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10 CFR 50.55a

RS-16-259

December 29, 2016

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

Byron Station, Units 1 and 2
Renewed Facility Operating License Nos. NPF-37 and NPF-66
NRC Docket Nos. STN 50-454 and STN 50-455

Subject: Response to Request for Additional Information for Byron Station Relief Request I4R-10: Proposed Alternative Requirements for the Repair and Examination of Reactor Vessel Head Penetrations for the Fourth Inservice Inspection Interval

References:

(1) Letter from Jacob Zimmerman, (U. S. NRC) to M. J. Pacilio, (EGC), "Braidwood Station, Units 1 and 2 and Byron Station, Unit Nos. 1 and 2 Relief Requests 13R-09 and 13R-20 Regarding Alternative Requirements for Repair of Reactor Vessel Head Penetrations (TAC Nos. ME6071, ME6073, and ME6074)," dated March 29, 2012 (ML120790647)

(2) Letter from David M. Gullott, (EGC) to U.S. NRC, "Revision to the Third 10-Year Inservice Inspection Interval Requests for Relief for Alternative Requirements for the Repair of Reactor Vessel Head Penetrations," dated September 8, 2014 (ML16229A250)

(3) Letter from Justin C. Poole, (U.S. NRC) to Bryan C. Hanson (EGC), "Byron Station, Units Nos. 1 and 2, and Braidwood Station, Units 1 and 2 – Relief from the Requirements of the ASME Code," dated January 21, 2016 (ML16007A185)

(4) Letter from David M. Gullott, (EGC) to U.S. NRC, "Relief Request for Alternative Requirements for the Repair and Examination of Reactor Vessel Head Penetrations for the Fourth Inservice Inspection Interval," dated August 16, 2016 (ML16229A250)

(5) Email from Joel Wiebe, (U.S. NRC) to Jessica Krejcie (EGC), "Preliminary Request for Additional Information (RAI) Regarding Relief Request I4R-10," dated December 8, 2016 (ML16343A252)

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NRR

In Reference 1, the NRC provided their authorization to implement Relief Requests I3R-09 and I3R-20, Revision 1 as a repair method for degradation identified in reactor vessel head penetrations. In Reference 2, Exelon Generation Company, LLC (EGC) submitted a relief request that was applicable to the third 10-Year Inservice Inspection (ISI) interval and requested inspection frequency relief for the reactor vessel head penetrations repair weld surface examinations (i.e., dye penetrant (PT)) for Braidwood Station, Units 1 and 2 and Byron Station, Units 1 and 2. In Reference 3, the NRC approved the request for the third ISI interval for Braidwood Station and Byron Station.

In Reference 4, EGC submitted a relief request similar to the relief request that was approved in Reference 3. The only differences between the Reference 4 request and that approved in Reference 3 were that the relief request was applicable to Byron Station only, minor formatting and editorial changes were made and the applicable code edition and addenda was updated to reflect the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, 2007 Edition, with the 2008 Addenda, which is the ASME Code applicable to the Byron Station 4th ISI interval.

In Reference 5, the NRC requested additional information related to their review of Reference 4. The response to the Reference 5 request is provided below.

**NRC RAI:**

*"By letter dated August 16, 2016, (Agencywide Documents Access and Management System (ADAMS) Accession No. ML16229A250), Exelon Generation Company, LLC (the licensee) requested the U.S. Nuclear Regulatory Commission (NRC) to authorize an alternative to the requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) regarding the repair of reactor vessel head penetrations (VHPs) at Byron Station Units 1 and 2 (Byron) for the fourth 10-year ISI interval. The licensee's request also included inservice inspection (ISI) examination requirements for future VHP repairs as well as previously repaired VHPs.*

*The licensee's alternative to use its VHP repair method during the third 10-year ISI interval, which ended on July 15, 2016, was approved by the NRC on March 29, 2012 (ADAMS Accession No ML120790647). This alternative was later revised by the licensee and approved by the NRC on January 21, 2016 (ADAMS Accession No ML16007A185). The revision was limited to alternative ISI examinations of repaired nozzles. The licensee's current alternative request indicates that 6 VHP's were repaired during the third 10-year ISI interval. To the NRC staff's knowledge, all of these repairs involved embedded flaws in the J-groove weld.*

