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PROPRIETARY INFORMATION – WITHHOLD UNDER 10 CFR 2.390
Attachment 5 contains proprietary Information – the balance of this letter is considered non-proprietary when Attachment 5 is removed.

10 CFR 50.55a

LG-17-080
May 16, 2017

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

Limerick Generating Station, Unit 2
Renewed Facility Operating License No. NPF-85
NRC Docket No. 50-353

Subject: Proposed Relief Request Associated with Reactor Pressure Vessel Nozzle Repairs

References:
1) Letter from D. P. Helker to U.S. Nuclear Regulatory Commission, "Proposed Relief Request Associated with Reactor Pressure Vessel Nozzle Repairs," dated May 15, 2017
2) Email from V. Sreenivas (U.S. Nuclear Regulatory Commission) to T. Loomis (Exelon Generation Company, LLC), "Limerick-Unit 2: Request for Additional Information for Relief request Associated with Reactor Pressure Vessel Nozzle Repairs (CAC No. MF9702)," dated May 16, 2017

In Reference 1, in accordance with 10 CFR 50.55a, Exelon Generation Company, LLC (EGC) requested approval of the attached relief request associated with the repair of a 2-inch instrument line nozzle at penetration N-16D on the Reactor Pressure Vessel (RPV). This relief request applies to one operating cycle for the fourth 10-year Inservice Inspection (ISI) interval. The fourth 10-year ISI interval for Limerick Generating Station (LGS), Unit 2 began on February 1, 2017 and will conclude January 31, 2027. The fourth 10-year ISI interval complies with the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI, 2007 Edition through 2008 Addenda.

On May 16, 2017 (Reference 2), the U.S. Nuclear Regulatory Commission (USNRC) requested additional information. Attachment 2 is our response to this request. As part of this request, the relief request supplied in Reference 1 has been updated as identified by the revision bars contained in the revised relief request. The updated relief request is supplied in Attachment 3.

PROPRIETARY INFORMATION – WITHHOLD UNDER 10 CFR 2.390
Attachment 5 contains proprietary Information – the balance of this letter is considered non-proprietary when Attachment 5 is removed.

Attachment 5 ("Corrosion Evaluation of the Limerick Unit 2 N16-D Reactor Vessel Nozzle Modification," Document Number 51-9271544-000), contains information proprietary to AREVA Inc. (AREVA). AREVA requests that the document be withheld from public disclosure in accordance with 10 CFR 2.390(a)(4). Attachment 6 contains a non-proprietary version of the AREVA document. An affidavit supporting this request is contained in Attachment 4.

Attachment 1 contains a summary of commitments.

If you have any questions or require additional information, please contact Tom Loomis at 610-765-5510.

Respectfully,

D. P. Helker

David P. Helker
Manager - Licensing & Regulatory Affairs
Exelon Generation Company, LLC

Attachments:
1) Summary of Commitments
2) Response to Request for Additional Information
3) Relief Request I4R-17, Revision 1
4) Affidavit
5) "Corrosion Evaluation of the Limerick Unit 2 N16-D Reactor Vessel Nozzle Modification," Document Number 51-9271544-000, Proprietary Version
6) "Corrosion Evaluation of the Limerick Unit 2 N16-D Reactor Vessel Nozzle Modification (Non-Proprietary)," Document Number 51-9271770-000

cc: USNRC Region I, Regional Administrator
USNRC Senior Resident Inspector, LGS
USNRC Project Manager, LGS
R. R. Janati, Pennsylvania Bureau of Radiation Protection

ATTACHMENT 1

Summary of Commitments

Summary of Commitments

The following table identifies commitments made in this document. (Any other actions discussed in the submittal represent intended or planned actions. They are described to the NRC for the NRC's information and are not regulatory commitments.)

COMMITMENT	COMMITTED DATE OR "OUTAGE"	COMMITMENT TYPE	
		ONE-TIME ACTION (Yes/No)	Programmatic (Yes/No)
The final one-cycle flaw analytical evaluation and design analysis will be submitted within 14 days following the end of the current LGS, Unit 2 refueling outage.	Within 14 days following the end of the current LGS, Unit 2 refueling outage.	Yes	No

ATTACHMENT 2

Response to Request for Additional Information

Question:

(1) (a) The relief request discussed performing a flaw evaluation, design analysis, and corrosion evaluation. However, these analyses are not included in the submittal. The relief request did not discuss when these analyses will be submitted for NRC review and approval. Please Clarify. Please, (b) Provide technical basis why the repair is acceptable for one fuel cycle, as relief was requested, in terms of the flaw evaluation, design analysis and corrosion evaluation.

Response:

The final one-cycle flaw analytical evaluation and design analysis will be supplied within 14 days following the end of the current Limerick Generating Station (LGS), Unit 2 refueling outage. The corrosion evaluation and affidavit are provided in Attachments 4, 5, and 6.

As required by the design specification, the nozzle repair is designed in accordance with the ASME Code, Section III. The ASME Code, Section III analysis will take no credit for the original J-groove weld and nozzle material. The Code requirements for weld sizing provide design margin against ejection which will ensure that the repair is acceptable for one cycle.

With regards to the flaw evaluation, the one cycle justification fracture mechanics analysis conservatively postulates that a flaw extends through the entire J-groove weld and butter. The postulated flaw could potentially propagate into the low alloy steel base material; however, operating experience indicates that under normal reactor operation there are no cases of RPV damage in BWR plants that indicate susceptibility of the low alloy steel base material to stress corrosion cracking. Using the constant load crack growth rate (CGR) correlation from BWRVIP-60-A, a crack growth of less than 1/16 inch is predicted over the desired two-year fuel cycle.

Other similar analyses for this type of half nozzle repair as part of relief requests from other licensees have shown that the flaw growth will not be significant for a duration of one fuel cycle (24 months) and will not affect the structural integrity of the RPV shell. Detailed weld residual stress analysis and as-left J-groove analysis will be performed within the next operating cycle to demonstrate the acceptability of the as-left J-groove flaw for long term operation.

Question:

(2) Because the relief is requested for one fuel cycle only, discuss the path forward after one fuel cycle with regard to the repaired nozzle.

