damage a "properly" applied hard-face material, the calculations included assumptions concerning flow, contact area and temperature dispersion, and specifically state the simplification is not representative of the actual configuration, which caused the NRC evaluators to question the validity or applicability of the

flow analysis. In addition, the vendor manual states, "The pumps are designed for continuous operation. Too many and too frequent starts can accelerate ageing and result in abnormally high wear and short life time. In case of many starts we recommend an intensive supervision and maintenance intervals should be shortened." While the licensee concluded that temperatures remained below the melting point of the bushing and hard face materials, the consequential effects of multiple thermal cycles on the hard-facing (due to operating in the standby mode over years rather than continuous operation) and the differences in conductance (i.e., different heating and cooling rates) and contact area between components created an operating environment that challenged the hard-facing application. While Exelon's vendor supplied supplemental information including a discussion of the Finite Failure Analysis performed, the effects of multiple heating cycles were discounted as small, while at the same time acknowledging that the fatigue properties of the hard-facing material were not well known.

In the supplemental information submitted on July 6, the licensee provided more information on the engineering models used to support their conclusions, and a summary letter from a third-party technical review. While the third-party reviewer generally agreed with the methodology, assumptions and conclusions drawn by Exelon and their contractor, the reviewer qualified the conclusions stating that they did not review the input/output files used in the code calculations. NRC reviewers recognized that the output of these models is heavily influenced by the inputs and assumptions. The NRC technical reviewers agreed that given the pump history, expected operating conditions, the unknown fatigue characteristics of the hard-face material, and the lack of attention to detail and planning in the material analysis of the failed components, the licensee would not be able to identify the root cause of the pump failure.

The NRC reviewed the supplemental information provided on the failure of the pump and, evaluated it along with the details of the performance deficiency as stated in NRC IR 05000461/2015001. The licensee's root cause evaluation performed after the 1990 failure documented as part of the corrective action plan the need to develop a modification that would provide a pump that would not require lake water for cooling for the pump. The purpose of this corrective action as identified in the 1990 causal evaluation was to prevent the accumulation of mud and silt in the pump as a result of using lake water for cooling/flushing the pump internals. To accomplish this, the licensee modified the original pump design by specifying in the purchase order that the pump include bronze bushings and an over laid shaft sleeve such that the pump would no longer require the use of internal flushing and cooling lines. The NRC concluded the shaft sleeve design was part of the detail required for the pump design.

Also, the licensee noted in the 1995 change package that the new design was similar to the self-lubricating bushings used in the Division 1 and 2 SX pumps, which had not shown any issues related to this design feature. The Division 1 and 2 SX pumps were much larger than the Division 3 SX pump and were designed and manufactured by a different vendor. A key difference between the pumps was the design of the lower bushing in the suction bell. The suction bell bushings for the Division 1 and 2 SX pumps were grease packed and had sand caps installed to prevent lake water from flushing the grease out of the bushings and did not rely on lake water to perform lubricating or cooling functions. Sand caps also serve to prevent silt and mud from settling into the suction bell bearing. These bearings were significantly different than the self-lubricating bushing design using lake water as cooling that failed in the Division 3 SX pump.

The inspectors identified that although the licensee noted the design modification for the Division 3 SX pump would be similar in design to the Division 1 and 2 SX pumps, they did not document an analysis showing what design differences existed such as: (1) the Division 1 and 2 pump bushings are bronze, but of a different bronze alloy than Division 3, and (2) the Division 1 and 2 pumps do not have shaft sleeves. The licensee also did not evaluate whether those differences had the potential to adversely affect the performance of the new bushing. Specifically, the licensee did not consider what degradation mechanisms could impact the bronze bushings and the over laid sleeve, resulting in the failure of the pump due to a degraded condition associated specifically with the design change.

As a result, the NRC determined that the performance deficiency existed as previously stated. That is, the licensee's failure to verify the suitability of the design for the Division 3 SX replacement pump installed in 1995 for conditions under which it was to be used was a performance deficiency within the licensee's ability to foresee and correct. After considering the additional information supplied by the licensee, the NRC has changed the specific deficiency from what was originally stated. Specifically, the licensee failed to verify the design to ensure the pump internals would not degrade under expected operating conditions, resulting in the failure of the pump.