*The Byron plant specific analysis, to support the embedded flaw technique, is documented in WCAP-16401, Revision 0, "Technical Basis for Repair Options for Reactor Vessel Head Penetration Nozzles and Attachment Welds: Byron and Braidwood Units 1 and 2," 2005. This document was submitted to the NRC as part of the licensee's submittal for its alternative in the third 10-year ISI interval and is referenced in the licensee's current proposed alternative for the fourth 10-year ISI interval.*

*WCAP-16401, Revision 0, Section 3.3.3, states "The fatigue crack growth result indicates that the repaired weld can last at least 10 years of service life based on the conservatively assumed initial flaw depth." The NRC staff's safety evaluation, as documented in the March 29, 2012 letter referenced above, states "The NRC staff finds WCAP-16401 provides a basis for any remaining ligaments of the flaws identified by the licensee in VHP nozzle J-groove weld material to be safely* *encapsulated for 10 years of operation." The NRC staff notes that all 6 previously repaired nozzles at Byron will exceed 10 years of operation during the current fourth 10-year ISI interval. The licensee has included these repaired VHPs in its current alternative.*

*Provide information that demonstrates that the previously repaired nozzles are acceptable for service during the duration of the 4th ISI Interval (e.g., revision to the WCAP-16401 and modifications, as necessary, to the relief request) or otherwise demonstrate that the previously repaired nozzles will be taken out of service (e.g., repaired/replaced in accordance with the ASME Code prior to reaching the 10th anniversary of their repair)."*

**EGC Response to NRC RAI:**

Embedded flaw repairs were previously performed on four Unit 1 reactor Vessel Head Penetrations (VHPs) and two Unit 2 VHPs. The embedded flaws were in two different locations; the head penetration nozzles and the penetration nozzle attachment welds. The following table summarizes which nozzles have been repaired, the repair outage with an approximate date of the repair, and the flaw location (i.e., penetration nozzle or attachment weld):

| Unit | Penetration | Repair Outage | Flaw Location |
|---|---|---|---|
| 1 | 31 | B1R17 (April 2011) | Attachment Weld |
| 1 | 43 | B1R17 (April 2011) | Attachment Weld |
| 1 | 64 | B1R17 (April 2011) | Penetration Nozzle |
| 1 | 76 | B1R17 (April 2011) | Penetration Nozzle |
| 2 | 68 | B2R13 (April 2007) | Penetration Nozzle and Attachment Weld (i.e., two flaw locations) |
| 2 | 6 | B2R18 (October 2014) | Attachment Weld |

As noted in the NRC RAI, WCAP-16401-P identifies that there are at least 10 years of service life for the repair of weld flaws using the embedded flaw repair methodology. Westinghouse Electric Company (Westinghouse) provided clarification associated with the service life of the embedded flaw repairs described in the WCAP. This clarification indicated the service life of an embedded flaw repair is reset to ten (or twenty) years each time the region is inspected via ISI, after the flaw size is compared to the last ISI inspection and confirmed to remain small (i.e., no appreciable change in size). Specifically, a service life of twenty years between inspections was determined for flaws in the reactor vessel head penetration nozzle and a service life of at least ten years between inspections was determined for a flaw in the penetration nozzle attachment weld. Therefore, the "acceptable service life" of embedded flaw repairs for reactor VHPs is determined by the results of the inspection and the period between inspections, not a fixed total life of the repair. For Unit 1, the last inspections were performed in September 2015. For Unit 2, the last inspections were performed in April 2016.

The head penetration nozzle repairs performed on penetrations U1-64 (i.e., Unit 1 Penetration 64), U1-76 and U2-68 were evaluated using WCAP-16401-P as clarified above. The evaluations determined that the embedded flaw repair method was acceptable for repair of the nozzle flaws and that the service life of twenty years between inspection was reset.

