Exelon Generation®

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NEI 03-08

March 6, 2020

LTR: Byron 2020-0013

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Byron Station, Unit 1
Renewed Facility Operating License No. NPF-37
NRC Docket No. 50-454

Subject: Notification of Deviation from Electric Power Research Institute (EPRI) Topical Report MRP-227, Revision 1, "Materials Reliability Program: Pressurized Water Reactor Internals Inspection and Evaluation Guideline"

Exelon Generation Company, LLC (EGC) is providing notification that Byron Station, Unit 1, has processed a deviation from a Nuclear Energy Institute (NEI) 03-08, "Guideline for the Management of Materials Issues," Revision 3, "Needed" work product element in EPRI report MRP 227-A, "Pressurized Water Reactor Internals Inspection and Evaluation Guidelines," with appropriate justification and documentation.

Control Rod Guide Tube (CRGT) guide card wear measurement is a "Needed" requirement specified in WCAP-17451-P, Revision 1, which the document listed in MRP-227-A containing the examination requirements for CRGT guide cards. Byron Unit 1 has elected to delay wear measurement of its CRGT guide cards for two additional Refueling Outages (from B1R23 in spring 2020 to B1R25 in spring 2023).

NEI 03-08 allows deviation from "Needed" elements with the appropriate justification and documentation. The deviation was approved with the appropriate levels of EGC management.

Attachment 1 provides the Byron Unit 1 Control Rod Guide Tube Guide Card Wear Measurement Deviation - B1R23 Technical Evaluation.

This notification is provided for information only. No approval or action is expected.

There are no regulatory commitments contained in this letter. If you have any questions concerning this letter, please contact Jamie Getchius, Principal Regulatory Engineer, at (815) 406-2991.

Respectfully,

Mark E. Kanavos
Site Vice President
Byron Nuclear Generating Station

MEK/WJG/rm

Attachment 1: Byron Unit 1 Control Rod Guide Tube Guide Card Wear Measurement Deviation - B1R23 Technical Evaluation 630551

cc: NRC Regional Administrator, Region III
NRC Senior Resident Inspector - Byron Station
Illinois Emergency Management Agency - Division of Nuclear Safety
NRC Plant Project Manager

Utility: Exelon

Applicable Site(s) and Unit No.: Byron Unit 1

Utility Contact(s): Don Merkle – Byron Engineering Programs; Robert Marcello - Corporate Asset Protection

Issue Program (IP) activity or document:

- PWROG Materials Committee: WCAP-17451-P, Revision 1, Reactor Internals Guide Tube Wear – Westinghouse Domestic Fleet Operational Projections
- EPRI Materials Reliability Program: Pressurized Water Reactor Internals Inspection and Evaluation Guidelines (MRP-227-1-A)

Scope / Description of Deviation:

Byron Unit 1 has developed a technical basis to delay wear measurement of the Control Rod Guide Tube (CRGT) Guide Cards for two additional Refueling Outages (from B1R23 to B1R25) with no compromise on nuclear safety. This is a change from the NEI 03-08 "Needed" requirement specified in WCAP-17451-P Revision 1, which is the document listed in MRP-227-1-A containing the examination requirements for CRGT Guide Cards.

For a Westinghouse Pressurized Water Reactor, there are nine Primary Components that must be inspected as part of MRP-227, in support of license extension activities. One of these components is the guide cards of the Control Rod Guide Tubes (CRGT). Examination frequency and coverage for this component are specified in WCAP-17451-P, Revision 2. Specifically, for Byron, denoted as "Plant Q", Table 5-14 specifies that an initial Guide Card Wear Measurement (GCWM) should take place prior to 26.5 EFPY. Further guidance specified in section 5.4 allows initial inspection measurements up to an additional 4 EFPY beyond 26.5 EFPY; which equates to 30.5 EFPY. The goal of this recommendation is to ensure that baseline inspections are performed in the Green Zone (i.e. while the guide cards have low/no wear). The inspection range specified for Byron was developed through review of guide card ligament wear seen in FME videos that were taken in past refueling outages.

