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March 25, 1999
PY-CEI/NRR-2380L

United States Nuclear Regulatory Commission
Document Control Desk
Washington, DC 20555

Perry Nuclear Power Plant
Docket No. 50-440
Request for Approval of Feedwater Nozzle Repair Plan

Ladies and Gentlemen:

In accordance with the Code of Federal Regulations, 10 CFR 50.55a, "Codes and Standards," and the Perry Nuclear Power Plant (PNPP) response submitted to Generic Letter 88-01, "NRC Position on IGSCC in BWR Austenitic Stainless Steel Piping," the Perry Nuclear Power Plant staff requests approval of the attached repair plan for the feedwater nozzle to safe-end weld N4C-KB.

The proposed repair plan complies with the applicable requirements of Section XI of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, ASME Code Case N-504, and the recommendations in NUREG-0313, Revision 2, and Generic Letter 88-01. A timely review of this repair plan is requested to support the weld overlay installation, which is scheduled to begin on April 11, 1999.

The details of the proposed weld overlay design and installation plan are included in Attachment 1. For reference, Attachment 2 provides the applicable preliminary weld procedure to be used.

If you have questions or require additional information, please contact Mr. Henry L. Hegrat, Manager - Regulatory Affairs, at (440) 280-5606.

Very truly yours,

Lew W Myers

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Attachments

cc: NRC Project Manager
NRC Resident Inspector
NRC Region III

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BACKGROUND

The Perry Nuclear Power Plant (PNPP) has several reactor vessel coolant nozzle to safe-end welds that are all dissimilar metal welds that contain an Inconel 182 buttering. In accordance with Generic Letter (GL) 88-01, "NRC Position on IGSCC in BWR Austenitic Stainless Steel Piping", (Reference 1) and NUREG-0313, Revision 2, January 1988, "Technical Report on Material Selection and Processing Guidelines for BWR Coolant Pressure Boundary Piping", (Reference 2) these welds are considered susceptible to Intergranular Stress Corrosion Cracking (IGSCC). As such, they require inservice Ultrasonic (UT) examination at least once every 2 refueling outages. The welds' initial inservice UT examinations were completed in Refuel Outage (RFO) 2. During RFO 2, a shallow flaw (i.e., less than 20% through-wall) was detected in feedwater nozzle to safe-end weld N4C-KB. The flaw was sized and evaluated as acceptable for continued operation in accordance with ASME Section XI, Article IWB-3600. In RFO 3, the IGSCC susceptible safe-end welds were treated with the Mechanical Stress Improvement Process (MSIP) and received Pre-MSIP and Post-MSIP inservice UT examinations. In accordance with NUREG-0313, MSIP is considered to be an effective mitigation technique for IGSCC susceptible welds that are not cracked, or have cracking that is less than or equal to 30% through-wall.

In accordance with NUREG-0313, General Electric (GE) re-examined the safe-end welds that were stress improved in RFO 3, including N4C-KB, in RFO 5. GE completed the re-examination in RFO 5 using GE's SMART 2000 automated UT system with TOMOSCAN analysis software. This examination showed only minor differences in the sizing results reported from the previous exams.

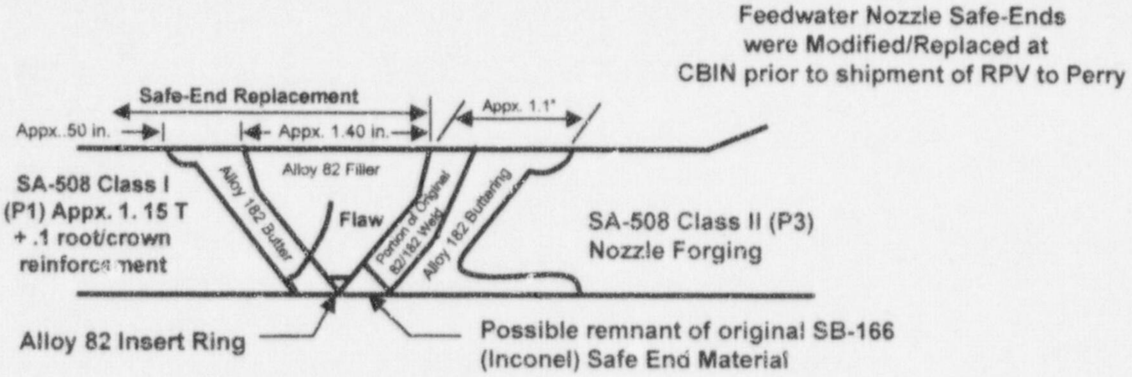
In 1996, the Hope Creek Generating Station experienced a through-wall flaw in one of their Core Spray nozzle to safe-end welds. The extent of this flaw had not been identified previously with the analysis techniques applied at the time. GE had previously examined the Hope Creek weld in 1992 and 1995 using GE's SMART system and did not report any flaws. A retrospective re-evaluation of the 1992 and 1995 data by GE using the same SMART system found that detection of the flaw in 1992 was questionable, but that it was definitely present in the 1995 data. There were extenuating circumstances (i.e., extensive weld repairs) that led to the oversight at Hope Creek. This prompted GE and other ISI vendors to pursue better data analysis procedures and software.

