Exelon Generation
4300 Winfield Road
Warrenville, IL 60555
630 657 2000 Office

RS-18-004 10 CFR 50.55a(z)(1)

January 4, 2018

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

Quad Cities Nuclear Power Station, Unit 2
Renewed Facility Operating License No. DPR-30
NRC Docket No. 50-265

Subject: Additional Information Supporting Reactor Pressure Vessel Penetration N-11B Repair Relief Request I5R-11

References:
1. Letter from P. R. Simpson (Exelon Generation Company, LLC) to U.S. NRC, "Reactor Pressure Vessel Penetration N-11B Repair Relief Request I5R-11," dated February 14, 2017
2. Email from K. Green (U.S. NRC) to K. Nicely (Exelon Generation Company, LLC), "Request for Additional Information Regarding Relief Request I5R-11, Revision 2," dated December 20, 2017

In Reference 1, Exelon Generation Company, LLC (EGC) submitted relief request I5R-11, Revision 2, for Quad Cities Nuclear Power Station (QCNPS) Unit 2. The proposed request seeks relief for the penetration N-11B repair, including the subsequent examination requirements, for the N-11B nozzle to be examined at least once each nine years starting in refueling outage Q2R27 (i.e., spring 2024) for the remaining life of the plant.

In Reference 2, the NRC requested additional information that is needed to complete review of the proposed relief request. Specifically, the NRC's request was:

> Please revise Relief Request I5R-11, Revision 2, to reflect a duration supported by the flaw evaluation (e.g., 9 years beyond the date when the NDE technique was performed in 2016) or provide justification to demonstrate that a longer interval can be technically supported without relying on future unknown NDE results.

In response to this request, EGC is revising relief request I5R-11 to reflect that the duration of the proposed alternative is 9 years beyond the date when the NDE technique was performed in 2016. The revised relief request is provided in the Attachment.

There are no regulatory commitments contained in this letter. Should you have any questions concerning this letter, please contact Mr. Kenneth M. Nicely at (630) 657-2803.

Respectfully,

Patrick R. Simpson
Manager – Licensing

Attachment: 10 CFR 50.55a Relief Request I5R-11, Revision 3

cc: NRC Regional Administrator, Region III
NRC Senior Resident Inspector – Quad Cities Nuclear Power Station

---

Request for Relief for Unit 2 Reactor Pressure Vessel
Penetration N-11B Repair
In Accordance with 10 CFR 50.55a(z)(1)
Alternative Provides Acceptable Level of Quality and Safety

---

1. <u>ASME Code Component(s) Affected:</u>

Code Class:	1
Reference:	IWB-2500, Table IWB-2500-1
Examination Category:	B-P
Item Number:	B15.10
Description:	Reactor Pressure Vessel (RPV) Water Level Instrument Penetration – 2" Nominal Pipe Size
Component Number:	RPV Penetration N-11B

2. <u>Applicable Code Edition and Addenda:</u>

The code of record for the fifth 10-year Inservice Inspection (ISI) Program interval at Quad Cities Nuclear Power Station (QCNPS) is the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (Code), Section XI, 2007 Edition through 2008 Addenda. The fifth 10-year interval is effective from April 2, 2013, through April 1, 2023.

The code of construction for the RPV is the ASME Code, Section III, 1965 Edition through Summer 1965 Addenda.

The code of construction for the instrument penetration nozzle is the ASME Code, Section III, 1965 Edition through Summer 1969 Addenda.

3. <u>Applicable Code Requirement:</u>

The specific ASME Code requirements for which use of the proposed alternative is being requested are listed below. These requirements are in the 2007 Edition through 2008 Addenda of the ASME Code. It should be noted that the repair and initial flaw analysis were both completed during the fourth 10-year ISI Program interval and the governing code for the fourth interval was the 1995 Edition through 1996 Addenda.