At the end of Cycle 22 (September 2018), Byron Unit 1 had 28.645 cumulative EFPY. It is anticipated that Byron Unit 1 will have approximately 30 EFPY at the start of Refueling Outage 23 (March 2020). This would be at the upper limit of when the baseline inspection is recommended to be performed. However, Byron Unit 1 has developed a technical basis to perform the baseline inspection during Refueling Outage (RFO) 25, which is currently scheduled for March 2023, and an anticipated accumulation of 33 EFPY; approximately 2.5 EFPY beyond the recommended inspection timing range.

Reason for Deviation:

Exelon has developed a technical basis that supports deferral of the guide card wear measurements from B1R23 (Spring 2020) to B1R25 (Spring 2023), which in turn reduces outage execution risks associated with multiple, parallel work activities, provides a more favorable business case for the station with no reduction in nuclear safety.

The B1R23 outage scope contains a large number of inspections associated with the RPV closure head, RPV nozzles and other (non-inspection) refuel floor and in-vessel work. The addition of CRGT guide card wear measurements presents an additional level of risk associated with coordination and execution of the large scope of activities, as well as added cost without any technical benefit. For example, the inspection of the CRGT guide

cards would introduce added complexity and cost associated with the fabrication of an Auxiliary Bridge required to perform the exam. Deferring the guide card wear inspections to B1R25 (Spring 2023) facilitates a much more favorable outage work risk profile and cost with no compromise on nuclear safety.

Due to these challenges, a technical review was performed to determine if the baseline GCWM could be deferred while maintaining margin to safety. The evaluation did conclude this was technically justifiable and is documented in EC 630551.

IR Number: 04315808 **EC Number:** 630551

Time Frame the Deviation will be in Effect:

This deviation will be in effect until refueling outage B1R25 (Spring 2023).

Deviation from this IP document is classified as: "NEEDED"

Prepared By:	Robert Marcello	Robert Marcello Date: 2/6/2020
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Byron Unit 1 Control Rod Guide Tube Guide Card Wear Measurement Deviation – B1R23
Technical Evaluation 630551

1. Reason for Evaluation/Scope:

Byron Unit 1 has elected to delay wear measurement of the Control Rod Guide Tube (CRGT)[1] guide cards for two additional Refueling Outages (from B1R23 to B1R25). This is a change from the NEI 03-08 "Needed" requirement specified in WCAP-17451-P Revision 1, which is the document listed in MRP-227-1-A containing the examination requirements for CRGT guide cards.

For a Westinghouse Pressurized Water Reactor, there are nine Primary Components that must be inspected as part of MRP-227, in support of license extension activities. One of these components is the CRGT guide cards. CRGT's are utilized in the upper internals to provide guidance of the Rod Cluster Control Assemblies (RCCAs) above the core fuel assemblies. Each CRGT houses one RCCA, which is made up of long, slender rodlets that are commonly attached to a drive rod by a coupling fixture called a spider. The drive rod, located above the RCCA, steps the RCCA into and out of the fuel assemblies. The RCCAs can also be released to allow them to drop into the fuel assembly when required for core shutdown. The individual rodlets are guided inside the guide tubes by approximately one-inch thick guide cards which are typically located about one foot apart and are also guided by a continuous guidance assembly located at the bottom of the lower CRGT assembly. The primary concern due to guide card wear is the possibility that with enough wear, loss of guidance of the individual control rodlets may occur inside a CRGT. If loss of guidance at a guide card occurs, the unsupported length of a rodlet will increase.

Examination frequency and coverage for this component are specified in WCAP-17451-P, Revision 2. Specifically, for Byron, denoted as "Plant Q"[2], Table 5-14 specifies that an initial Guide Card Wear Measurement (GCWM) should take place prior to 26.5 EFPY. Further guidance specified in section 5.4 allows initial measurements up to an additional 4 EFPY beyond 26.5 EFPY; which equates to 30.5 EFPY. The goal of this recommendation is to ensure that baseline inspections are performed in the Green Zone (i.e. while the guide cards have no low/wear). The inspection range specified for Byron was developed through review of guide card ligament wear seen in FME videos that were taken in past refueling outages.