Applying this lesson learned to preparations for PNPP's RFO 7, previous N4C-KB weld data was analyzed using the new TOMOVIEW analysis software for results comparison. The re-evaluation of N4C-KB weld data showed the pre-existing flaw to have changed slightly in length and significantly in the through-wall dimension. The N4C-KB flaw depth and length was determined to be as much as 0.75 inches in depth, rather than the 0.25 inch depth that was reported in RF0 5.

GE evaluated the change in flaw size for the N4C-KB nozzle weld and determined that the projected flaw size would meet ASME Code requirements at the time of shutdown for PNPP's RFO 7, scheduled for March 27, 1999.

Applying guidance from Generic Letter 91-18, "Information to Licensees Regarding NRC Inspection Manual Section on Resolution of Degraded and Nonconforming Conditions" (Reference 1), the structural integrity of the N4C-KB nozzle weld was found to support operation until RFO 7. Upon learning of the sizing differences, the PNPP staff requested that Electric Power Research Institute (EPRI) Non Destructive Examination (NDE) Center personnel perform an independent review of GE's re-evaluation of the RFO 5 data with the new TOMOVIEW software. EPRI personnel concurred with GE's re-evaluation of the flaw size.

For information, Figure 1 below depicts weld N4C-KB and the projected flaw location.



CBIN = Chicago Bridge and Iron

Figure 1

The safe-end is fabricated from SA-508, Class I (P1 Group 2 material) and the nozzle material is SA-508, Class II (P3 Group 3 material). Both the nozzle and the safe-end are buttered with Alloy 182. The butt weld was made with Alloy 82 filler. The flaw is projected to be located in the butter and the weld associated with the safe-end replacement. A portion of the original weld and nozzle-to-weld butter were left in place.

<u>EXAMINATION AND REPAIR PLAN</u>

A weld overlay repair is proposed to be completed for the flawed weld. The flaw in the weld will not be removed.

The repair activities will be performed by qualified personnel from Welding Services Incorporated (WSI) and shall be in accordance with WSI's Nuclear Repair (NR) Certificate of Authorization. The repair will be performed in accordance with a feedwater nozzle repair package as defined by WSI's Nuclear Repair Manual. The repair package will incorporate appropriate sign-off steps that specify each operation by sequence. Structural Integrity Associates (SIA) performed the design activities for the repair in accordance with their QA program.

An NR-1 data report will be completed by WSI documenting these repairs. The ASME Section XI, NIS 2 form will be generated by PNPP for incorporation into the Summary Report.

The weld overlay will be applied with water on the inside surface of the nozzle. The weld overlay will be applied using IGSCC resistant UNS N06052 Alloy 52 wire (ASME Code Case 2142), which will extend from the safe-end SA 508 Class I material over the weld and beyond the defect, but no closer than 0.125 inches from the low alloy steel SA 508 Class II nozzle. Any local repairs to be performed manually prior to start of the weld overlay shall be performed using UNS W86152 plus Alloy 152 (ASME Code Case 2143) electrodes. The welders and welding procedures shall be qualified in accordance with ASME Sections III and IX.

The welding consumables shall be in accordance with ASME Code Cases 2142 and 2143.

The weld overlay repair is designed to be at least 0.425 inches thick beyond an initial layer of 0.075 inches, which is not considered as part of the structural weld overlay. This results in a minimum thickness of 0.5 inches. The initial layer is designed to account for any dilution with the underlying base metal so that the entire structural weld overlay is resistant to IGSCC initiation and growth. The repair will be applied by welding the stress corrosion resistant Alloy 52 filler material using machine Gas Tungsten Arc Welding (GTAW) technology and applying the weld around the entire circumference of the safe-end and girth weld for the required design length, thereby providing a replacement pressure boundary for the original joint.