During the Regulatory Conference Exelon stated that the influential factors affecting risk were recovery of the Division 3 SX pump (suction bell not critical, mechanics demonstrated shaft movement); unavailability of the pump coinciding with summer operation (no major system outages/higher equipment availabilities); and reduced likelihood of plant and switchyard-centered loss of offsite power events during the summer. In response to NRC questions, Exelon stated that no formal human reliability analysis was performed for recovery of the pump and stated they agreed with the results of the Significance Determination Process conducted by the NRC.

In the supplemental information provided on July 6, 2015, in response to open questions during the Regulatory Conference, Exelon provided additional information regarding calculations and models used to support the station's conclusions. The NRC considered the additional information provided by Exelon against the revised performance deficiency and original significance determination, and concluded that the original significance determination as discussed in NRC Inspection Report 05000461/2015001 remains valid. The Significance Determination of White and the violations were determined to remain applicable as previously stated.

## LIST OF ATTENDEES

### NRC

Cynthia Pederson, Regional Administrator, Region III  
Kenneth O'Brien, Director, RIII Division of Reactor Safety (DRS)  
Anne Boland, Director, RIII Division of Reactor Projects (DRP)  
John Giessner, Deputy Director, RIII DRP  
James McGhee, Acting Chief, DRP Branch 1  
Rick Skokowski, Enforcement/Investigations Officer, RIII EICS  
William Schaup, Senior Resident Inspector, Clinton  
Elba Sanchez-Santiago, Resident Inspector, Clinton  
Atif Shaikh, Reactor Inspector, DRS  
Nicholas Valos, Senior Reactor Analyst, RIII DRP  
Jeff Circle, Team Leader, PRA Operations and Human Factors Branch, HQ  
Eva Brown, Project Manager, HQ DORL  
Nestor Feliz-Adorno, Enforcement Coordinator, HQ  
Ching Ng, Reliability and Risk Analyst, HQ  
Dave Alley, Chief, Component Performance, NDE, & Test, HQ  
Samson Lee, Deputy Director, Division of Risk Assessment, HQ  
Douglas Copeland, Reliability and Risk Analyst, HQ  
Robert Davis, Senior Materials Engineer, HQ  
Robert Wolfgang, Senior Mechanical Engineer, HQ

### STATE OF ILLINOIS

Cecil Settles, Section Head, Illinois Emergency Management Agency (IEMA)  
Steve Mischke, Resident Inspector – Clinton, IEMA

### EXELON

Mark Newcomer, Site Vice President, Clinton Power Station (CPS)  
J. Bradley Fewell, Senior Vice President, Regulatory Affairs and General Council, Exelon  
Scott Greenlee, Senior Vice President, Engineering & Technical Services, Exelon  
Jake Smith, Director of Engineering, CPS  
Michael Heger, Senior Manager-Plant Engineering, CPS  
Glen Kaegi, Director of Licensing, Exelon  
Gregory Krueger, Director Risk Management, Exelon  
Patrick Simpson, Corporate Licensing Manager, Exelon  
Duane Avery, Senior Regulatory Engineer, Clinton

### PUBLIC

Mike Mulligan, Citizen

## NOTICE OF VIOLATION

Exelon Generation, LLC  
Clinton Power Station

Docket NO. 50-461  
License NO. NPF-62  
EA-15-064

During a U.S. Nuclear Regulatory Commission (NRC) inspection conducted between January 1 and March 31, 2015, a violation of NRC requirements was identified. In accordance with the NRC Enforcement Policy, the violation is listed below:

Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, Appendix B, Criterion III, "Design Control," requires in part, that measures be established for the selection and review for suitability of application of materials, parts, equipment, and processes that are essential to the safety-related functions of the structures, systems, and components.

Technical Specification (TS) 3.7.2, Division 3 Shutdown Service Water (SX) Subsystem, Limiting Condition for Operation requires, in part, that in Modes 1, 2 and 3, the Division 3 SX subsystem shall be operable. Required Action A.1 states, in part, that if the Division 3 SX subsystem is inoperable, declare the High Pressure Core Spray (HPCS) system inoperable immediately.