At the end of Cycle 22 (September 2018), Byron Unit 1 had 28.645 cumulative EFPY (Ref. 5.8). It is anticipated that Byron Unit 1 will have approximately 30 EFPY at the start of Refueling Outage 23 (anticipated to be March 2020). This would be at the upper limit of when the baseline inspection should occur. However, Byron Unit 1 has elected to perform the baseline inspection during Refueling Outage (RFO) 25, which is currently scheduled for March 2023 and an anticipated accumulation of 33 EFPY; approximately 2.5 EFPY beyond the recommended baseline inspection timing range.

Per NEI 03-08, a "Needed" work product is "to be implemented wherever possible, but alternative approaches are acceptable". When a utility determines that "Needed" work product elements will not be fully implemented or will not be implemented in a manner consistent with their intent, or when a work product will not be implemented within the timeframe specified, a technical justification shall be developed. This Technical Evaluation justifies delay of the Byron Unit 1 CRGT GCWM.

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[1] Also referred to as "guide tube" within this document

[2] Although WCAP-17451-P does not reveal that Plant Q is Byron, for proprietary reasons, this has been verified by Westinghouse in Reference 5.13.

2. Detailed Evaluation:

Exelon has developed a technical basis that supports deferral of the guide card wear measurements from B1R23 (Spring 2020) to B1R25 (Spring 2023), which in turn reduces outage execution risks associated with multiple parallel work activities, and provides a more favorable business case for the station with no reduction in nuclear safety.

The B1R23 outage scope contains a large number of inspections associated with the RPV closure head, RPV nozzles and other (non-inspection) refuel floor and in-vessel work. The addition of CRGT guide card wear measurements presents an additional level of risk associated with coordination and execution of the large scope of activities, as well as added cost without any technical benefit. For example, the inspection of the CRGT guide cards would introduce added complexity and cost associated with the fabrication of an Auxiliary Bridge required to perform the exam. B1R24 (Fall 2021) presents a similar level of risk associated with coordination and execution, as well as added cost, without any technical benefit, as the reactor-side outage window is too short to accommodate this exam and the outage would have to be extended solely to accommodate this exam. Deferring the guide card wear inspections to B1R25 (Spring 2023) facilitates a much more favorable outage work risk profile and cost with no compromise on safety.

Comparison to DC Cook Unit 2 provides technical support of deferring GCWM by two Refueling Outages. DC Cook Unit 2 is a PWROG-provided data source which best matches Byron Unit 1. DC Cook Unit 2 is a 4-loop, 17x17 Standard 150-inch CRGT, chrome plated control rod plant. There are several other units which operate similarly to Byron Unit 1, but utilize ion nitride plated control rods, which are known to wear guide cards at a quicker rate. Several of these units will be discussed later in this evaluation. Byron Engineering Evaluation 629608 was done to draw a correlation between the results of the DC Cook Unit 2 inspection and the anticipated results of Byron Unit 1. The objective of Engineering Evaluation 629608 was to determine the Byron Unit 1 accumulated burnup calendar date which corresponds with the accumulated limiting projection burnup at DC Cook Unit 2.

Inspections at DC Cook were complete at an accumulated burnup of 26.74 EFPY, with an expected need for additional inspections at an additional accumulated burnup of 8.8 EFPY, based on WCAP-17451 Revision 1 wear prediction calculations. Therefore, DC Cook's accumulated limiting projection burnup is 35.54 EFPY. The calculation methodology used in Revision 1 of WCAP-17451 is more conservative than that in Revision 2 of WCAP-17451. Per Westinghouse Letter LTR-RIDA-20-4, Revision 2 methodology dictates the same DC Cook limiting guide tube be inspected at an additional accumulated burnup of 82.6 EFPY beyond the 26.74 EFPY when the inspections occurred. Therefore, wear which had to be immediately addressed was not identified. Although, no short-term additional actions were necessary, two guide tubes were proactively swapped so that the site would not have to take long term actions for the rest of their 60 year license (Ref. 5.14).