Response:

A relief request will be submitted to justify continued use of the nozzle repair for the life of the plant. This permanent relief request, which will contain the appropriate analyses and justification for the remainder of the plant operating life, will be submitted prior to the end of the upcoming cycle.

Question:

(3) Wordings of the diagram in Enclosure 2 are not legible. Please, (a) Provide a legible diagram. (b) Provide the gap between the remnant nozzle and the new half

nozzle. Discuss whether the gap is sufficient for the thermal expansion of the remnant nozzle and new half nozzle.

Response:

A revised Enclosure 2 with the gap between the remnant nozzle and the new half nozzle is provided in Attachment 3. A gap of 1/16" to 1/8" will be left between the remnant of the original nozzle and the new nozzle. This gap is sufficient to absorb differential thermal expansion between the low alloy steel shell and the nozzle components and is consistent with Section III requirements.

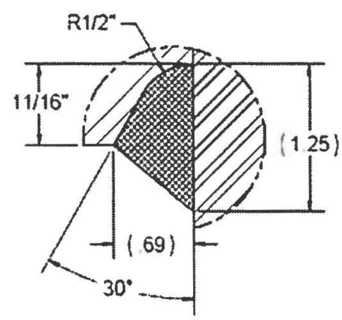
Question:

(4) The proposed repair involves three new welds and a new reinforcement weld pad. The three welds are---a partial penetration weld joins the new half nozzle and the new reinforcement pad, a fillet weld joins the new half nozzle and new reducing insert, and a fillet weld joins the new reducing insert and the pipe. (a) Identify the size of the three welds and the thickness of the weld pad. (b) Discuss whether the welding of the three welds is performed in accordance with the ASME Code, Section IX. (c) Discuss the welding technique used on these three welds. (d) Discuss in detail the nondestructive examinations on the three welds. (e) Discuss whether all three welds and the weld pad are considered the pressure boundary. (f) Discuss whether a pressure test will be performed in accordance with the ASME Code, Section XI after the repair but prior to the plant startup.

Response:

a) The sizes of the three welds and the thickness of the weld pad are as follows:

- Partial penetration weld with fillet reinforcement (see diagram below)



- Fillet weld between replacement nozzle and reducing insert = 5/16 x 5/8 inch leg sizes
- Fillet weld between reducing insert and piping = 5/16 x 5/8 inch leg sizes
- Alloy 52M weld build-up pad thickness = 7/8 inch

The weld sizing and weld pad thickness dimensions have also been added to the diagram as provided in response to RAI-3 which is contained in Enclosure 2 to the revised relief request (Attachment 3).

b) The requirements of the ASME Boiler and Pressure Vessel Code, Section XI, 2007 Edition through 2008 Addenda, ASME Section III, 2007 Edition through 2008 Addenda, and the Original Section III, 1968 Edition through Summer 1969 Addenda Code of Construction, all require that ASME Section IX (latest edition) be utilized for qualification of welding, welders, and welding operators, with the exception of those qualification details outlined in Code Case N-638-4 for the machine GTAW ambient temperature temper-bead Alloy 52M weld metal build-up pad. All welds will be performed in accordance with ASME Section IX and, where applicable, the alternative requirements in Code Case N-638-4 with conditions as imposed in NRC Regulatory Guide 1.147, Revision 17.

c) The Alloy 52M reinforcement weld pad will be performed with the Machine Gas Tungsten Arc Welding (GTAW) technique. The partial penetration weld joint with reinforcing fillet weld between the Alloy 52M weld pad and the Alloy 690 nozzle will be performed utilizing the manual GTAW technique. The Alloy 690 nozzle to reducer insert fillet weld will be performed with the manual GTAW technique. The reducer insert to pipe fillet weld will be performed with the manual GTAW technique.

d) Final acceptance NDE of the Alloy 52M weld build-up pad shall be performed at least 48 hours after completion of the third temper bead weld layer and shall consist of the following:

   1) Liquid Penetrant (PT) examination of the weld pad shall be in accordance with ASME Boiler and Pressure Vessel Code, Section III, Div. 1, 2007 Edition through 2008 Addenda, NB-5111(a) and NB-5350.

   2) Ultrasonic (UT) examination shall be in accordance with ASME Boiler and Pressure Vessel Code, Section III, Div. 1, 2007 Edition through 2008 Addenda, NB-5300, for the weld, Heat Affected Zone (HAZ) and E8018-NM weld buildup beneath the Alloy 52M pad, and Section III NB-2530 for the remaining applicable portion of the vessel shell base material.

   The J-groove weld between the Alloy 690 nozzle to Alloy 52M weld build-up pad shall be progressively PT examined in accordance with ASME Boiler and Pressure Vessel Code, Section III, Div. 1, 2007 Edition through 2008 Addenda, NB-5245, and shall include a PT of the completed hot pass.

   The nozzle to reducing insert and reducing insert to pipe fillet welds shall be PT examined in accordance with ASME Boiler and Pressure Vessel Code, Section III, Div. 1, 2007 Edition through 2008 Addenda, NB-5350.

e) All welds, including the Alloy 52M weld pad build-up, the partial penetration with reinforcing fillet weld joining the Alloy 690 nozzle to Alloy 52M weld build-up pad, and the nozzle to reducing insert and reducing insert to pipe fillet welds, are considered Class 1 pressure boundary materials and welds.

f) Pressure testing and visual examination (VT-2) shall be performed in accordance with ASME B&PV Code, Section XI, Div. 1, 2007 Edition through 2008 Addenda, IWA-4540 and IWA-5000.

Question:

(5) The licensee submitted the relief request pursuant to 10 CFR 50.55a(z)(1) because the licensee concludes that the proposed alternatives provide an acceptable level of quality and safety. However, the relief request does not include a flaw evaluation, design analysis and corrosion evaluation. It is difficult for the NRC staff at this time to determine that the propose

alternatives provide an acceptable level of quality and safety. However, the relief request may be submitted under alternate regulatory rules (e.g., 10 CFR 50.55a(z)(2)), provided that hardship and unusual difficulties can be justified if an ASME Code repaired is performed.

Response:

The relief request, contained in Attachment 3, has been revised to justify approval pursuant to 10 CFR 50.55a(z)(2).