The attachment weld repairs performed on penetrations U1-31, U1-43, U2-68, U2-6 have been inspected each outage since the repairs were performed and have been evaluated by comparing current ISI data to the previous examination data and confirmed that no measurable changes have been observed. Since no measurable changes have been observed, the service life for the embedded flaw repairs has been reset to 10 years from the last inspection.

The head penetration nozzles and attachment weld repairs will continue to be inspected in subsequent outages during the 4th ISI Interval. Based on the most recent inspection results, EGC concludes that the embedded flaw weld repairs will remain acceptable for service for the duration of the 4th ISI Interval. If a measurable change in the embedded flaws is detected during the 4th ISI Interval inspections, additional analysis or repairs will be performed at that time.

The Reference 4 Attachment 1 relief request has been revised to add a new Reference 12 which provides clarification on the life expectancy of the embedded flaw repairs as described above. The revised relief request (i.e. I4R-10 Revision 1), is included as an Attachment.

The fourth interval of the Byron ISI Program began on July 16, 2016 and is scheduled to end on July 15, 2025. The attached relief request addresses potential repairs and inspections that would be performed during a refueling outage within the fourth interval and therefore, EGC requests approval of the proposed relief request by February 20, 2017, prior to the beginning of the Byron Station Unit 1 refueling outage in Spring 2017 (B1R21).

There are no regulatory commitments contained in this letter.

If you have any questions regarding this matter, please contact Jessica Krejcie at (630) 657-2816.

Respectfully,

David M. Gullott
Manager - Licensing
Exelon Generation Company, LLC

Attachment: 10 CFR 50.55a Relief Request I4R-10, Revision 1, Alternative Requirements for the Repair of Reactor Vessel Head Penetrations in Accordance with 10 CFR 50.55a(z)(1)

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

**ATTACHMENT**

10 CFR 50.55a Relief Request I4R-10, Revision 1, Alternative Requirements for the Repair of Reactor Vessel Head Penetrations in Accordance with 10 CFR 50.55a(z)(1)

**10 CFR 50.55a RELIEF REQUEST I4R-10**
**Revision 1**


**Request for Relief**
**Alternative Requirements for the Repair of Reactor Vessel Head Penetrations**
**In Accordance with 10 CFR 50.55a(z)(1)**

## 1.0 ASME CODE COMPONENT(S) AFFECTED

| | |
|---|---|
| Component Numbers | Byron Station, Units 1 and 2, Reactor Vessels 1RC01R (Unit 1) and 2RC01R (Unit 2) |
| Description: | Alternative Requirements for the Repair of Reactor Vessel Head Penetrations (VHPs) and J-groove Welds |
| Code Class: | Class 1 |
| Examination Category: | ASME Code Case N-729-1 |
| Code Item: | B4.20 |
| Identification: | Byron Units 1 and 2, VHP Numbers 1 through 78, (P-1 through P-78)<br>Previous repairs (I3R-14): Unit 2, P-68[1]<br>(I3R-19): Unit 1, P-31, P-43, P-64, and P-76[1]<br>(I3R-20): Unit 2, P-6[1] |
| Drawing Numbers: | Various |

## 2.0 APPLICABLE CODE EDITION AND ADDENDA

Inservice Inspection and Repair/Replacement Programs: American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, 2007 Edition, with the 2008 Addenda. Examinations of the VHPs are performed in accordance with 10 CFR 50.55a(g)(6)(ii)(D), which specifies the use of Code Case N-729-1, with conditions.

Code of Construction [Reactor Pressure Vessel (RPV)]: ASME Section III, 1971 Edition through Summer 1973 Addenda.

[1] This relief request includes Inservice Inspection (ISI) examination requirements for repairs previously completed in accordance with I3R-14, I3R-19, and I3R-20 in the previous inspection interval.

**10 CFR 50.55a RELIEF REQUEST I4R-10**
**Revision 1**


## 3.0 APPLICABLE CODE REQUIREMENT

IWA-4000 of ASME Section XI contains requirements for the removal of defects from and welded repairs performed on ASME components. The specific Code requirements for which use of the proposed alternative is being requested are as follows:

ASME Section XI, IWA-4421 states:

*Defects shall be removed or mitigated in accordance with the following requirements:*

- *(a) Defect removal by mechanical processing shall be in accordance with IWA-4462.*
- *(b) Defect removal by thermal methods shall be in accordance with IWA-4461.*
- *(c) Defect removal or mitigation by welding or brazing shall be in accordance with IWA-4411.*
- *(d) Defect removal or mitigation by modification shall be in accordance with IWA-4340.*

Note that use of the "Mitigation of Defects by Modification" provisions of IWA-4340 is prohibited per 10 CFR 50.55a(b)(2)(xxv).