At the end of Cycle 22 (9/10/2018) Byron had accumulated 28.645 EFPY. Using the more conservative Revision 1 WCAP-17451 methodology, the difference between DC Cook's accumulated limiting projection burnup and Byron's accumulated burnup at the conclusion of Cycle 22 is 6.895 EFPY. Taking these values into consideration, with an assumption-based calendar date, Byron would reach an accumulated burnup of 35.54 EFPY on 8/2/2025.

Given that the proposed deferral date of GCWM at Byron is during B1R25 (Spring 2023), Byron is well bounded by DC Cook's reinspection time frame and B1R25 inspections are not expected to find

conditions requiring immediate replacement. Should B1R25 reveal CRGT guide card wear indicating that future replacements are needed sooner than anticipated, there would be enough time to determine replacement quantity and locations to support B1R26, which currently has a projected start date of September 2024.

As stated above, several other plants operate similarly to Byron Unit 1, but utilize the more aggressive ion nitride plated control rods. These units include Diablo Canyon Unit 1, Salem Unit 1, and Salem Unit 2. As shown in Westinghouse Letter LTR-RIDA-20-4, each of these units has measured their guide card wear between 25 EFPY and 29 EFPY. Taking into account wear predictions of WCAP-17451 Revision 2, the most limiting guide tube from these plants is not anticipated to reach the start of the Red Zone for another 14.2 EFPY beyond the point of inspection, or a total of 41.87 EFPY. This is well beyond the time frame in which Byron Unit 1 is deferring their inspections.

Westinghouse Letter LTR-RIDA-20-4 has also re-evaluated the baseline inspection timing requirements and the projected timing for wear through for the worst two guide tubes at Byron Unit 1 using the combined operational time extension curves from Revision 2 of WCAP-17451, as opposed to the most limiting curves in Revision 1 of WCAP-17451. The two worst guide tubes analyzed were N11 and H08. The worst worn guide card slot width reaching the unworn rodlet diameter (i.e. the time for the slot width to reach the end of the red zone) for N11 is projected to be 33.08 EFPY, which is projected to be near the Byron unit 1 Spring 2023 RFO. The worst worn guide card slot width reaching the unworn rodlet diameter for H08 is projected to be at 40.41 EFPY. It must be noted that the remaining guide cards in each of the respective guide tubes will only add margin. So, while the worst worn guide card in N11 has the potential to break through in the Spring of 2023, it is expected that the remaining guide cards within that guide tube will remain intact.

Westinghouse Letter LTR-RIDA-20-4 has also reviewed the FME videos of the two worst guide tubes in order to measure the ligament and chamfer on each image captured for each guide card. Guide tubes N11 and H08 were inspected with this method and estimated the time for each guide tube's slot width to reach the start of the Red Zone. Using the WCAP-17451 Revision 2 criteria, guide tube N11 is projected to reach the start of the red zone at 82.0 cumulative EFPY and guide tube H08 is projected to reach the start of the Red Zone at 66.8 cumulative EFPY. Using the WCAP-17451 Revision 1 criteria, guide tube N11 is projected to reach the start of the red zone at 59.9 cumulative EFPY and guide tube H08 is projected to reach the start of the Red Zone at 47.4 cumulative EFPY, showing adequate margin to safety with uncertainty by deferring the baseline GCWM to approximately 33 cumulative EFPY.

A Probabilistic Risk Assessment (PRA) has also been done by Exelon to evaluate the risk of deferring the Byron Unit 1 CRGT GCWM from B1R23 to B1R25 (refer to Attachment 1). The PRA model was used to estimate the core damage risk by increasing the probability of an ATWS event, which for Byron is defined as 10 of 50 rods (i.e. 20%) failing to drop on a reactor trip demand. Given the likelihood of failure of the rods to insert remains linear through the B1R25 Refueling Outage, the core damage risk increases due to ATWS associated with this extension is very small (1E-8/yr). This is considered an acceptable change in risk as discussed in NRC Regulatory Guide 1.174, where Core Damage Frequency increases less than 1E-6 are considered very small changes.