ATTACHMENT 3

Limerick Generating Station, Unit 2

Proposed Relief Request Associated with Reactor Pressure Vessel Nozzle Repairs

RELIEF REQUEST I4R-17, Revision 1

1. ASME CODE COMPONENTS AFFECTED

Code Class:	1
Reference:	IWB-2500, Table IWB-2500-1
Exam Category:	B-P
Item Number:	B15.10
Description:	Reactor Pressure Vessel (RPV) Instrument Penetration – 2-inch Nominal Pipe Size
Component Number:	N-16D

2. APPLICABLE CODE EDITION AND ADDENDA

The current edition for the Inservice Inspection (ISI) interval is the American Society of Mechanical Engineers (ASME) Code, Section XI, 2007 Edition with the 2008 Addenda. The code of construction for the RPV is the ASME Code Section III, 1968 Edition up to and including Summer 1969 Addenda except that Article 4 of the Winter 1969 Addenda applies.

3. APPLICABLE CODE REQUIREMENT

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-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, 1968 Edition up to and including Summer 1969 Addenda except that Article 4 of the Winter 1969 Addenda applies, requires repair of weld defects including removal of defects detected by leakage tests.

Flaw Evaluation

- IWB-3522.1 states, in part, "A component whose visual examination (IWA-5240) detects any of the following relevant conditions shall meet IWB-3142 and IWA-5250 prior to continued service ... "

- 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."

- 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, in part, "For purposes of evaluation by analysis, the depth of flaws in clad components shall be defined in accordance with Fig. IWB-3610-1 ... "

- The implementing reply of N-749 states "It is the opinion of the Committee that, in lieu of IWB-3610 and IWB-3620, flaws in ferritic steel components operating in the upper shelf temperature range may be evaluated using the following acceptance criteria." The methods and criteria of N-749 are based on the methods of elastic-plastic fracture mechanics (EPFM).

- 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."

Peening

- NB-4422 states "Controlled peening may be performed to minimize distortion. Peening shall not be used on the initial layer, root of the weld metal, or on the final layer unless the weld is postweld heat treated."

4. REASON FOR REQUEST

On May 8, 2017, during the pre-startup system leakage testing of the Limerick Generating Station (LGS), Unit 2 RPV following a routine refueling outage, a leak of approximately one pint per minute was observed between the RPV wall and a 2-inch instrument line nozzle (see Enclosure 1) at penetration N-16D.

As a result of leakage indications on the RPV penetration N-16D, Exelon Generation Company, LLC (EGC) is planning to partially replace the existing nozzle assembly with a nozzle penetration that is resistant to Intergranular Stress Corrosion Cracking (IGSCC).

EGC is proposing to apply a welded pad to a pre-existing weld pad on the Outer Diameter (OD) of the RPV using IGSCC resistant nickel Alloy 52M (ERNiCrFe-7A) filler metal. The pre-existing weld pad was installed as part of the RPV initial design. The new weld pad will be welded using the machine Gas Tungsten Arc Welding (GTAW) Ambient Temperature Temper Bead (ATTB) welding technique. EGC is proposing to attach an IGSCC resistant nozzle to the new weld pad with a partial penetration weld using a non-temper bead manual welding technique, using IGSCC resistant nickel Alloy 52M filler metal.

The original partial penetration attachment weld and a remnant of the original nozzle will remain in place. A flaw evaluation demonstrates the acceptability of leaving the original partial penetration attachment weld, with a maximum postulated flaw, in place for one fuel cycle (see "Flaw Analytical Evaluation" below). IWA-4410 and IWA-4611 contain requirements for the removal of, or reduction in size of defects. The defect on N-16D will not be removed; therefore, relief is sought from these requirements.

IWB-3400 and IWB-3600 were written with the expectation that volumetric Non-Destructive Examination (NDE) techniques such as Ultrasonic Testing (UT) would be used to determine the flaw size and shape. In support of the flaw evaluation to applicable acceptance criteria, the ASME Code paragraphs IWB-3420 and IWB-3610(b) require characterization of the flaw in the leaking penetration. Although demonstrated, there is not a qualified technique to perform NDE 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.

The flaw evaluation methods presented in IWB-3610 and Appendix A of Section XI are based on Linear Elastic Fracture Mechanics (LEFM) methods. Code Case N-749 was developed to provide criteria for the use of Elastic-Plastic Fracture Mechanics (EPFM) methods as acceptable alternatives to the LEFM methods currently contained in IWB-3610 and Appendix A, for operating conditions where ferritic vessel materials are operating on the material toughness upper shelf. This Code Case is proposed as Conditionally Accepted in the draft Revision 18 of NRC Regulatory Guide 1.147 (Draft Regulatory Guide DG-1296).

NB-4422 does not allow peening to be performed on the initial layer unless the weld is post-weld heat treated. If any leakage is observed prior to performing the J-groove weld, peening would be required to stop the leakage. This contingent activity would be used to seal the unacceptable indication; therefore, relief is requested.

NB-4620 requires all welds to be post-weld heat treated except as otherwise permitted in NB-4622.7. Relief is requested to install 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 dissimilar materials.

5. PROPOSED ALTERNATIVE AND BASIS FOR USE

In accordance with 10 CFR 50.55a, "Codes and standards," paragraph (z)(2), EGC proposes the following alternatives to the requirements specified in Section 3 above on the basis that performing a Code required repair results in a hardship without a compensating increase in quality and safety. A repair in accordance with the ASME Code, which would remove the flaw from the inner portion of the vessel, would require a full core offload to access the repair location, result in significant risk associated with the inclusion of loose parts and foreign material, and result in significant increase in radiological exposure. These areas of concern result in a significant hardship over the currently planned modification.

In lieu of the ASME Code compliant repair, the following alternatives are proposed:

- As an alternative to flaw removal or reduction in size to meet the applicable acceptance standards IWA-5250(a)(3), EGC proposes to implement an OD repair of the RPV instrument nozzle N-16D utilizing an OD weld pad as described in the repair of nozzle penetration section below.

- As an alternative to performing the NDE required to characterize the flaw under IWB-3420 and IWB-3610(b) in penetration N-16D, EGC proposes analyzing a maximum postulated flaw that bounds the range of flaw sizes that could exist in the original J-groove weld and nozzle.

