Clinton Power Station
8401 Power Road
Clinton, IL 61727

U-604233
July 6, 2015

Regional Administrator, Region III
ATTN: James McGhee
U.S. Nuclear Regulatory Commission
2443 Warrenville Road
Lisle, Illinois 60532-4352

Clinton Power Station, Unit 1
Facility Operating License No. NPF-62
NRC Docket No. 50-461

Subject: Requested Information from June 25, 2015 Regulatory Conference

On June 25, 2015, Exelon Generation Company, LLC (EGC) participated in a Regulatory Conference at the NRC's Region III Office in Lisle, Illinois, regarding a preliminary white finding associated with a failure of the Division 3 Shutdown Service Water (SX) system pump that occurred in September 2014. At this meeting the NRC requested information by July 6, 2015, to support the NRC's final determination of the pump failure. This letter provides the requested information.

If you have any questions and/or concerns regarding this information, please contact Mr. Jeffrey Cunningham, Regulatory Assurance Manager, at (217) 937-2800.

Respectfully,

for Mark Newcomer
Mark M. Newcomer
Site Vice President
Clinton Power Station

JLP/cas

Attachment – Response to Requested Information

cc: NRC Document Control Desk
NRC Project Manager, NRR – Clinton Power Station
NRC Senior Resident Inspector – Clinton Power Station

RGN01

Exelon Generation®

With regard to the questions asked by the NRC at the recent Regulatory Conference as it relates to the failure of the Division 3 Shutdown Service Water Pump, the following responses are provided.

1) If Exelon would like the NRC to consider recovery actions, then the recovery analysis should be provided.
    - As stated in the Regulatory Conference, Exelon agrees with the results of the Significant Determination Process. No further recovery analysis will be provided.

2) Provide information to determine if the indications (i.e., cracking) pre-existed prior to service following application of the spray-on hard facing.
    - The original pump manufacturer Sulzer has indicated that the sleeve hardfacing was applied by a third party vendor. The vendor that Sulzer used in the application of the overlay noted that the sleeves were post-weld stress relieved (PWHT) and PT examined after overlay application and rough grinding. Sulzer indicates the only records available are the CMTRs for the 410 sleeve substrate (in which the Ni content is limited to 0.25% to preclude substrate cracking), the manufacturing drawings, the design change records, and the Bill of Material for the pump, including sleeves and bushings. The vendor(s) have not produced records of the PT examination and therefore no documentation existence to prove absence of cracks prior to service. Exelon assumes that the presence of cracks or defects during the PT would cause reject of the part.

3) Manufacturer assessment regarding our insights/conclusions about the Sulzer spray-on hard facing process.
    - The information gathered by Exelon was provided to Sulzer for review; calculations and Exelon failure analysis report. On 7-2-2015 Sulzer provided the following information:
        - The hardfacing 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 PT examined again with approved procedures by our vendor. Sulzer concludes that some form of thermal shocking is thought to have been at play in order for the crack to develop in the hardfacing. Sulzer concluded that their original position remains valid and do not believe that a design defect was responsible for the 2014 pump failure. Again, the documentation of weld procedures and PT results are not available.
    - During the initial investigation Sulzer contracted ATS to conduct failure analysis of the failed bushing. In the ATS report dated Oct-31-2014 provided to Exelon by Sulzer, ATS concludes "The hardfacing appeared to be a thermal spray with minor porosity." This ATS report was provided as supporting material to the Regulatory Conference on June 25, 2015.
    - Supplemental Memo to Report CPS-86766, dated July 6, 2015 (Attachment A) summarized the investigation of the hardfacing/substrate microstructure by Exelon PowerLabs. PowerLabs determined if the hardfacing was welded, there would be a dilution zone that contains both a high concentration of nickel (from the hardfacing) and a high concentration of iron from the iron-based 400 series stainless steel base-metal. The results showed that there was a distinct separation of materials which suggests the overlay was not applied by a welding process.
    - Based on the ATS report cited above and the attached supplemental report from Exelon PowerLabs, Exelon has concluded that there is a distinct layer showing separation of materials not consistent with the results of a welded hardface that produces a metallurgical bond.

4) The CFD model and results for no flow conditions that show temperatures on the order of 200 degrees.