For the removal or mitigation of defects by welding, ASME Section XI, IWA-4411 states, in part, the following.

> *Welding, brazing, fabrication, and installation shall be performed in accordance with the Owner's Requirements and ... in accordance with the Construction Code of the item...*

The applicable requirements of the Construction Code required by IWA-4411 for the removal or mitigation of defects by welding from which relief is requested are as follows.

Base Material Defect Repairs:

For defects in base material, ASME Section III, NB-4131 requires that the defects are eliminated, repaired, and examined in accordance with the requirements of NB-2500. These requirements include the removal of defects via grinding or machining per NB-2538. Defect removal must be verified by a Magnetic Particle (MT) or Liquid Penetrant (PT) examination in accordance with NB-2545 or NB-2546, and if necessary to satisfy the design thickness requirement of NB-3000, repair welding in accordance with NB-2539.

ASME Section III, NB-2539.1 addresses removal of defects and requires defects to be removed or reduced to an acceptable size by suitable mechanical or thermal methods.

ASME Section III, NB-2539.4 provides the rules for examination of the base material repair welds and specifies they shall be examined by the MT or PT methods in accordance with NB-2545 or NB-2546. Additionally, if the depth of the repair cavity exceeds the lesser of 3/8-inch or 10% of the section thickness, the repair weld shall be examined by the radiographic method in accordance with NB-5110 using the acceptance standards of NB-5320.

Weld Metal Defect Repairs (This applies to the CRDM penetration J-Groove weld.)

ASME Section III, NB-4450 addresses repair of weld metal defects.

ASME Section III, NB-4451 states; that unacceptable defects in weld metal shall be eliminated and, when necessary, repaired in accordance with NB-4452 and NB-4453.

ASME Section III, NB-4452 addresses elimination of weld metal surface defects without subsequent welding and specifies defects are to be removed by grinding or machining.

ASME Section III, NB-4453.1 addresses removal of defects in welds by mechanical means or thermal gouging processes and requires the defect removal to be verified with MT or PT examinations in accordance with NB-5340 or NB-5350 and weld repairing the excavated cavity. In the case of partial penetration welds where the entire thickness of the weld is removed, only a visual examination is required to determine suitability for re-welding.

As an alternative to the requirements above, repairs will be conducted in accordance with the appropriate edition/addenda of ASME Section III and the alternative requirements, based on WCAP-15987-P, Revision 2-P-A, "Technical Basis for the Embedded Flaw Process for Repair of Reactor Vessel Head Penetrations," December 2003, (Refer to Reference 1, hereafter known as WCAP-15987-P).

## 4.0 REASON FOR THE REQUEST

Exelon Generation Company, LLC (EGC) will conduct examinations of the reactor Vessel Head Penetrations (VHPs) in accordance with Code Case N-729-1, as amended by 10 CFR 50.55a. Flaw indications that require repair may be found on the VHP tube material and/or the J-groove attachment weld(s) on the underside of the reactor vessel head.

Relief is requested from the requirements of ASME Section XI, IWA-4411 to perform permanent repair of future defects that may be identified on the VHP's and/or J-groove attachment weld(s) in accordance with the rules of the ASME Section III Construction Code as described in this relief request.

Specifically, relief is requested from:

- The requirements of ASME Section III, NB-4131, NB-2538, and NB-2539 to eliminate and repair defects in materials.
- The requirements of ASME Section III, NB-4450 to repair defects in weld metal.

**10 CFR 50.55a RELIEF REQUEST I4R-10**
**Revision 1**


## 5.0 PROPOSED ALTERNATIVE AND BASIS FOR USE

5.1 Proposed Alternative

EGC proposes to use the less intrusive embedded flaw process (Reference 1) for the repair of VHP(s) as approved by the NRC (Reference 2) as an alternative to the defect removal requirements of ASME Section XI and Section III.