- As an alternative to performing post-weld heat treatment of the weld under NB-4422, EGC proposes to allow peening on the initial layer of the weld material, if necessary, to seal the unacceptable indication. The thickness of this layer will not be used in meeting the weld reinforcement design thickness requirements.

- As an alternative to NB-4620, relief is requested to install 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 dissimilar materials.

Basis for Use

A. Background

The LGS, Unit 2 RPV is manufactured from SA-533, Grade B quenched and tempered low alloy steel that is ID clad with stainless steel. There is an 11 5/8 inch diameter 2-inch thick nozzle reinforcement weld build-up on the outside of the RPV shell that was installed using E8018-NM weld material. The RPV instrument penetrations are fabricated with Alloy 600 components. See Enclosure 1 for a sketch of N-16D.

During refueling outage Li2R14, EGC discovered a leak at the instrument penetration nozzle N-16D located on the RPV. Visual examination detected active leakage at the nozzle interface (annular gap) with the RPV OD during the Class 1 system leakage test. EGC intends to repair the N-16D based on the discussion provided in the following sections.

B. Cause of Leakage

Following discovery of the leak, a sealing plug was installed in the N-16D nozzle inside diameter to facilitate the half nozzle repair (see Enclosure 2). Following plug installation, leakage was still observed indicating the flaw progressed through the nozzle into the weld or through the weld alone. A visual examination was performed of the N-16D wetted surfaces from the inside of the RPV with a black and white camera and a volumetric ultrasonic examination was performed from the RPV exterior surface. The initial volumetric ultrasonic examination was performed prior to plug installation for informational purposes only and is not qualified in accordance with ASME Section XI, Appendix VIII (see "Examination of the J-groove Weld" below).

The visual examination did not identify any apparent leak path in the nozzle or Alloy 82 weld overlay (see Enclosure 1) on the RPV inside surface of the N-16D. The BWRVIP demonstrated longitudinal wave volumetric ultrasonic examination observed indications along the weld fusion line between the nozzle and J-groove weld. Neither defined cracking, nor a leak path, was able to be identified. The BWRVIP demonstrated shear wave UT observations in the RPV low alloy steel or weld butter revealed no indications. The Alloy 82 weld overlay was not distinguishable from the original J-groove weld material and a determination of the presence of indications in the overlay could not be made. These results are consistent with fabrication defects; however, the presence of IGSCC cannot be ruled out.

The NDE data does not provide sufficient information to definitively determine the leak path; however, the available data combined with the fabrication information can be used to determine a most-probable leak path. The Alloy 600 nozzle was machine bored from a solid forging. This machining operation may have introduced residual stresses from the cold work process on the nozzle Inner Diameter (ID). Additionally, an Alloy 82 weld overlay was applied over the Alloy 182 J-groove weld inside the RPV. Alloy 82 is considered resistant to IGSCC and is used to mitigate the risk of cracking. From this information it is possible that an IGSCC flaw initiated in the nozzle inside surface and propagated through wall into and along the fusion line with the J-groove weld.

C. Extent of Condition

As a result of the leak identified on the N-16D, all nozzles with the same design as the N-16D had a bare metal VT-2 performed at a minimum pressure of 1045 psig. This exam looked for evidence of through-wall leakage, degradation due to corrosion of a pressure retaining boundary and evidence of pressure/flow loss or flow impairment. Nine nozzles were visually inspected (N-16A, N-16B, N-16C, N-11A, N-11B, N-12A, N-12B, N-12C, N-12D) and there was no evidence of leakage identified on any of the nozzles during the examination.

D. Examination of the J-groove Weld

A visual examination was performed from the RPV ID using a black and white camera at the N-16D location. The exam volume encompassed the Alloy 82 weld overlay and the outer portions of the Alloy 600 nozzle bore. No surface cleaning was performed prior to examination. Although there is a suspect area, there were no apparent crack-like indications observed on either the weld overlay or the nozzle bore.

A volumetric (UT) examination was performed on the N-16D J-groove weld from the RPV OD in accordance with BWRVIP-03, Rev. 19. This examination was conducted for informational purposes to supplement visual examinations performed from the RPV ID. This volumetric exam has been demonstrated to provide crack detection within the J-groove weld material and to detect planar flaw indications in the low alloy vessel material, but has not been qualified in accordance with ASME Section XI, Appendix VIII. The exam volume included the J-groove weld, weld butter, and the RPV low alloy steel interface. The weld overlay and nozzle could not be distinguished with this volumetric technique. No crack-like indications were identified in the RPV low alloy steel or the Alloy 182 weld butter. Several aligned fabrication like flaws were detected along the nozzle to J-groove weld fusion line although IGSCC could not be ruled out. As the Inconel 82 weld overlay at the RPV ID surface could not be distinguished by this exam, no determination of whether the fabrication defects were open to the surface could be made. No definitive crack or leak path was observed; however, this exam provides reasonable confidence that the flaw has not propagated into the RPV low alloy steel.

E. Flaw Analytical Evaluation

A flaw evaluation in accordance with IWB-3610 (LEFM method), as well as per Code Case N-749 (EPFM method), as applicable, is being performed for one cycle of operation based on the following:

- Conservatively assume that the entire as-left Alloy 182 J-groove weld is initially flawed;
  - Both the circumferential and radial-axial flaw orientations are considered. The analysis is performed for the worse case flaw orientation based on the higher stresses perpendicular to the orientation of the flaw.
- The maximum postulated flaw geometry assumes that the Alloy 182 J-groove weld is completely cracked, no credit is taken for any remaining life of this material, and flaw growth in this material is not required;
- Weld residual stresses are conservatively based on room temperature yield strength of the Alloy 182 J-groove weld material; and
- The fracture mechanics evaluation for the as-left Alloy 182 J-groove weld uses the stresses of the low alloy steel shell (with consideration of the equivalent steel weld pad) from the 2-D axisymmetric finite element analysis of instrument nozzle N-16D with the nozzle repair design configuration to be installed.

The ASME Section XI flaw evaluation requires a projection of crack growth for the flaw in the Alloy 182 J-groove weld of the remnant nozzle being abandoned in-place, and potentially into the RPV material. The potential crack propagation is into the RPV low alloy steel by fatigue and stress corrosion cracking. Prediction of fatigue crack growth requires the weld residual and design basis transient event through-wall stresses for the RPV shell at the nozzle. For this fracture mechanics analysis a conservative evaluation is being performed. This evaluation is used to demonstrate compliance with a combination of IWB-3610 and Code Case N-749, as applicable.