Clarification note: The CFD analysis results were not used directly to calculate the temperatures in the bearing in the event of blocking of the cooling channels. Rather, a thermal structural evaluation of the bearing was performed using the ANSYS finite element analysis code. The analysis model evaluated the postulated case in which the bearing is completely water-starved. The evaluation of the results of the thermal/structural model against available hard facing material information is summarized in the MPR Calculation Summary Report (Attachment B).

- Sulzer to validate against their experience/data.
  - Sulzer received a copy of the recent documentation comprised of the MPR calculations and analysis. Sulzer stated; the MPR CFD model appears well thought out however [Sulzer] was not given sufficient time to have the assumptions and results independently verified. Sulzer did not provide any alternative calculations, data, or modeling of the bushing temperatures.

- What benchmarking of the CFD model has been done?
  - The preparer of the Exelon calculations, MPR Associates, Inc. (MPR), provided the station with a Calculation Summary Report providing further information about the calculations performed. The MPR analysis was completed using 3 software packages; JURBNR portion of the Advanced Rotating Machinery Dynamics (ARMD) suite of tools, ANSYS CFX code, and with ANSYS finite element analysis (FEA) code. These analytical tools are validated through the MPR Appendix B Quality Assurance (QA) program however the calculations were not prepared as Appendix B safety related analysis.
    1. JURBNR Software –
       The pedigree of the JURBNR software is addressed as the ARMD suite is widely used in the analysis of bearings with over 350 users worldwide including major bearing, turbine, and pump vendors. Program validation for the JURBNR software is addressed by previous verification of JURBNR (for journal bearings) and THRSBR (for thrust bearings) portions of the ARMD code by performing formal verification calculations, in which the results from the software package were compared against published solutions for selected analysis cases. The Commercial Software Verification performed by MPR is formally documented in accordance with MPR's QA Program requirements. MPR performs a check and review of all software inputs. The reviewer ensures the software and analysis are appropriate for the analysis being performed and that results and outputs are reasonable.
    2. ANSYS CFX Software –
       The pedigree of ANSYS CFX was established by MPR using the "ANSYS Fluid Dynamics Verification Manual, Release 15.0, ANSYS Inc., November 2013."
       Program validation was performed by MPR using their Standard Quality Assurance program. MPR performs a check and review of all software inputs. The reviewer ensures the software and analysis are appropriate for the analysis being performed and that results and outputs are reasonable. Additionally in order to validate the specific CFD models and methods used, two comparison calculations were performed to ensure agreement between CFD results and the hand calculations.
    3. ANSYS FEA Software –
       The pedigree of ANSYS finite element analysis code was established using the "ANSYS, Inc., Release 15.0,"ANSYS Mechanical APDL Verification Manual."
       Program validation was performed by MPR using their Standard Quality Assurance program. MPR performs a check and review of all software inputs. The reviewer ensures the software and analysis are appropriate for the analysis being performed and that results are reasonable.

- Any 3rd party review conclusions of the CFD model and results?
  - An independent third party review (ITPR) was performed by Fauske & Associates calculations prepared for Exelon by MPR (Attachment C). All calculations were reviewed except MPR Calculation 0065-0055-010, "1SX01PC Suction Bell Bushing Performance,"

Revision 0. This calculation is a standalone product used for insight of bearing performance and not used in the preparation of other analysis or to draw conclusions.

- The following comments are summarized from the ITPR: Fauske & Assoc. generally agree with the methodology, assumptions and conclusions drawn by MPR and had only minor comments on approach and suggestions for improvements.

5) Do we think a Technical Specifications violation existed?
   - Yes, the station believes the pump seized upon the cooldown from the last pump run in May, 2014 resulting in the pump being inoperable from that time until discovery and repairs in September 2014. This exceeded the completion time allowed by Technical Specification 3.7.2 Division 3 Shutdown Service Water (SX) Subsystem and 3.5.1 ECCS Operating.

The response provided for the 5 questions above continues to support the station's conclusions and are consistent with the information discovered during the station's investigation in to the pump failure. The metallurgical analysis provide evidence that cracking/delamination was found in 5 additional shaft bearings that were not expected and were found to be free of mud and silt during disassembly. Exelon continues to put forth that properly applied hard facing would not show cracking or delamination at normal operation conditions. Furthermore, the analysis and modeling of a completely blocked cooling channel would not generate temperatures greater than 200 degrees Fahrenheit which is again within the capabilities of the material.