Prior to initiation of the overlay, the design length will be marked using low stress dies. A second set of marks will be applied approximately 0.5 to 1 inch outside either end of the design overlay length. Punch marks shall be placed at 4 azimuth locations. The axial distance between each set of marks will be measured and recorded. Following the weld overlay application, these measurements will be repeated and dimensions recorded to determine axial shrinkage, which will occur during the overlay operation. Following surface machining, the final weld overlay thickness will be determined using UT techniques.

For reference, Attachment 2 provides the applicable preliminary weld procedure.

Prior to the final weld overlay examination, the final weld overlay surface will be machined to an approximate finish of 250 RMS (no waviness). Subsequent to machining, the final weld overlay will be examined using Liquid Penetrant (PT) and UT methods in accordance with ASME Code Case N-504 and NUREG-0313 (modified as necessary for examination of Ni-Cr-Fe overlays). The examination requirements for the weld overlay repairs of feedwater nozzle to safe-end weld N4C-KB are summarized in the table on the following page.

Examination Description	Method	Technique	Acceptance Criteria	Notes
Thickness and Contour Measurements	UT	0° Long.	N/A	N/A
As-Found Exam	Auto UT	45°Shear 45° Ref. Long. 60° Ref. Long.	N/A	N/A
As-Found Sizing	Auto UT	70° Ref. Long. OD Creeping Wave	IWB-3514	Note 1
Weld and Safe-End Overlay Surface Preparation Exam	PT	Visible Dye	IWB-3514	Note 1
First Weld Overlay Layer Thickness Checks	UT	0° Long. or Hand Meas.	N/A	N/A
First Weld Overlay Layer Surface Exam	PT	Visible Dye	NB-5352	Note 2 Note 4
Exam of Completed Overlay for Lack-of-Bond and Thickness	Auto UT	0° Long.	IWB-3514	Note 1 Note 3
Surface Exam of Completed Overlay	PT	Visible Dye	NB-5352	Note 4
Volumetric Exam of Completed Overlay	Auto UT	70° Ref. Long. OD Creeping Wave	IWB-3514	Note 1
Pre-Service Exam of Completed Overlay and the Upper 25% of the Flawed Weld and adjacent 1"	Auto UT	60° Ref. Long. 70° Ref. Long.	IWB-3514	Note 1 Note 5

TABLE NOTES:

General Note: The weld overlay examinations comply with the recommendations of NUREG-0313, Revision 2, and also with EPRI NP-4720-LD, "Examination of Weld-Overlayed Pipe Joints", as supplemented by EPRI TR-101681, "Addendum to Examination of Weld-Overlayed Pipe Joints."

1. The Edition and Addenda for the ASME Section XI acceptance criteria is the 1989 Edition with no Addenda.
2. A PT exam will be performed on the first layer of the overlay to ensure there is no cracking. It will also be performed to be consistent with PNPP's commitment to the NRC to perform PT examinations of the root (pass) layers of Class 3 butt weld repairs when Code Case N-416-1 is to be used for pressure testing (Reference PNPP letter PY-CEI/NRR-1851L dated October 31, 1994 and NRC Safety Evaluation response - TAC No. M91005). The implication of the NRC requirement for a root pass PT for Class 3 butt welds was that Class 3 butt welds would not receive a radiographic examination under ASME Section III, whereas Class 1 and 2 butt welds would. Similarly, the weld overlay will not receive an ASME Section III radiographic examination.
3. The lamination acceptance criteria of ASME Table IWB-3514-3 will be applied.
4. The Edition and Addenda for the ASME Section III acceptance criteria is the 1992 Edition with no Addenda. This is the Edition and Addenda of Section III that is specified by Code Case N-416-1, which is to be used for pressure testing.
5. Dependent upon the final overlay thickness, a 45° Refracted Longitudinal (RL) Beam search unit may be substituted for the 70° RL.

Following the repair, a system leakage test shall be performed in accordance with ASME Section XI, 1992 Edition, no Addenda per ASME Code Case N-416-1. Use of ASME Code Case N-416-1 at the PNPP was requested via letter PY-CEI/NRR-1851L, dated October 31, 1994, and granted by the NRC on February 10, 1995 (TAC No. M91005). ASME Code Case N-416-1 specifies that Non-Destructive Examination (NDE) shall be performed in accordance with the methods and acceptance criteria of the applicable Subsection of the 1992 Edition of ASME Section III.