F. Repair of Nozzle Penetration

EGC is planning to replace this existing nozzle assembly with a nozzle penetration that is resistant to IGSCC, which meets ASME Section XI and Code Case N-638-4 as conditionally approved by the NRC in Regulatory Guide 1.147, Revision 17 and ASME Section III. See Enclosure 2 for a sketch of the planned RPV instrument nozzle repair. A welded pad will be applied to the existing weld build-up pad on the OD of the RPV using IGSCC resistant nickel Alloy 52M filler metal and will be welded using the machine GTAW ATTB welding technique. The IGSCC resistant nozzle will be attached to the new weld pad with a partial penetration weld using a non-temper bead manual welding technique and IGSCC resistant filler metal. The original partial penetration attachment weld and a remnant of the original nozzle are planned to remain in place.

The planned steps of the proposed repair are described below. This plan may change due to varying conditions present during the work. Changes to the plan detailed below will remain in compliance with applicable Code requirements.

1. Cut the existing nozzle outboard of the RPV.

2. Installation/attachment of studs for boring tool.
3. Bore to partially remove the existing N-16D nozzle.
4. Measure the bore.
5. Perform surface and volumetric examinations on the existing weld pad in preparation for the new weld pad.
6. Bore for weld dam.
7. Measure bore.
8. Machine, inspect and perform a surface examination of the weld dam.
9. Install the weld dam. The weld dam will have an O-ring to keep any leaking water from the nozzle from affecting deposition of the new weld pad.
10. Deposit the new weld pad, in accordance with Code Case N-638-4.
11. Perform post weld grinding of the weld pad.
12. Dimensional inspection of weld pad.
13. Start the 48-hour hold after completing the third layer of the new weld pad, in accordance with Code Case N-638-4.
14. Perform a surface examination of weld pad and radial band around weld pad.
15. UT of weld pad and radial band around weld pad.
16. Bore the weld pad to the final size and remove the weld dam.
17. Measure and perform a surface examination of the final bore.
18. Machine, inspect, and perform a surface examination of the replacement nozzle.
19. Weld new reducing insert to nozzle.
20. Inspect and perform a surface examination of the nozzle-reducing insert weld.
21. Machine J-prep in weld pad.
22. Inspect and perform a surface examination of the J-groove.
23. Replacement nozzle installation and welding. Surface conditioning may be completed on the root pass to keep the area dry the remainder of the welding. The root pass will not be credited for the structural strength of the weld.
24. Inspect and perform a surface examination of the nozzle weld.
25. Install the piping and perform a surface examination.
26. Remove studs attached to RPV for boring tool.
27. Perform surface examination of RPV at stud attachment locations in accordance with ASME Section III.
28. Removal of sealing plug.

The repair discussed in the above plan will be performed in accordance with ASME Code Section XI, 2007 Edition with the 2008 Addenda.

A design analysis is being performed in accordance with the design requirements of ASME Section III. The analysis will confirm that the new nozzle will not eject from the RPV under design conditions. The new design is reconciled to the original construction code and addresses design and transient loads to ensure all Code requirements are met.

The N-16D nozzle is in the beltline region (high fluence region) when projecting fluence values out to 37 Effective Full Power Years (EFPY). The fast neutron fluence value (E>1.0 MeV) determined for this nozzle at the inside diameter (0T) of the vessel is 1.27 E+17 neutron/cm^2.

The outside diameter (1T) value of fast neutron fluence is 2.64 E+16 neutron/cm^2 at 37 EFPY. These values use the DPA-weighted attenuation methods as described in Regulatory Guide 1.99. However, accumulated exposure for this nozzle area to date of this repair is less. The current accumulated EFPY for LGS, Unit 2 is 25.21. The fast neutron fluence accumulated to date (25.21 EFPY) at the inside diameter (0T) of the vessel is 8.37 E+16 neutron/cm^2 and the outside diameter (1T) is 1.78 E+16 neutron/cm^2. Both values are below the threshold level of 1E+17 neutron/cm^2 (E > 1.0 MeV). The material in the area of this repair is not expected to have decreased fracture toughness and ductility associated with damage of low alloy steels in the beltline region. Therefore, there is not a weldability concern for the repair.

Additionally, NDE is planned as described in the list of operations above. The new weld pad and original weld pad are examined with a UT following completion as required by ASME Code Case N-638-4. The base metal surrounding the bored area is examined with a surface dye penetrant (PT). These examinations will verify there are no unacceptable defects (cracking or fabrication) within the bore area, newly installed weld pad, or original base metal material.

G. Corrosion Evaluation

A corrosion evaluation was performed to consider potential material degradation due to the repair of the N-16D RPV instrumentation nozzle. The repair will result in the RPV low alloy steel and the associated low alloy steel weld pad being exposed to the reactor coolant. The corrosion review addressed general corrosion, crevice corrosion, and galvanic corrosion of the exposed low-alloy steel (LAS) in the gap. LGS Unit 2 operation implements On-Line Noble Metal Chemical (OLNC) addition with Hydrogen Water Chemistry (HWC) to mitigate corrosion. The reactor water chemistry of LGS, Unit 2, meets the requirements of the latest BWRVIP Water Chemistry Guidelines (BWRVIP-190).

The corrosion evaluation concluded that the modification of the N16-D RPV nozzle, which will expose the low alloy steel RPV to a water environment and introduce new materials (Alloy 690 and Alloy 52M), is acceptable.

H. Loose Parts Evaluations

Given the original N-16D nozzle will not be entirely removed, EGC completed a lost-parts evaluation to assess the potential for nozzle segments to enter the RPV during power operation. Two evaluations were completed to address the potential impact on the fuel and the potential impact on internal RPV components. The evaluations determined that the potential for lost parts did not pose any safety concerns. The evaluations considered interfacing systems and other RPV internal components, flow blockage, and adverse chemical reactions.

<u>Conclusion</u>

Based on the above, in accordance with 10 CFR 50.55a(z)(2), EGC has concluded that compliance with the ASME Code to perform the repair results in a hardship without a compensating increase in quality and safety. The proposed alternatives provide an acceptable level of quality and safety as discussed above.