Existing station processes also offer deferral risk mitigation. Technical Specification Surveillance Requirements include direct measurement of Rod Control Cluster Assembly drop time measurements following every refueling outage. These data, in combination with the same data collected in the past, can identify anomalies which can merit further assessments and actions. Performance characteristics of

the RCCA Guide Tubes have been collected over the past eight refueling outages (approximately 12 years). Results have shown that the most recent Byron Unit 1 Rod Drop Timing Surveillance measurements are statistically the same as all previous seven sequential executions. Technical Specification Operability and performance characteristics have been maintained and will continue to be monitored.

3. Conclusion/Findings:

The proposed Byron Unit 1 CRGT GCWM deferral from B1R23 to B1R25 remains supported through margins demonstrated in Westinghouse Letter LTR-RIDA-20-4 and is bounded by DC Cook Unit 2 reinspection timeframes to ensure safety. Deferral risks are abated through several avenues such as: expansion of industry CRGT GCWM data during the deferral period, availability of refueling outage B1R26 to potentially perform unanticipated corrective maintenance while still within the DC Cook Unit 2 CRGT guide card reinspection window, and routine performances of the Technical Specification Rod Drop Timing surveillance.

4. Attachments/Supporting Information:

4.1 Risk Evaluation for Deferring Byron Unit 1 Guide Tube Wear Inspection, November 1, 2019

5. References:

5.1 NEI 03-08, Revision 3, "Guideline for the Management of Materials Issues," February 2017.
5.2 WCAP-17451-P, Revision 1, "Reactor Internals Guide Tube Wear – Westinghouse Domestic Fleet Operational Projections," October 2013.
5.3 WCAP-17451-P, Revision 2, "Reactor Internals Guide Tube Wear – Westinghouse Domestic Fleet Operational Projections," November 2018.
5.4 MRP-227, Revision 1-A, "Materials Reliability Program: Pressurized Water Reactor Internals Inspection and Evaluation Guidelines", Product ID 3002017168, December 2019.
5.5 Byron Unit 1 Engineering Evaluation 629608
5.6 Byron Unit 1 Engineering Evaluation 627840
5.7 Byron Unit 1 Engineering Evaluation 627842
5.8 Byron Unit 1 Engineering Evaluation 625863
5.9 Exelon Probabilistic Risk Assessment for Byron Unit 1, "Risk Evaluation for Deferring Byron Unit 1 Guide Tube Wear Inspection," November 1, 2019.
5.10 Byron Unit 1 Technical Specification Rod Drop Timing surveillance 1BOSR 1.4.3-1a
5.11 Byron Unit 1 Technical Specification Rod Drop Timing surveillance 2BOSR 1.4.3-1a
5.12 2019 Materials Programs Technical Information Exchange Meeting Presentation, "Guide Card Wear Activities", by Heather Malikowski, PWROG MSC RI Planning Team Lead (Exelon), May 21, 2019.
5.13 Westinghouse Letter LTR-RIDA-20-4, "Guide Card Wear Baseline Inspection Deferral Inputs for Byron Unit 1", 2/4/2020.
5.14 MRP-219, Revision 12, "Materials Reliability Program: Inspection Data Survey Report", Product ID 3002007933, February 2018.

6. Approval:

Prepared By:	Robert Marcello	(See Passport for Approval)
Byron Site Materials Engineer Review:	Don Armbruster	(See Passport for Approval)
PRA Risk Evaluation Preparer:	Robert Cavedo	(See Passport for Approval)
PRA Risk Evaluation Reviewer:	Ethan Graven	(See Passport for Approval)
Independent Review:	Ed Englert	(See Passport for Approval)
Station Program Manager Approval:	Don Merkle	(See Passport for Approval)

7. Embedded Attachment:

Westinghouse Letter LTR-RIDA-20-4:

Adobe Acrobat
PDFXML Document

Byron Unit 1 Control Rod Guide Tube Guide Card Wear Measurement Deviation – B1R23
Technical Evaluation 630551

Summary

The following evaluates the risk of deferring the Byron Unit 1 Guide Tube Wear inspection from B1R23 to B1R25. The Byron PRA model is used to estimate the core damage risk by increasing the probability of an ATWS event. An ATWS event for Byron is defined as 10 rods failing to drop on a reactor trip demand. There is an increased likelihood that individual rods will fail to insert over the extension period as wear increases over time; however, this non-ATWS condition does not contribute to core damage.