Exelon Generation. Exelon PowerLabs

To: **Dan Cummings, Clinton Station**

Subject: **Clinton 1C SX Pump Bearing Hardfacing Evaluations (Supplemental Memo to Report CPS-86766))**

Per your request, I am providing some additional comments on the hardfacing that was applied to the bearing sleeves.

PowerLabs would interpret a 'welding process' as involving the melting of both the base metal and the weld metal to form a metallurgical bond. A welding process would result in a dilution layer which contains a mixture of both the base metal and filler metal. If the hardfacing was welded, there should be a dilution zone that contains both a high concentration of nickel (from the hardfacing) and a high concentration of iron from the iron-based 400 series stainless steel base-metal.

Based on the metallurgical cross-sections that we evaluated, the hardfacing consisted of two layers: a thin layer near the base metal interface and then a thicker layer that completed the remainder of the overlay. During our evaluations, we performed qualitative SEM-EDS evaluations of the base metal, the hardfacing thin layer and the hardfacing thick layer. The results showed that there was a distinct separation of materials between the nickel-based hardfacing layers and the iron-based sleeve base metal (See the individual elemental scans for nickel and iron in the attachment to this memo), which suggests the overlay was NOT applied by a welding process. As a result, it may be possible that the vendor is interpreting the term 'welding process' to have a different meaning.

Reported by: Jim Chynoweth 7/06/2015
Manager, PowerLab West

PowerLabs did not find evidence that the hardfacing was welded to the sleeves. Every hardfacing/base metal interface showed a distinct boundary between the sleeve and the coating with no evidence of dilution from welding as shown in Figure A below. Additonal metallurgical photos of the interface regions were provided in the following photos of PowerLabs Report CPS-86766.

- Sleeve A: Report Figures 46 and 47, Sleeve C: Figure 48, Sleeve E: Figure 42, Sleeve F: Figure 30, and Sleeve G: Figure 22

Figure A - SEM-EDS Evaluations of Sleeve F Interface

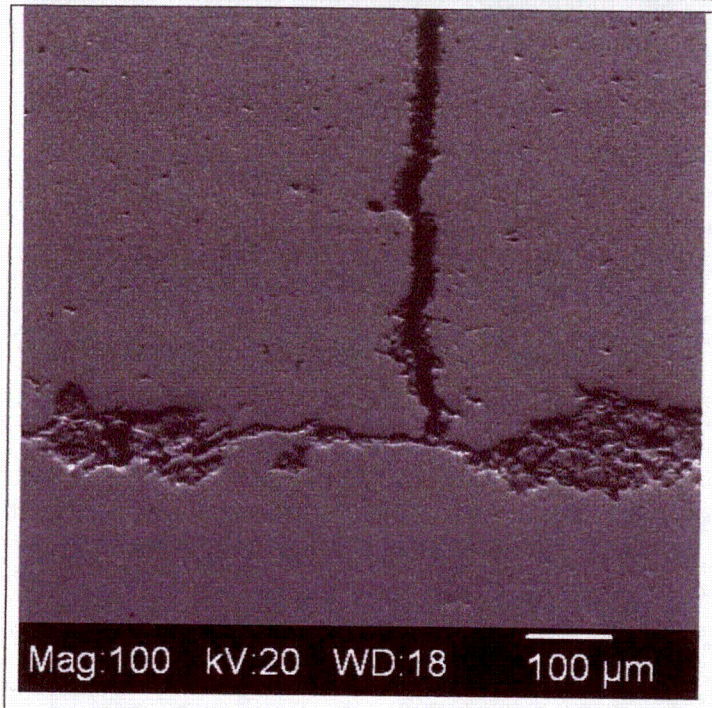
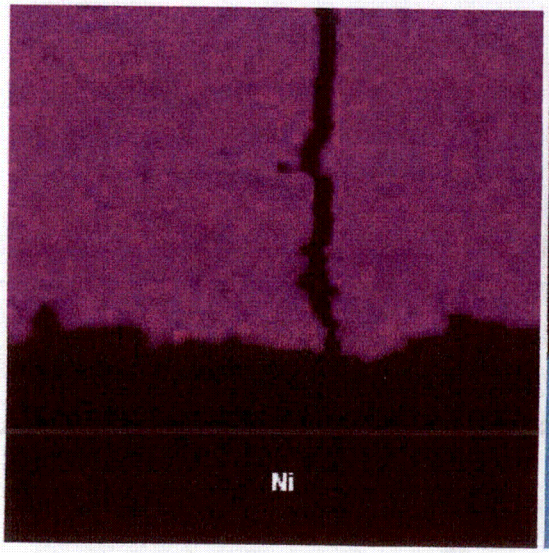
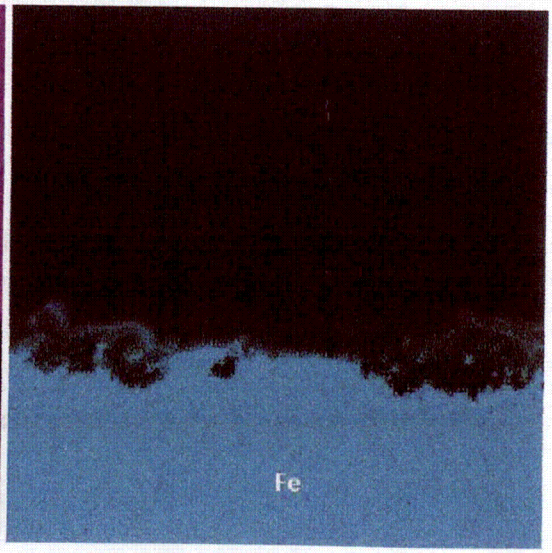