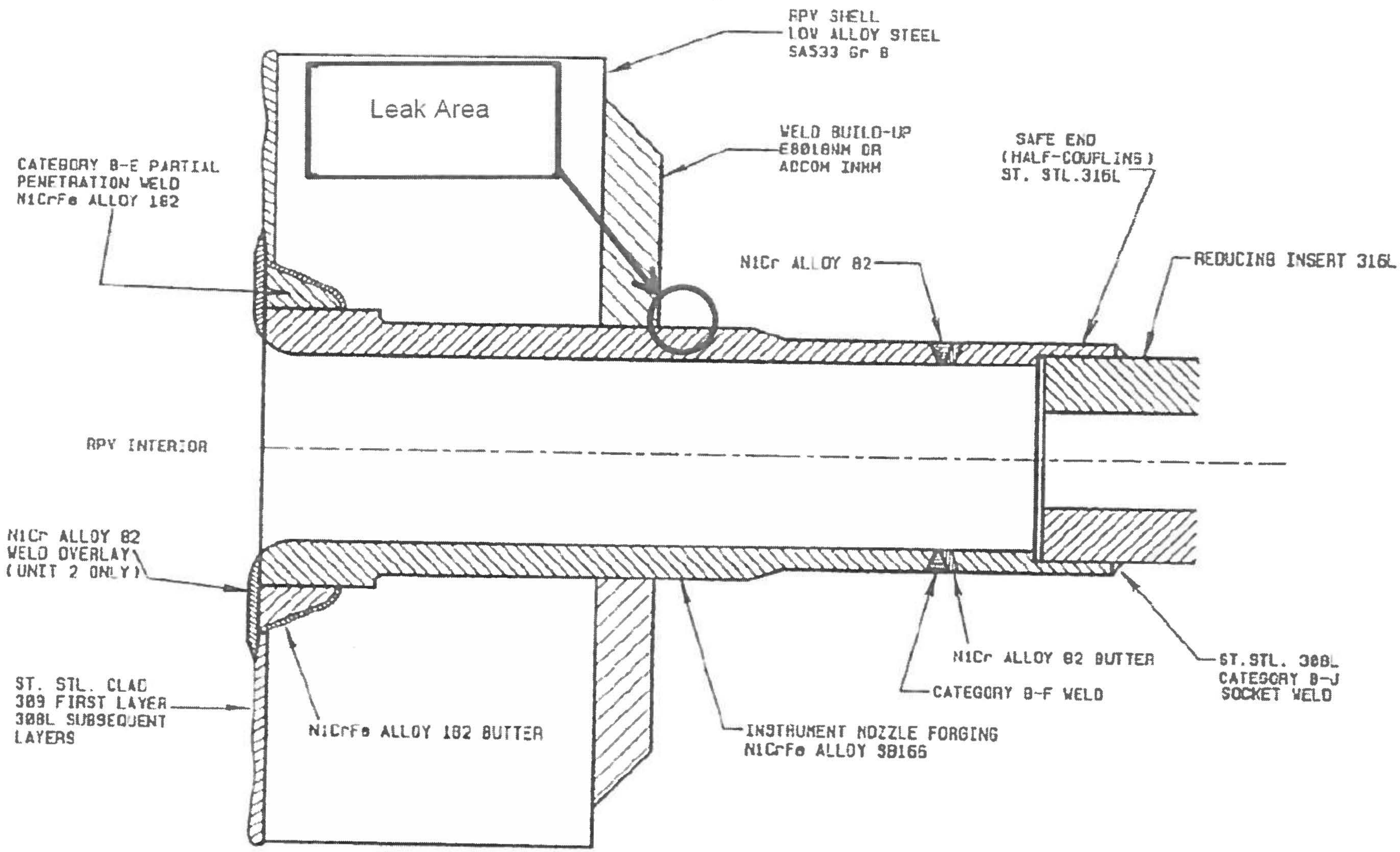
6. DURATION OF PROPOSED ALTERNATIVE

Relief is requested for the duration of LGS Unit 2 Cycle 15, which is currently scheduled to conclude in the Spring of 2019.