Flaw Removal

- IWA-5250(a)(3) states "Components requiring corrective action shall have repair/replacement activities performed in accordance with IWA-4000 or corrective measures performed where the relevant condition can be corrected without a repair/replacement activity."

- IWA-4412 states "Defect removal shall be accomplished in accordance with the requirements of IWA-4420."

- IWA-4421(d) states "Defect removal or mitigation by modification shall be in accordance with IWA-4340."

- IWA-4340 states:

  Modification of items may be performed to contain or isolate a defective area without removal of the defect, provided the following requirements are met.

  (a) The defect shall be characterized using nondestructive examination and evaluated to determine its cause and projected growth.

  (b) The modification shall provide for the structural integrity of the item such that it no longer relies on the defective area, including projected growth. The modification shall meet the Construction Code and Owner's Requirements for the item in accordance with IWA-4220.

  (c) In lieu of reexamination of the defective area in accordance with IWA-4530(a), the Owner shall prepare a plan for additional examinations to detect propagation of the flaw beyond the limits of the modification, and when practicable, to validate the projected growth. The frequency and method of examination shall be determined by the Owner.

- IWA-4611.1(a) states "Defects shall be removed in accordance with IWA-4422.1. A defect is considered removed when it has been reduced to an acceptable size."

- N-528 of Section III, 1965 Edition through Summer 1965, requires repair of weld defects including removal of defects detected by leakage tests.

Flaw Evaluation

- IWB-3522.1 states "A component whose visual examination (IWA-5240) detects any of the following relevant conditions[8] shall meet IWB-3142 and IWA-5250 prior to continued service…"

  1. IWB-3142.1(b) states "A component whose visual examination detects the relevant conditions described in the standards of Table IWB-3410-1 shall be unacceptable for continued service, unless such components meet the requirements of IWB-3142.2, IWB-3142.3, or IWB-3142.4."

2. IWB-3142.4 states "A component containing relevant conditions is acceptable for continued service if an analytical evaluation demonstrates the component's acceptability. The evaluation analysis and evaluation acceptance criteria shall be specified by the Owner. A component accepted for continued service based on analytical evaluation shall be subsequently examined in accordance with IWB-2420(b) and (c)."

- IWA-3300(a) states in part "Flaws detected by the preservice and inservice examinations shall be sized…"
- IWA-3300(b) states in part "Flaws shall be characterized in accordance with IWA-3310 through IWA-3390, as applicable…"
- IWB-3610(b) states "For purposes of evaluation by analysis, the depth of flaws in clad components shall be defined in accordance with Fig. IWB-3610-1…"
- IWB-3420 states "Each detected flaw or group of flaws shall be characterized by the rules of IWA-3300 to establish the dimensions of the flaws. These dimensions shall be used in conjunction with the acceptance standards of IWB-3500."

4. Reason for Request:

During QCNPS Unit 2 refueling outage Q2R21 (i.e., spring 2012), and as a result of leakage indications on the RPV penetration N-11B, Exelon Generation Company, LLC (EGC) partially replaced this existing nozzle assembly with a nozzle penetration that is resistant to Intergranular Stress Corrosion Cracking (IGSCC). This repair was performed in accordance with ASME and construction codes applicable at the time, except as noted in Relief Request I4R-19 submitted for NRC review on April 6, 2012 (ML12100A012). Relief Request I4R-19 was approved by the NRC on January 30, 2013 (ML13016A454).

As described in I4R-19, a welded pad was applied to the outside surface (OD) of the RPV using IGSCC resistant nickel Alloy 52M (ERNiCrFe-7 or -7A) filler metals and was welded using the machine gas tungsten arc welding (GTAW) ambient temperature temper bead (ATTB) welding technique. An IGSCC resistant nozzle was attached to the new weld pad with a partial penetration weld using a non-temper bead manual welding technique. The original partial penetration attachment weld and a remnant of the original nozzle remained in place. A failure assessment was completed prior to startup from refueling outage Q2R21 to demonstrate the acceptability of leaving the original partial penetration attachment weld, with a maximum postulated flaw, in place for the operating cycle, which ended in April 2014.