5.1.1 The criteria for flaw evaluation established in 10 CFR 50.55a(g)(6)(ii)(D), which specifies the use of Code Case N-729-1, will be used in lieu of the "Flaw Evaluation Guidelines" specified by the NRC Safety Evaluation for WCAP-15987-P (Refer to Reference 5).

5.1.2 Consistent with WCAP-15987-P, Revision 2-P-A methodology, the following repair requirements will be performed.

1. Inside Diameter (ID) VHP Repair Methodology

   a. An unacceptable axial flaw will be first excavated (or partially excavated) to a maximum depth of 0.125 inches. Although this depth differs from that specified in WCAP-15987-P, the cavity depth is not a critical parameter in the implementation of a repair on the ID surface of the VHP. The goal is to isolate the susceptible material from the primary water (PW) environment. The purpose of the excavation is to accommodate the application of at least two (2) weld layers of Alloy 52 or 52M, which is resistant to Primary Water Stress Corrosion Cracking (PWSCC), to meet that requirement. The depth specified in WCAP-15987-P is a nominal dimension and the depth needed to accommodate three weld layers while still maintaining the tube ID dimension. Since two (2) weld layers will be applied, less excavation is required and only 0.125 inches of excavation is necessary. The shallower excavated cavity for 2 weld layers would mean a slightly thinner weld, which would produce less residual stress.

      The excavation will be performed using an Electrical Discharge Machining (EDM) process to minimize VHP tube distortion. After the excavation is complete, either an ultrasonic test (UT) or surface examination will be performed to ensure that the entire flaw length is captured. Then a minimum of 2 layers of Alloy 52 or 52M weld material will be applied to fill the excavation. The expected chemistry of the weld surface is that of typical Alloy 52 or 52M weldment with no significant dilution. The finished weld will be conditioned to restore the inside diameter and then examined by UT and surface examination to ensure acceptability.

   b. If required, unacceptable ID circumferential flaw will be either repaired in accordance with existing code requirements; or will be partially excavated to reduce the flaw to an acceptable size, examined by UT or surface examination, inlaid with Alloy 52 or 52M, and examined by UT and surface examination as described above.

2. Outside Diameter (OD) VHP and J-groove Weld Repair Methodology

a. An unacceptable axial or circumferential flaw in a tube below a J-groove attachment weld will be sealed off with an Alloy 52 or 52M weldment. Excavation or partial excavation of such flaws is not necessary. The embedded flaw repair technique may be applied to OD axial or circumferential cracks below the J-groove weld because they are located away from the pressure boundary, and the proposed repair of sealing the crack with Alloy 690 weld material would isolate the crack from the environment as stated in Section 3.6.1 of the NRC Safety Evaluation for WCAP-15987-P.

b. Unacceptable radial flaws in the J-groove attachment weld will be sealed off with a 360 degree seal weld of Alloy 52 or 52M covering the entire weld. Excavation or partial excavation of such flaws is not necessary.

c. If EGC determines an excavation is desired (e.g., boat sample), then

- The excavation will be filled with Alloy 52 or 52M material.

- It is expected that a portion of the indication may remain after the boat sample excavation; however, a surface examination will be performed on the excavation to assess the pre-repair condition.

- Depending on the extent and/or location of the excavation, the repair procedure requires the Alloy 52 or 52M weld material to extend at least one half inch outboard of the Alloy 82/182 to stainless steel clad interface.

d. Unacceptable axial flaws in the VHP tube extending into the J-groove weld will be sealed with Alloy 52 or 52M as discussed in Item 5.1.2.2.a above. In addition, the entire J-groove weld will be sealed with Alloy 52 or 52M to embed the axial flaw. The seal weld will extend onto and encompass the portion of the flaw on the outside diameter of the VHP tube.

e. For seal welds performed on the J-groove weld, the interface boundary between the J-groove weld and stainless steel cladding will be located to positively identify the weld clad interface to ensure that all of the Alloy 82/182 material of the J-groove weld is seal welded during the repair.

f. The seal weld that will be used to repair an OD flaw in the nozzles and the J-groove weld will conform to the following.