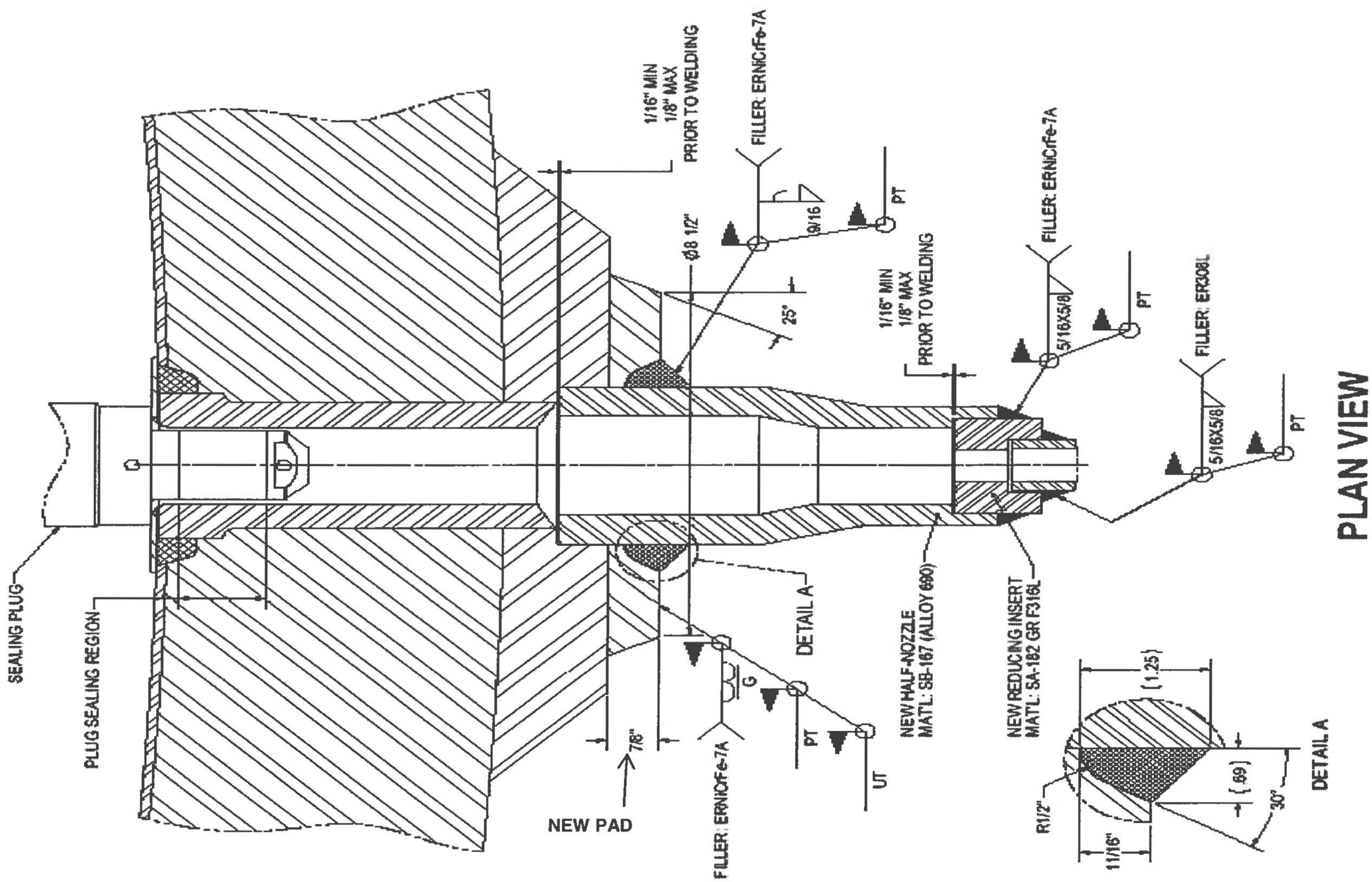
7. PRECEDENTS

A similar relief request was previously approved via a verbal authorization on April 15, 2012 for Quad Cities, Unit 2 (ML12107A472). The NRC Safety Evaluation was subsequently issued on January 30, 2013.

Enclosure 1
N-16D Figure



Enclosure 2 - Reactor Pressure Vessel Level Instrument Nozzle Repair



ATTACHMENT 4

Affidavit

AFFIDAVIT

COMMONWEALTH OF VIRGINIA)
) ss.
CITY OF LYNCHBURG)

1. My name is Tom Ryan. I am Manager, Product Licensing, for AREVA Inc. (AREVA) and as such I am authorized to execute this Affidavit.

2. I am familiar with the criteria applied by AREVA to determine whether certain AREVA information is proprietary. I am familiar with the policies established by AREVA to ensure the proper application of these criteria.

3. I am familiar with the AREVA information contained in the AREVA document "51-9271544–000, Corrosion Evaluation of the Limerick Unit 2 N16-D Reactor Vessel Nozzle Modification", and referred to herein as "Document." Information contained in this Document has been classified by AREVA as proprietary in accordance with the policies established by AREVA Inc. for the control and protection of proprietary and confidential information.

4. This Document contains information of a proprietary and confidential nature and is of the type customarily held in confidence by AREVA and not made available to the public. Based on my experience, I am aware that other companies regard information of the kind contained in this Document as proprietary and confidential.

5. This Document has been made available to the U.S. Nuclear Regulatory Commission in confidence with the request that the information contained in this Document be withheld from public disclosure. The request for withholding of proprietary information is made in

accordance with 10 CFR 2.390. The information for which withholding from disclosure is requested qualifies under 10 CFR 2.390(a)(4) "Trade secrets and commercial or financial information."

6. The following criteria are customarily applied by AREVA to determine whether information should be classified as proprietary:

(a) The information reveals details of AREVA's research and development plans and programs or their results.

(b) Use of the information by a competitor would permit the competitor to significantly reduce its expenditures, in time or resources, to design, produce, or market a similar product or service.

(c) The information includes test data or analytical techniques concerning a process, methodology, or component, the application of which results in a competitive advantage for AREVA.

(d) The information reveals certain distinguishing aspects of a process, methodology, or component, the exclusive use of which provides a competitive advantage for AREVA in product optimization or marketability.

(e) The information is vital to a competitive advantage held by AREVA, would be helpful to competitors to AREVA, and would likely cause substantial harm to the competitive position of AREVA.

The information in this Document is considered proprietary for the reasons set forth in paragraphs 6(a), 6(c) and 6(d) above.

7. In accordance with AREVA's policies governing the protection and control of information, proprietary information contained in this Document has been made available, on a limited basis, to others outside AREVA only as required and under suitable agreement providing for nondisclosure and limited use of the information.

8. AREVA policy requires that proprietary information be kept in a secured file or area and distributed on a need-to-know basis.

9. The foregoing statements are true and correct to the best of my knowledge, information, and belief.

SUBSCRIBED before me this 15th

day of May, 2017.

Sherry L. McFaden
NOTARY PUBLIC, COMMONWEALTH OF VIRGINIA
MY COMMISSION EXPIRES: 10/31/18
Reg. # 7079129

SHERRY L. MCFADEN
Notary Public
Commonwealth of Virginia
7079129
My Commission Expires Oct 31, 2018

ATTACHMENT 6

"Corrosion Evaluation of the Limerick Unit 2 N16-D Reactor Vessel Nozzle Modification (Non-Proprietary)," Document Number 51-9271770-000

AREVA

AREVA Inc.

Engineering Information Record

Document No.: 51 - 9271770 - 000

Corrosion Evaluation of the Limerick Unit 2 N16-D Reactor Vessel Nozzle Modification (Non-Proprietary)

Corrosion Evaluation of the Limerick Unit 2 N16-D Reactor Vessel Nozzle (Non-Proprietary)

Safety Related? ☒ YES ☐ NO

Does this document establish design or technical requirements? ☐ YES ☒ NO

Does this document contain assumptions requiring verification? ☐ YES ☒ NO

Does this document contain Customer Required Format? ☐ YES ☒ NO

Signature Block

Name and Title/Discipline	Signature	P/LP, R/LR, M, A-CRF, A	Date	Pages/Sections Prepared/Reviewed/ Approved or Comments
Ryan Hosler Supervisory Engineer Materials Engineering	[signature]	P	5/15/17	All
Matt DeVan Advisory Engineer Materials Engineering	[signature]	R	5/15/17	All
Pavan Thallapragada Manager MSAU	[signature]	A	5/15/17	All

Note: ~~P/LP designates Preparer (P), Lead Preparer (LP)~~
M designates Mentor (M)
R/LR designates Reviewer (R), Lead Reviewer (LR)
A-CRF designates Project Manager Approver of Customer Required Format (A-CRF)
A designates Approver/RTM – Verification of Reviewer Independence

Project Manager Approval of Customer References (N/A if not applicable)

Name (printed or typed)	Title (printed or typed)	Signature	Date
David Skulina	Project Manager	[signature]	5/15/2017

Record of Revision

Revision No.	Pages/Sections/ Paragraphs Changed	Brief Description / Change Authorization
000	All	Original submittal; Note proprietary version is 51-9271544-000.