Relief Request I5R-11 Revision 1 was submitted to demonstrate the acceptability of leaving the original partial penetration attachment weld, with a maximum postulated flaw, in place for two additional cycles (i.e., through Unit 2 Cycle 24 currently scheduled to end spring 2018). This relief request was approved by the NRC on February 28, 2014 (ML14055A227).

IWA-4412 and IWA-4611 contain requirements for the removal of, or reduction in size of defects. The defect on N-11B will remain in service without removal or reduction in size; therefore, relief is sought from these requirements.

IWB-3400 and IWB-3600 were written with the expectation that nondestructive examination techniques such as ultrasonic testing (UT) would be used to determine the flaw size and shape. In support of the flaw evaluation and application of applicable acceptance criteria, paragraphs IWA-3300, IWB-3420, and IWB-3600 require characterization of the flaw in the leaking penetration. When I5R-11 Revision 1 was submitted, there was no qualified or demonstrated technique to perform volumetric nondestructive examination of the partial penetration weld in this configuration that can be used to accurately characterize the location, orientation, or size of a flaw in the weld. However, since approval of I5R-11 Revision 1, a demonstrated technique has been developed and was successfully used during refueling outage Q2R23 (i.e., spring 2016).

The repair was performed by installing a welded pad using ATTB welding in accordance with ASME Code Case N-638-4. The NRC has conditionally approved ASME Code Case N-638-4 to allow ATTB welding of ferritic materials without the requirement for preheat or post-weld heat treatment.

5. <u>Proposed Alternative and Basis for Use:</u>

<u>Proposed Alternative</u>

In accordance with 10 CFR 50.55a(a)(3)(i), EGC proposes the following alternatives to the ASME Code Section XI requirements specified in Section 3 above.

A. As an alternative to flaw removal or reduction in size to meet the applicable acceptance standards, EGC implemented an OD repair of the RPV instrument nozzle N-11B utilizing an OD weld pad as described below in the discussion of the repair of nozzle penetration.

B. As an alternative to performing the nondestructive examination required to characterize the flaw under IWB-3420 and IWB-3610(b) in RPV instrument nozzle N-11B, EGC proposes analyzing a maximum postulated flaw that bounds the range of flaw sizes that could exist in the J-groove weld and nozzle. The maximum postulated flaw size assumed in the analysis will be verified using demonstrated nondestructive examination techniques.

C. As an alternative to performing the subsequent nondestructive examination required by IWB-3142.4 in accordance with IWB-2420(b) and (c) to assess potential growth of the flaw in RPV instrument nozzle N-11B, EGC proposes analyzing a maximum postulated flaw that bounds the potential growth of the existing flaw.

<u>Basis for Use</u>

A. Background

The QCNPS Unit 2 RPV is manufactured from SA-302, Grade B, modified by Code Case 1339, carbon steel that is clad with stainless steel. The RPV water level instrument penetrations are fabricated with Alloy 600 components. IGSCC of Alloy 600 components and welds exposed to boiling water reactor (BWR) cooling water has been observed in the nuclear industry over the recent past. In particular, dissimilar metal welds (DMWs) made with nickel Alloy 182 weld metal exposed to elevated operating temperatures, such as nozzle J-groove welds, pose a heightened propensity to IGSCC.

During refueling outage Q2R21, EGC discovered a leak in water level instrument penetration nozzle N-11B located on the RPV upper shell. The examination that detected the defect consisted of a visual examination in which active leakage was observed at the nozzle interface with the RPV OD during the Class 1 system leakage test. This observation necessitated repair of this water level instrument nozzle using the methodology described herein.