- Prior to the application of the Alloy 52 or 52M seal weld repair on the RPV clad surface, at least three beads (one layer) of ER309L stainless steel buffer will be installed 360° around the interface of the clad and the J-groove weld metal.

- The J-groove weld will be completely covered by at least three (3) layers of Alloy 52 or 52M deposited 360° around the nozzle and over the ER309L stainless steel buffer. Additionally, the seal weld will extend onto and

**10 CFR 50.55a RELIEF REQUEST I4R-10**
**Revision 1**


encompass the outside diameter of the penetration tube Alloy-600 material by at least one half inch.

- The VHP tube will have at least two (2) layers of Alloy 52 or 52M deposited over the flaw on the VHP tube, extending out at least one half inch beyond the flaw, or to the maximum extent allowed by the nozzle geometry (e.g., limited length of the VHP tube).

g. Nondestructive examinations of the finished seal weld repair (i.e., Repair NDE) and during subsequent outages (i.e., ISI NDE) are summarized in the table below.

| Repair Location in Original Component | Flaw Orientation in Original Component | Repair Method | Repair NDE Note (2) | ISI NDE Note (2) |
|---|---|---|---|---|
| VHP Nozzle/Tube ID | Axial or Circumferential | Seal weld | UT and Surface | UT or Surface |
| VHP Nozzle/Tube OD above J-groove weld | Axial or Circumferential | Note (1) | Note (1) | Note (1) |
| VHP Nozzle/Tube OD below J-groove weld | Axial or Circumferential | Seal weld | UT or Surface | UT or Surface |
| J-groove weld | Axial | Seal weld | UT and Surface, Note (3) | UT and Surface, Notes (3) and (4) |
| J-groove weld | Circumferential | Seal weld | UT and Surface, Note (3) | UT and Surface, Notes (3) and (4) |

Notes:

(1) Repair method to be approved separately by NRC.
(2) Preservice and Inservice Inspection to be consistent with 10 CFR 50.55a(g)(6)(ii)(D), which requires implementation of Code Case N-729-1 with conditions; or NRC-approved alternatives to these specified conditions.
(3) UT personnel and procedures qualified in accordance with 10 CFR 50.55a(g)(6)(ii)(D), which requires implementation of Code Case N-729-1 with conditions. Examine the accessible portion of the J-groove repaired region. The UT plus surface examination coverage equals to 100%.
(4) Surface examination of the embedded flaw repair (EFR) shall be performed to ensure the repair satisfies ASME Section III, NB-5350 acceptance standards. The frequency of examination shall be as follows:
   a. Perform surface examination during the first and second refueling outage after installation or repair of the EFR.

**10 CFR 50.55a RELIEF REQUEST I4R-10**
**Revision 1**


b. When the examination results in 4.a above verify acceptable results then re-inspection of the EFR will be continued at a frequency of every other refueling outage. If these examinations identify unacceptable results that require flaw removal, flaw reduction to acceptable dimensions or welded repair the requirements of 4.a above shall be applied during the next refueling outage.

5.1.3 J-Groove Weld ISI NDE Requirements

Note 4 permits a reinspection frequency of every other cycle when the surface examination results of the EFR are verified to be acceptable for two consecutive cycles after the original installation or repair of the EFR. Westinghouse Report LTR-PSDR-TAM-14-005, Revision 3 (Reference 9) provides the technical bases for reducing surface examination requirements for J-groove weld repairs. This technical justification includes a detailed review of PT examination history, review of potential causes of PT indications in EFRs, and the use of crack resistant alloys in the EFR. The EFR is a robust design that is resistant to PWSCC. EFR installation, examination, and operational history indicate that the EFR performs acceptably. Examination and removed sample history indicate that the flaws identified shortly after installation of EFR weld material were due to embedded weld discontinuities and not due to service induced degradation. With inspection of the EFR every other cycle of operation, the nozzles are adequately monitored for degradation by ultrasonic examination methods similar to the nozzles without EFR repairs.