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1.0 PURPOSE

The repair of the N16-D reactor vessel instrumentation nozzle in the Limerick Generating Station Unit 2 (LGS-2) reactor vessel will change the penetration configuration in the following ways: 1) the repair will expose the SA-533 Grade B, Class 1 low alloy steel reactor vessel and E8018-NM low alloy steel weld pad to water conditions, 2) a new Alloy 690 nozzle will be part of the pressure boundary, and 3) a new Alloy 52M weld pad and partial penetration J-groove weld will also be part of the pressure boundary [1,2]. Also, the reducing insert to nozzle weld will now be an Alloy 52M dissimilar metal weld. The following corrosion evaluation will consider potential material degradation due to each of these changes. The original configuration and the final repair configuration are shown in Figure 1-1 and Figure 1-2, respectively. Note that the weld joining the stainless steel reducing insert (i.e., F316) to the stainless steel pipe in the original configuration is assumed to be stainless steel because the joined base metals are both stainless steel.

Figure 1-1: Original Configuration [1,2]

Figure 1-2: Final Repair Configuration [1,2]

2.0 ASSUMPTIONS

2.1 Assumptions Requiring Verification

There are no assumptions requiring verification.

2.2 Justified Assumptions

The weld joining the stainless steel reducing insert to the stainless steel pipe in the original configuration is assumed to be stainless steel because the joined base metals are both stainless steel.

3.0 CORROSION OF EXPOSED LOW ALLOY STEEL

The low alloy steel reactor vessel material exposed due to the repair will be in the water space environment given the elevation of the N16-D nozzle. LGS-2 implements the water chemistry control requirements of BWRVIP-190 Revision 1 to mitigate corrosion [3, 4].

3.1 General Corrosion

[ ]

3.2 Galvanic Corrosion

[ ]

[ ]

3.3 Crevice Corrosion

[ ] The environmental conditions in a crevice can become aggressive with time and can cause accelerated local corrosion. [ ]

The test results are supported by operating experience (and simulated operating experience) in light water reactors. [ ]

3.4 Stress Corrosion Cracking

[ ]

4.0 CORROSION OF ALLOY 690 AND ALLOY 52M

Stress corrosion cracking failures of Alloy 600 and its associated weld metals (Alloy 82/182) have occurred in domestic and international light water reactors. The BWR industry addressed this issue by replacing or modifying affected materials with a modified version of Alloy 82 [9]. The modified version of Alloy 82 adds carbide stabilizers (Niobium and Titanium) to minimize chromium depletion at the grain boundaries. The PWR industry selected Alloy 690 and Alloy 52/152 as replacement materials [10]. Alloy 690 was also thermally treated to improve the microstructure, but grain boundary chromium depletion of Alloy 690/52/152 was avoided by doubling the chromium content (from ~15% to ~30%) instead of using carbide stabilizers. Alloys 690/52/152 have been in service for decades with no reported failures. Laboratory studies indicate that Alloy 690 and Alloy 52/152 have superior SCC resistance relative to the Alloy 600 and Alloy 82/182.

Although most testing of Alloy 690/52/152 has been under PWR conditions, some studies have been performed in environments more similar to BWRs. Creviced U-bend specimens of Alloy 600 and Alloy 690 were tested at 600°F for 48 weeks with an environment of 6 ppm oxygen [11]. The Alloy 600 readily cracked, whereas Alloy 690 showed no cracking. Also, testing of Alloy 690 in high purity water containing 36 ppm oxygen at 289°C (~550°F) for 47 weeks resulted in no cracking [11].

Extensive testing has been performed on Alloy 52/152 in high temperature deaerated water, which indicate that Alloy 52/152 is much less susceptible to SCC compared to Alloy 82/182 (the Alloy 600 weld metal) [10,12,13]. Test data of Alloy 52/152 in a high temperature oxygenated environment is not readily available, but Alloy 52/152 is expected to have a low susceptibility to SCC under these conditions as well, based on the similarity of Alloy 52/152 to Alloy 690.

The only difference between the Alloy 52M to be used in the repair and Alloy 52/152 are small alloying additions to improve weldability. The corrosion resistance is similar.

5.0 CONCLUSION

The modification of the N16-D reactor vessel nozzle at LGS-2, which will expose the low alloy steel reactor vessel to a water environment and introduce new materials (Alloy 690 and Alloy 52M), is found acceptable. [

] Based on laboratory studies and operating experience, the replacement higher chromium content nickel-based alloys (Alloy 690 and Alloy 52M) have a high resistance to SCC.

6.0 REFERENCES

References identified with an (*) are maintained within Exelon Records System and are not retrievable from AREVA Records Management. These are acceptable references per AREVA Administrative Procedure 0402-01, Attachment 8. See page 2 for Project Manager Approval of customer references.

1. [ ]
2. [ ]
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4. LGS UFSAR – Appendix A, "Updated Final Safety Analysis Report Supplement," Revision 18.
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6. D.C. Vreeland, et al., "Corrosion of Carbon and Low-Alloy Steels in Out-of-Pile Boiling-Water-Reactor Environment," Corrosion, Vol. 17, No. 6, 1961.
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Degradation of Materials In Nuclear Power Systems – Water Reactors, Aug 10-14 1997, Amelia Island, FL, ANS.

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The Vice President of Products and Engineering has approved the use of Reference 5.

Carl Fisher (Vice President of Products and Engineering) [signature] For C. Fisher per telecon.
Jeffrey Fleck