B. Q2R21 Repair of Nozzle Penetration

EGC replaced the existing nozzle assembly with a nozzle penetration that is resistant to IGSCC, meeting Section XI and Code Case N-638-4 as conditionally approved by the NRC in Regulatory Guide 1.147, Revision 17. Figure 1 provides a diagram of a typical RPV water level instrument nozzle repair. A welded pad was applied to the OD of the RPV using IGSCC resistant nickel Alloy 52M (ERNiCrFe-7 or -7A) filler metals and was welded using the machine GTAW ATTB welding technique. The IGSCC resistant nozzle was attached to the new weld pad with a partial penetration weld using a non-temper bead manual welding technique. The original partial penetration attachment weld and a remnant of the original nozzle currently remain in the RPV, and will continue to remain, in place. A weld flaw evaluation, described below, was completed to demonstrate the acceptability of leaving the original partial penetration attachment weld in service.

C. Examination of J-Groove Weld

<u>BWRVIP-IP-1 Mockup</u>

The nondestructive examination mockup was fabricated from a section of canceled RPV material that the Electric Power Research Institute (EPRI) obtained from a cancelled BWR/6 RPV. The Boiling Water Reactor Vessel and Internals Project (BWRVIP) requested and received fabrication drawings from several BWRVIP members and selected two different penetration configurations to include in the mockup design. The mockup design included two BWR instrument penetrations. Both consisted of Alloy 600 penetration tubes that are joined to the inside surface of the RPV using an Alloy 82/182 partial penetration J-groove weld. One penetration configuration was based on site-supplied information provided by QCNPS Units 1 and 2, Dresden Units 2 and 3, Peach Bottom Units 2 and 3, and Browns Ferry Units 1 and 2. The other

penetration was similar, except that the penetration tube and weld joint configuration represented later BWR designs. Both penetrations contained three manufactured cracks located in the Alloy 82/182 J-groove welds. Some of the cracks propagate into the low-alloy RPV material.

A more detailed description of the BWRVIP-IP-1 nondestructive examination mockup can be found in Section 14.4.1 of BWRVIP-03, Revision 19, BWR Vessel and Internals Project, Reactor Pressure Vessel and Internals Examination Guidelines, EPRI technical report TR-105696-R19 (Product ID 3002008095).

BWRVIP H9 Weld Mockups

In addition to the BWRVIP-IP-1 mockup, three flaws in the series of BWRVIP H9 shroud support plate weld mockups were also used during the nondestructive examination demonstration. These three flaws propagate out of the H9 welds, into the low-alloy RPV material to represent flaws that have propagated out the top of BWRVIP instrument penetration J-groove welds. These flaws were selected to increase the number of demonstration flaws that initiate within dendritic Alloy 82/182 weld material and propagate into fine-grain low-alloy RPV material.

Additional information regarding the BWRVIP H9 mockups and their flaws is provided in Section 5.3.2 of BWRVIP-03, Revision 19, BWR Vessel and Internals Project, Reactor Pressure Vessel and Internals Examination Guidelines, EPRI technical report TR-105696-R19 (Product ID 3002008095).

NDE Demonstration

Using the lessons learned during the initial BWRVIP development of the ultrasonic examination techniques for BWR instrument penetration J-groove welds, EGC coordinated with their inspection vendor to begin developing a fully field-deployable examination procedure. Using the BWRVIP-IP-1 and BWRVIP H9 weld mockups (BWRVIP-E, BWRVIP-E1, and BWRVIP-E2 mockups), EGC's inspection vendor developed and demonstrated a manual phased array ultrasonic examination technique. This technique used longitudinal waves as the primary examination technique and shear waves as a supplemental examination technique. The longitudinal wave technique is used to locate flaws contained within the dendritic structure of the Alloy 82/182 J-groove weld. Similar to the BWRVIP developed examination techniques, the inspection vendor used the shear wave examination technique to enhance the ability to reliably determine if flaws have propagated into the low-alloy steel RPV material. Ultrasonic shear waves do not readily penetrate into the dendritic Alloy 82/182 weld structure, but are much more sensitive to locate flaws present in fine grain ferritic base material. There were five flaws in the demonstration set that initiate within Alloy 82/182 weld material and propagate into low-alloy RPV material. The shear wave technique detected all of the flaws that propagated into the low-alloy RPV material.