Byron Station's presentation, "Byron Unit One RCCA Guide Tube Inspection Deferral from B1R23 to B1R25" presents evidence that Byron's guide tubes will not enter the wear out region through B1R25. The PRA analysis assumes that the failure probability of an ATWS event is linear (i.e. the failure rate is constant) over the analysis period. Given the likelihood of failure of the rods to insert remains linear through the B1R25 outage (10-of-50 rods)[3], the core damage risk increases due to ATWS associated with this extension is very small (1E-8/yr). This is considered an acceptable change in risk as discussed in NRC Regulatory Guide 1.174, where CDF increases less than 1E-6 are considered very small changes.

Analysis

The Unit 1 Byron CDF due to an ATWS event is 9.68E-8. This is determined by quantifying model Gate 1T-ATWS with rod stuck event,1ATW-MSR---XRXXX (and set to 0.5 at a truncation of 1E-6). After the quantification, the basic event is restored to its original value to arrive at an ATWS contribution of 9.68E-8. At Byron Unit 1, an ATWS is defined to be 10-of-50 rods[1] (i.e. 20%) failing to insert. The generic likelihood of this is 1.21E-6 (per NUREG/CR-5500 Vol 2 pg. E-27).

Byron Unit 1 went critical in February 1985; and is currently at 35 years of service as of outage B1R23. Although individual rods could potentially be approaching wear limits (i.e. projected stress beyond material strength) for the worst case, the majority of rods will not be near the wear limit over the extension period, coupled with the lower stresses on typical reactor trips. As such, Byron Unit 1 as a rod group can be effectively considered in the linear failure region (i.e. Weibull with a Beta of 1) regarding Guide Tube Wear through the B1R25 outage. Therefore, standard linear extension techniques can be applied. It is further assumed for this evaluation that an inspection in B1R23 could have discovered a trending issue that could have had an impact by B1R25, increasing the likelihood of control rods failing to insert by 4/35. This increased risk - while in the flat portion of the Weibull distribution (i.e. failure rate not near the wear point as a group)- represents a 1.11E-8/yr. increase in CDF.

The reason for this small increase in the extended period is multi-fold. The likelihood of stuck rods in general is low. A large number of rods (20%) would be required to not insert to cause an ATWS condition. Further, even during an ATWS event, the event can be mitigated by establishing emergency boration (3% failure likelihood per 1RC-EB-ATWSHSYOA) while increasing feed to the steam generators. In some cases, the initiating event disables either the increase feeding option or the boration option. Even when considering the range of initiating events and possible MTC, there is only a 7.6E-2 annual likelihood (i.e. frequency when ATWS set to true) an ATWS will progress to core damage.

A review of FPIE model CDF and LERF cutsets indicates an ATWS cutset ratio for LERF/CDF is more than a factor of ten; therefore, CDF is the bounding metric for this evaluation. As a sensitivity, the likelihood of the rods failing to insert would have to increase by more than factor of ten for the 1E-6 threshold to be exceed (i.e. approximately a hundred times larger than the 4/35 increase).

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[3] Generic data for the control rods failing mechanically was taken from NUREG/CR-5500 Vol 2. Pages E-26 and E-27 of the NUREG provides the assumptions and results related to rod criteria failure. The NUREG states that Westinghouse plants have an average of 50 control rods and as such, this value was used for this analysis. Byron in fact has 53 control rods. This number of rods is within the analysis bounds of the NUREG.