Technical Specification 3.5.1, Emergency Core Cooling Systems (ECCS) – Operating, Limiting Condition for Operation, requires, in part, that in Modes 1, 2 and 3 the High Pressure Core Spray (HPCS) system shall be operable. Required Action B.2 states, in part, that if the HPCS system is inoperable, then restore the system to operable status within 14 days. Required Action D.1 states, in part, that the reactor be in Mode 3 within 12 hours after the completion time specified in Required Action B.2 is not met.

Contrary to the above, on or about October 3, 1995, the licensee failed to review the suitability of application of the Division 3 SX pump modifications essential to the safety related functions of the HPCS system. Specifically, the licensee failed to ensure the modified pump internals would not degrade under expected operating conditions in a way that impacted the safety function. The causal evaluation determined the pump failed at the conclusion of its surveillance run on May 30, 2014, and this condition did not reveal itself until the attempted pump start on September 16, 2014. This resulted in the pump being inoperable for approximately 108 days, a period greater than the allowed limiting condition for operation outage times provided in TS 3.7.2 and 3.5.1. Additionally, because the licensee was not aware of the pump's inoperability during the unit's operation cycle, the required actions of TS 3.7.2.A.1, 3.5.1.B.2 and 3.5.1.D.1 were not followed.

This violation is associated with a White Significance Determination Process finding.

The NRC has concluded that information regarding: (1) the reason for the violation; (2) the corrective actions taken and planned to correct the violation and prevent recurrence; and (3) the date when full compliance was achieved is already adequately addressed on the docket in Inspection Report 05000461/2015001, dated March 13, 2015. However, if the description therein does not accurately reflect your corrective actions or your position you are required to submit a written statement or explanation pursuant to 10 CFR 2.201. In that case, or if you choose to respond, clearly mark your response as a "Reply to a Notice of Violation - EA-15-064," and send it to the U.S. Nuclear Regulatory Commission, ATTN:

Document Control Desk, Washington, DC 20555-0001, with a copy to the Regional Administrator, Region III, and a copy to the NRC Resident Inspector at Clinton Power Station, within 30 days of the date of the letter transmitting this Notice of Violation (Notice).

If you contest this enforcement action, you should also provide a copy of your response, with the basis for your denial, to the Director, Office of Enforcement, United States Nuclear Regulatory Commission, Washington, DC 20555-0001.

If you choose to respond, your response will be made available electronically for public inspection in the NRC Public Document Room or from the Agencywide Documents Access and Management System, accessible from the NRC Web site at <http://www.nrc.gov/reading-rm/adams.html>. Therefore, to the extent possible, the response should not include any personal privacy, proprietary, or safeguards information so that it can be made available to the Public without redaction.

Dated this 11<sup>th</sup> day of August 2015.

B. Hanson

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electronically for public inspection in the NRC Public Document Room or from the NRC's ADAMS, accessible from the NRC Web site at <http://www.nrc.gov/reading-rm/adams.html>. To the extent possible, your response should not include any personal privacy, proprietary, or safeguards information so that it can be made available to the Public without redaction.

Sincerely,

*/RA/*

Cynthia D. Pederson  
Regional Administrator

Docket No. 50-461  
License No. NPF-62

Enclosures:

1. Summary of Regulatory Conference
2. Notice of Violation

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NAME	Pederson					
DATE	08/07/15					

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<sup>1</sup> OE concurrence provided via e-mail from K. Hanley on August 04, 2015

<sup>2</sup> NRR concurrence provided via e-mail from N. Feliz-Adorno on August 04, 2015

Letter to Mr. Bryan C. Hanson from Ms. Cynthia D. Pederson dated August 7, 2015

SUBJECT: FINAL SIGNIFICANCE DETERMINATION OF A WHITE FINDING WITH  
ASSESSMENT FOLLOWUP AND NOTICE OF VIOLATION; NRC INSPECTION  
REPORT NO. 05000461/2014009; CLINTON POWER STATION

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