Additional information regarding the new BWRVIP nondestructive examination demonstration is provided in Section 14.5.2 of BWRVIP-03, Revision 19, BWR Vessel

and Internals Project, Reactor Pressure Vessel and Internals Examination Guidelines, EPRI technical report TR-105696-R19 (Product ID 3002008095).

<u>Manual Phased Array Examination</u>

During refueling outage Q2R23, the instrument penetration was examined using both the longitudinal and shear wave techniques. A refracted longitudinal wave probe was used to interrogate the Alloy 82/182 weld material and a shear wave probe was used to interrogate the ferritic material surrounding the J-groove weld.

The Alloy 82/182 J-groove weld material was examined using the manual phased array technique that was demonstrated in accordance with BWRVIP-03 requirements because there are no qualification criteria in ASME Code, Section XI, 2007 Edition through 2008 Addenda, Mandatory Appendix VIII for BWR instrument penetrations. The ferritic material surrounding the Alloy 82/182 J-groove weld was interrogated by personnel who have successfully completed a Performance Demonstration for ASME Code, Section XI, 2007 Edition through 2008 Addenda, Mandatory Appendix VIII, Supplement 4 for detection and sizing of flaws located in the ferritic material at nozzle inner-radius locations.

To familiarize the examiner with the BWR instrument penetration configuration, the examiner performed an ultrasonic examination of the full-scale NDE instrument penetration NDE mockup, using the demonstrated phased array procedure, immediately prior to the QCNPS examination. However, given the configuration differences between the instrument penetration and a nozzle inner-radius, the qualified nozzle inner-radius technique was modified as necessary so that it could be applied to the QCNPS instrument penetration configuration. The technique modifications were captured in a new proprietary inspection vendor examination procedure and validated using the BWRVIP mockups. EPRI/BWRVIP independently reviewed and documented the vendor's validation in accordance with BWRVIP-03 requirements.

<u>Results</u>

An inside surface connected indication was identified within the Alloy 82/182 J-groove weld material. The indication initiates at the toe of the J-groove weld, and connects to the J-groove weld root, at the annulus between the instrument nozzle N11B and the RPV. The indication progresses perpendicular to the RPV surface, along the J-groove weld to penetration tube interface. No indications were present in the low-alloy RPV base metal. The inner nozzle is no longer part of the credited pressure boundary due to repairs made in 2012. A total of two indications were found within the bounded volume of the J-groove weld. No propagation has occurred into the low-alloy RPV base metal. The indications are characterized as follows:

1. The first indication was identified at approximately 202.5 degrees from top dead center in the clockwise direction. The indication was oriented circumferentially, and was sized at approximately 0.25 inches in length. The indication initiates from the inside surface of the J-groove weld, and propagates perpendicular to the RPV surface along the Alloy 600 penetration tube – to – Alloy 82/182 J-groove weld

interface. The ultrasonic indication exhibited characteristics that are consistent with stress corrosion cracking. The indication is the apparent origin of the leakage that was identified and repaired during the Q2R21 refueling outage as the indication connects the inside surface of the J-groove weld to the penetration tube-to-RPV penetration bore hole annulus. The indication intersects the J-groove weld root at the penetration tube annulus location, so it does not intersect the low-alloy RPV material.

2. The second indication was identified at approximately 90 degrees from top dead center in the clockwise direction. This indication was wholly contained within the J-groove weld and did not propagate into the low-alloy RPV base metal. It was sized at approximately 0.25 inches in length circumferentially with no measureable axial depth. The indication was not connected with the ID of the RPV and was below recording criteria for the procedure. The indication does not connect to the low-alloy steel RPV base metal. The embedded nature of this indication would not provide a path for the leakage that was identified during the Q2R21 refueling outage.