Figure A – The scanning electron photograph to the left shows the interface of the cracked hardfacing (upper areas) in Sleeve F with the base metal (lower area). The sample was evaluated using SEM-EDS techniques and the individual elemental distributions for nickel and iron are shown in the photo below. Note there was no evidence of a welding induced dilution layer, which would have contained significant levels of both nickel and iron.





MPR

July 5, 2015
LTR-0065-0055-016, Rev. 0

Mr. Michael Heger
Sr. Manager Plant Engineering
Clinton Power Station
8401 Power Rd.
Clinton IL, 61727-9182

Subject: Clinton Power Station 1SX01PC Pump September 2014 Bearing Failure – Calculation Summary Report

Dear Mr. Heger:

A meeting was held with the NRC on June 25, 2015, to discuss the cause of the bearing failure which had been experienced by the Division 3 Shutdown Service Water (1SX01PC) pump in September 2014. The results of calculations which had been performed to develop insights into potential mechanisms were discussed in the meeting. Several questions were asked during the meeting which indicated that the following would assist in the review process: 1) a document which clarifies the relationship between the various calculations, especially as it relates to the relationship between the CFD analyses and the thermal structural analyses which support the conclusion that the temperatures seen in a water-starved bearing are within the capabilities of the materials, and 2) additional discussion on the measures taken to ensure the calculations were accurate and reasonable.

The attached report has been compiled to address that need. The report:

- Provides a roadmap for the calculations, including an overview of the calculations and a discussion of the relationship between the calculations.
- Provides a summary of the analysis models and software, and the approach taken to verify the results.
- Provides a summary of the key observations developed from the calculations.

As discussed in Section 4.3 of the attached report, the CFD analysis results were not used directly to calculate the temperatures seen in the bearing in the event of blocking of the cooling channels. Rather, a thermal structural evaluation of the bearing was performed using the ANSYS finite element analysis code. The analysis model evaluated the postulated case in which the bearing is completely water-starved. The evaluation of the results of the thermal/structural model against available hard facing material information is summarized in Section 3 of the enclosed report. Additional discussion on hard facing materials was included in MPR's June 17, 2015 PowerPoint presentation (Reference 3 of the attached report).

Please give Nicholas Marrone (703-519-0537) or Kevin Myers (703-519-0416) a call if you have any questions regarding this letter or the enclosed report.

Sincerely,

Nicholas L. Marrone

Nicholas Marrone

Enclosure

cc: R. Kerestes, Exelon (Clinton)
D. Cummings, Exelon (Clinton)