EGC projects that the reduction of the PT examination of nozzles would result in a dose savings of approximately 0.4 to 0.7 REM per nozzle examination. The historical radiation dose associated with these examinations is presented in Reference 9, Table 2.

The proposed changes to the inservice examination requirements assure that the EFR repaired nozzles are adequately monitored through a combination of volumetric and surface examinations throughout the life of the installation at a frequency approved by the NRC, thus ensuring the EFR repaired nozzles will continue to perform their required function.

5.1.4 Reporting Requirements and Conditions on Use

EGC will notify NRC of the Division of Component Integrity or its successor of changes in indication(s) or findings of new indication(s) in the penetration nozzle or J-groove weld beneath a seal weld repair, or new linear indications in the seal weld repair, prior to commencing repair activities in subsequent outages.

5.2 Technical Basis for Proposed Alternative

As discussed in WCAP-15987-P, the embedded flaw repair technique is considered a permanent repair. As long as a PWSCC flaw remains isolated from the Primary Water (PW) environment, it cannot propagate. Since an Alloy 52 or 52M weldment is considered highly resistant to PWSCC, a new PWSCC flaw should not initiate and grow through the Alloy 52 or 52M seal weld to reconnect the PW environment with the embedded flaw. Structural integrity of the affected J-groove weld and/or nozzle will be maintained by the remaining unflawed portion of the weld and/or the VHP. Alloy 690 and Alloy 52/52M are highly resistant to stress corrosion cracking, as demonstrated by multiple laboratory tests, as well as over twenty years of service experience in replacement steam generators.

The residual stresses produced by the embedded flaw technique have been measured and found to be relatively low because of the small seal weld thickness. This implies that no new flaws will initiate and grow in the area adjacent to the repair weld. There are no other known mechanisms for significant flaw propagation in the reactor vessel closure head and penetration tube region since cyclic loading is negligible, as described in WCAP-15987-P. Therefore, fatigue driven crack growth should not be a mechanism for further crack growth after the embedded flaw repair process is implemented.

The thermal expansion properties of Alloy 52 or 52M weld metal are not specified in the ASME Code. In this case the properties of the equivalent base metal (Alloy 690) should be used. For Alloy 690, the thermal expansion coefficient at 600 degrees F is 8.2E-6 in/in/degree F as found in Section II part D. The Alloy 600 base metal has a coefficient of thermal expansion of 7.8E-6 in/in/degree F, a difference of about 5 percent. The effect of this small difference in thermal expansion is that the weld metal will contract more than the base metal when it cools, thus producing a compressive stress on the Alloy 600 tube or J-groove weld. This beneficial effect has already been accounted for in the residual stress measurements reported in the technical basis for the embedded flaw repair, as noted in the WCAP-15987-P.

WCAP-16401-P, Revision 0 (Reference 3), as clarified by Reference 12, provides the plant-specific analysis performed for Byron and Braidwood Stations using the same methodology as WCAP-15987-P. This analysis provides the means to evaluate a broad range of postulated repair scenarios to the reactor vessel head penetrations and J-groove welds relative to ASME Code requirements for allowable size and service life. Based on Reference 3 and most recent inspection results (for Unit 1, September 2015 and for Unit 2, April 2016), a service life of twenty (20) years was determined for flaws in the VHP nozzles and a service life of at least ten (10) years was determined for flaws in the J-groove attachment welds. Per Reference 12, the service life of an embedded flaw repair is reset to the ten (or twenty) year mark each time the region is inspected and the flaw size confirmed to remain small (no appreciable change). Embedded flaw repairs will continue to be inspected per the Table in section 5.1.2.2(g) and if a measurable change in the embedded flaw is detected, additional analysis or repairs will be performed at that time.

The above proposed embedded flaw repair process is supported by applicable generic and plant specific technical bases, and is therefore considered to be an alternative to Code requirements that provides an acceptable level of quality and safety, as required by 10 CFR 50.55a(z)(1).

## 6.0 DURATION OF THE PROPOSED ALTERNATIVE

The duration of the proposed alternative is for the Byron Station Units 1 and 2, Fourth Inservice Inspection Interval currently scheduled to end in July 15, 2025.