Validation

The entire circumference of the J-groove weld was interrogated with the supplemental shear wave examination technique that was demonstrated using the full-scale mockups. No indications were identified to suggest that a flaw has propagated into the low-alloy steel RPV base metal. The apparent planar flaw identified from the longitudinal wave examination was not identified during the shear wave examination, which provides additional evidence that the flaw tip is contained within the dendritic structure of the Alloy 182 weld material. If the flaw tip had propagated into the fine grain microstructure of the low-alloy steel RPV base metal, it is expected that a recognizable response would have been present during the shear wave examination. Therefore, this UT examination demonstrates reliable capability in identifying flaws in J-groove welds in RPV instrument nozzles.

Flaw Evaluation

A flaw evaluation based on Linear Elastic Fracture Mechanics (LEFM) analysis was used to determine the acceptability of the postulated flaws in the remnant J-groove weld. This flaw evaluation is documented in AREVA NP Inc. document 32-9215236-002, "Quad Cities Unit 2 Instrument Nozzle J-Groove Weld LEFM Flaw Evaluation," which was previously submitted to the NRC as Attachment 1 of a letter dated December 20, 2013 (ML13358A401). The NRC's review of the flaw evaluation is documented in a letter dated February 28, 2014 (ML14055A227).

Based on the LEFM flaw evaluation, postulated circumferential and axial flaws were determined to be acceptable for at least nine years of operation using BWRVIP-60-A crack growth rates. Examination of the J-groove weld flaw during refueling outage Q2R23 (i.e., spring 2016) using the now available NDE technique showed no indication is extending out into the ferritic low-alloy RPV base metal. This condition supports an additional nine year period of operation from the spring 2016 refueling outage requiring

examination during the 2024 refueling outage rather than the spring 2018 refueling outage as currently approved by the NRC.

Conclusion

10 CFR 50.55a(z)(1) states: "Alternatives to codes and standards requirements. Alternatives to the requirements of paragraphs (b) through (h) of this section or portions thereof may be used when authorized by the Director, Office of Nuclear Reactor Regulation, or Director, Office of New Reactors, as appropriate. A proposed alternative must be submitted and authorized prior to implementation. The applicant or licensee must demonstrate that:

(1) *Acceptable level of quality and safety*. The proposed alternative would provide an acceptable level of quality and safety; or

(2) *Hardship without a compensating increase in quality and safety*. Compliance with the specified requirements of this section would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Current LEFM analysis authorized under relief request I5R-11 Revision 1 (ML14055A227) projects a conservative growth rate of nine years after refueling outage Q2R20 (i.e., spring 2010) if the indication is connecting to the low-alloy RPV base metal. Examination has demonstrated that the indication is located within the J-groove weld and is not in contact with the low-alloy RPV base metal. Therefore, it is prudent to re-examine this area in refueling outage Q2R27 (i.e., spring 2024) based on the successful examination in refueling outage Q2R23 to ensure the approved analysis remains bounded.

EGC concludes that the proposed alternative of this request provide an acceptable level of quality and safety. The weld pad on the RPV was installed using Nickel Alloy 52M filler metal using a qualified ATTB welding procedure. The RPV penetration was replaced with an IGSCC resistant nozzle welded to the OD of the RPV with Alloy 52M. The supporting flaw evaluation demonstrates that the RPV is acceptable without removal of the original nozzle remnant and partial penetration weld. Recent nondestructive examination of the flaw shows no flaw progression beyond the J-groove weld into the low-alloy RPV base metal. Therefore, EGC requests that the NRC authorize the proposed alternative in accordance with 10 CFR 50.55a(z)(1).

