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10 CFR 50.55a

LG-17-077
May 15, 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

In accordance with 10 CFR 50.55a, "Codes and standards," paragraph (z)(1), Exelon Generation Company, LLC (EGC) requests 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 8, 2017, LGS, Unit 2 performed a system leakage test of the RPV in accordance with IWB-5210(a). A leak of approximately one pint per minute was observed from the N-16D instrument penetration. EGC intends to repair the penetration by modifying the presently installed weld pad using Ambient Temperature Temper Bead (ATTB) welding in accordance with ASME Code Case N-638-4, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique, Section XI, Division I."

In support of the flaw evaluation and applicable acceptance criteria, ASME Code Paragraphs IWB-3420 and IWB-3600 require characterization of the flaw in the penetration. Currently there is not a qualified technique to perform volumetric Non-Destructive Examination (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. As an alternative to performing the NDE required to characterize the flaw in instrument penetration N-16D, EGC is proposing to analyze a maximum postulated flaw that bounds the range of flaw sizes that could exist in the original J-groove weld and nozzle, as discussed in the attachment.

In accordance with 10 CFR 50.55a(z)(1), the proposed alternatives may be approved by the NRC, provided an acceptable level of quality and safety are maintained. EGC concludes that the proposed alternatives meet this requirement.

EGC requests approval of the proposed alternatives in order to support the return to service from the current LGS, Unit 2 refueling outage (Li2R14). EGC is requesting approval of this relief request by May 17, 2017. Relief is requested for the duration of the upcoming LGS Unit 2 Cycle 15 which is currently expected to conclude in the Spring of 2019.

There are no regulatory commitments contained in this relief request.

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

Attachment: Relief Request I4R-17

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

ATTACHMENT

Limerick Generating Station, Unit 2

Proposed Relief Request Associated with Reactor Pressure Vessel Nozzle Repairs

RELIEF REQUEST I4R-17

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 will demonstrate the acceptability of leaving the original partial penetration attachment weld, with a maximum postulated flaw, in place for one 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)(1), EGC proposes the following alternatives to the requirements specified in Section 3 above on the basis that they provide an acceptable level of quality and safety:

- 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, will be 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 will be considered. The analysis will be 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 will conservatively be 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 will use 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 will be performed. This evaluation will be 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 will be 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.

Conclusion

Based on the above, in accordance with 10 CFR 50.55a(z)(1), EGC has concluded that the proposed alternatives provide an acceptable level of quality and safety.

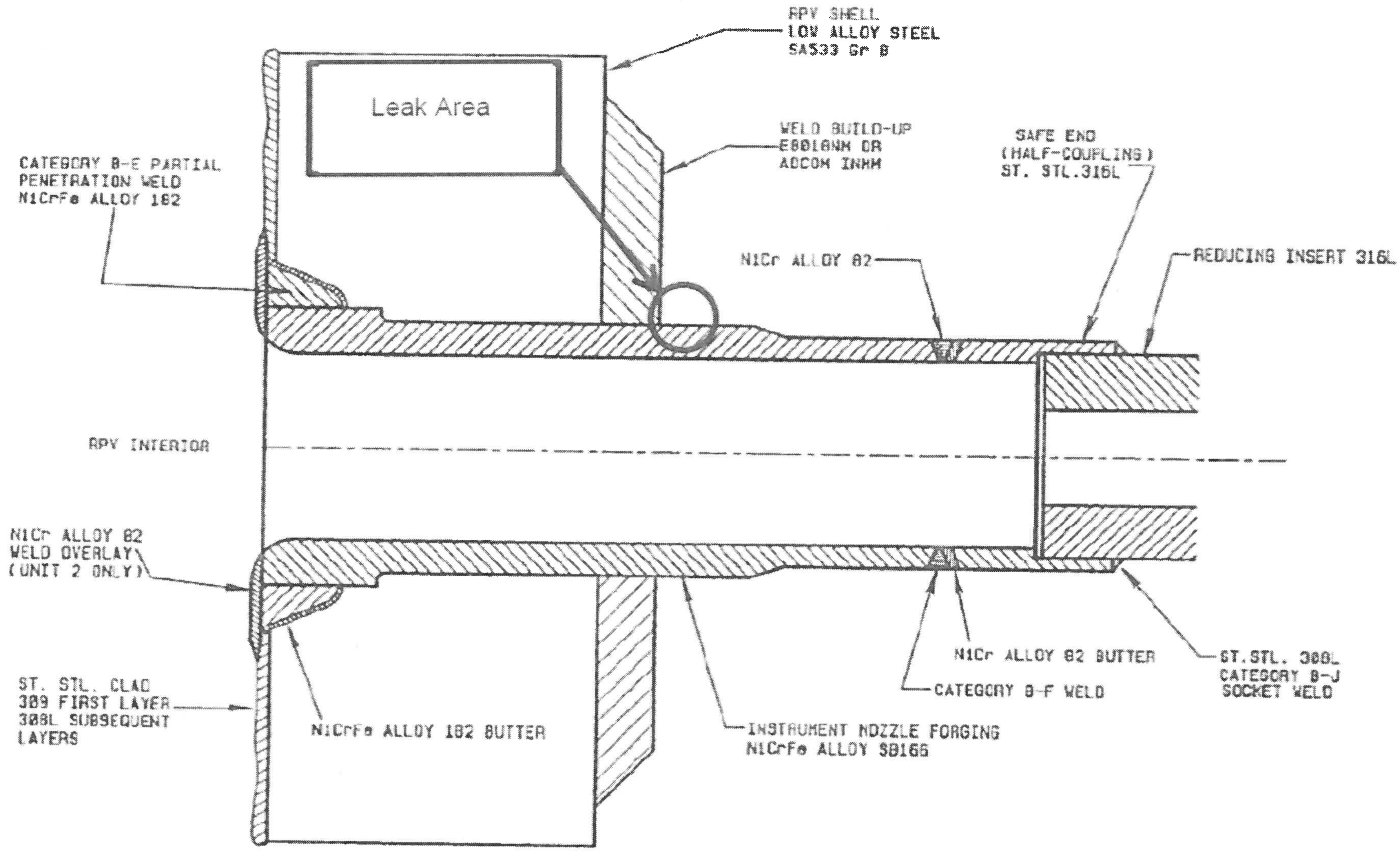
6. DURATION OF PROPOSED ALTERNATIVE

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 Sketch