**10 CFR 50.55a RELIEF REQUEST I4R-10**
**Revision 1**


## 7.0 PRECEDENTS

In Reference 8, the NRC provided their authorization to implement Relief Requests I3R-09 and I3R-20, Revision 1 as a repair method for degradation identified in Reactor Vessel Head Penetrations.

In Reference 11, the NRC provided their authorization to implement Relief Requests I3R-09 and I3R-20, Revision 2 during the Third ISI Interval. The Fourth ISI Interval Relief Request utilizes the same approach that was previously approved under the January 21, 2016 Safety Evaluation for Byron Station Units 1 and 2.

## 8.0 REFERENCES

1. Westinghouse WCAP-15987-P, Revision 2-P-A, "Technical Basis for the Embedded Flaw Process for Repair of Reactor Vessel Head Penetrations," December 2003

2. Letter from H. N. Berkow (U. S. NRC) to H. A. Sepp (Westinghouse Electric Company), "Acceptance for Referencing – Topical Report WCAP-15987-P, Revision 2, 'Technical Basis for the Embedded Flaw Process for Repair of Reactor Vessel Head Penetrations,' (TAC NO. MB8997)," dated July 3, 2003

3. Westinghouse WCAP-16401-P, Revision 0, "Technical Basis for Repair Options for Reactor Vessel Head Penetration Nozzles and Attachment Welds: Byron and Braidwood Units 1 and 2," March 2005

4. Letter LTR-NRC-03-61 from J. S. Galembush (Westinghouse Electric Company) to Terence Chan (U. S. NRC) and Bryan Benney (U.S. NRC), "Inspection of Embedded Flaw Repair of a J-groove Weld," dated October 1, 2003

5. Letter from R. J. Barrett (U. S. NRC) letter to A. Marion (Nuclear Energy Institute), "Flaw Evaluation Guidelines," dated April 11, 2003

6. American Society of Mechanical Engineers Boiler and Pressure Vessel Case N-729-1, "Alternative Examination Requirements for PWR Reactor Vessel Upper Heads With Nozzles Having Pressure-Retaining Partial-Penetration Welds Section XI, Division 1"

7. Letter from R. Gibbs (U. S. NRC) to C. M. Crane (EGC), "Byron Station, Unit No. 2 – Relief Request I3R-14 for the Evaluation of Proposed Alternatives for Inservice Inspection Examination Requirements (TAC No. MD5230)," dated May 23, 2007 (ML071290011)

8. Letter from Jacob Zimmerman, (U. S. NRC) to M. J. Pacilio, (EGC), "Braidwood Station, Units 1 and 2 and Byron Station, Unit Nos. 1 and 2 – Relief Requests I3R09 and I3R-20 Regarding Alternative Requirements for Repair of Reactor Vessel Head Penetrations (TAC Nos. ME6071, ME6073, and ME6074)," dated March 29, 2012, (ML120790647)

**10 CFR 50.55a RELIEF REQUEST I4R-10**
**Revision 1**


9. Westinghouse Report LTR-PSDR-TAM-14-005, Revision 3, "Technical Basis for Optimization or Elimination of Liquid Penetrant Exams for the Embedded Flaw Repair," dated May 2015

10. Letter from J. Zimmerman (U.S. NRC) to M. Pacilio (EGC), "Byron Station, Unit No. 1 – Inservice Inspection Relief Request I3R-19: Alternative Requirements for the Repair of Reactor Vessel Head Penetrations (TAC Nos. ME5877 and ME5948)," dated February 1, 2012 (ML112990783)

11. Letter from Justin C. Poole, (U.S. NRC) to Bryan C. Hanson (EGC), "Byron Station, Units Nos. 1 and 2, and Braidwood Station, Units 1 and 2 – Relief from the Requirements of the ASME Code," dated January 21, 2016 (ML16007A185)

12. Westinghouse Letter LTR-PAFM-16-77, Revision 2, "Life Expectancy of Embedded Flaw Repairs of the RV Head Penetrations for Byron and Braidwood Units 1 and 2," dated December 21, 2016