6. Duration of Proposed Alternative:

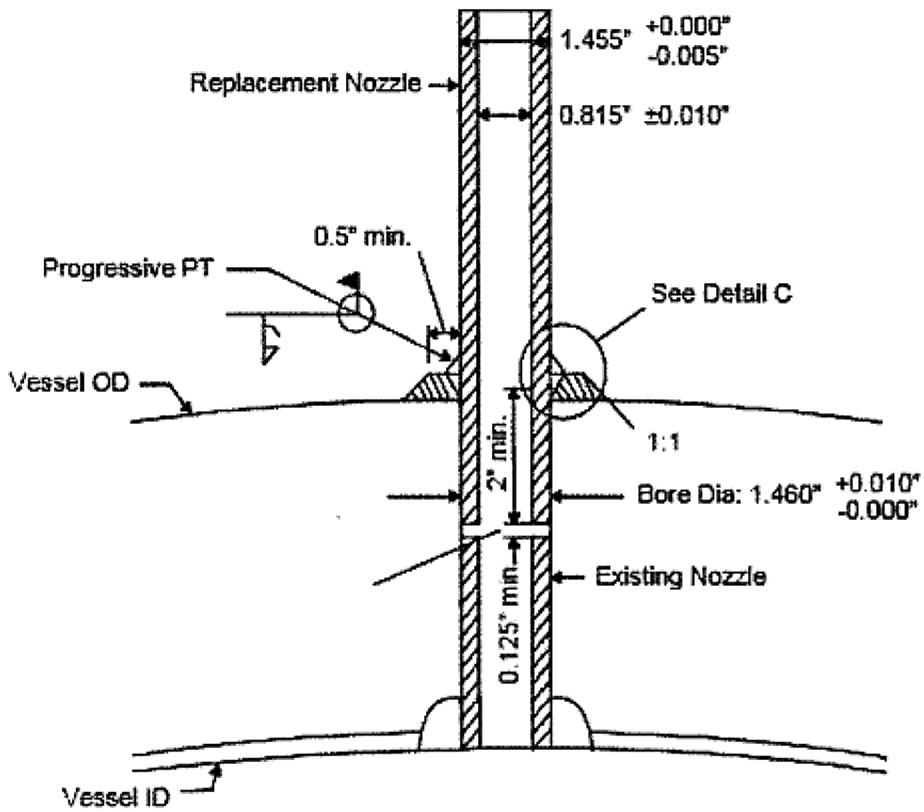
Relief is requested for three (3) additional cycles following the Unit 2 spring 2018 refueling outage (i.e., through Unit 2 Cycle 27 currently scheduled to end in spring 2024). This supports the nine (9) years beyond Unit 2 spring 2016 refueling outage when the NDE technique was performed.

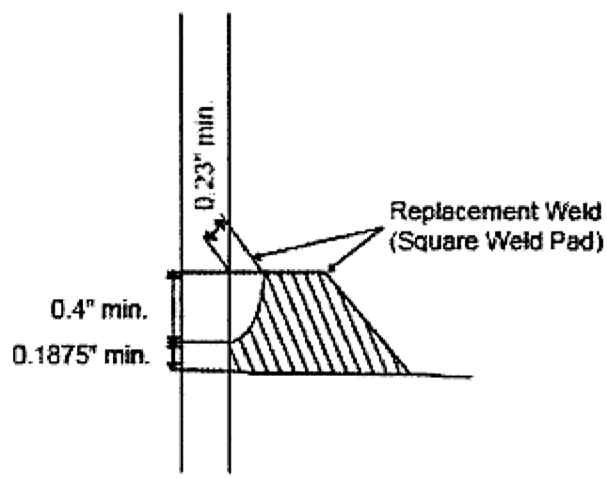
7. <u>Precedents:</u>

As noted above, a relief request was previously approved for Quad Cities Unit 2 (I5R-11, Revision 1) by the NRC in a Safety Evaluation dated February 28, 2014. (i.e., NRC Accession No. ML14055A227).

Figure 1

Typical Reactor Pressure Vessel Water Level Instrument Nozzle Repair





Detail C