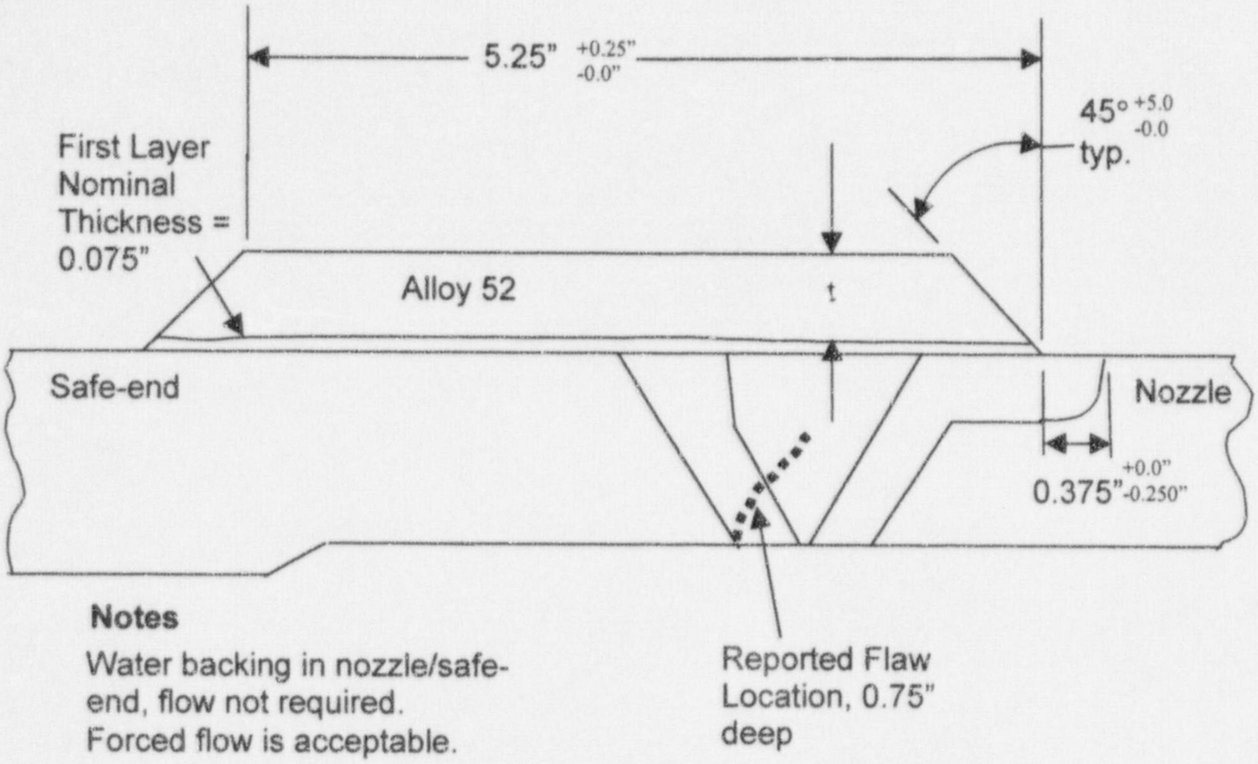
There is no ASME Section III Subsection that directly applies to weld overlays. For the surface examination, the PT examination acceptance standards of ASME Section III, 1992 Edition, NB-5352 (applicable to most Class I welds) will be used. However, ASME Section III volumetric examination methods (i.e., typically radiography) are not practical for examination of the weld overlay repair. Also, NUREG-0313 specifies that Ultrasonic examination, using methods and personnel qualified through the EPRI NDE Center, be used. Furthermore, NUREG-0313 states that the Ultrasonic examinations should be performed in general in accordance with the requirements of the applicable edition of the ASME Code. PNPP's Code of record for the current 10-year inservice inspection interval is the 1989 edition of ASME Section XI with no Addenda. Therefore, the acceptance criteria that will be used for the volumetric examinations will be those of IWB-3514, "Standards for Examination Category B-F, Pressure Retaining Dissimilar Metal Welds, and Examination Category B-J, Pressure Retaining Welds in Piping."

REPAIR JUSTIFICATION

Weld overlays involve the application of weld metal circumferentially around the pipe in the vicinity of the flawed weld to restore ASME Section XI margins as required by ASME Code Case N-504. Weld overlays have been used in the nuclear industry to repair flawed welds since 1982. The application of weld overlay repairs have shown to produce favorable compressive residual stresses on the inner portion of the pipe wall, which helps to minimize further crack growth (Reference 3).

The overlay for the N4C-KB nozzle is designed using the standard method for size determination. This approach has been used before for the design and application of weld overlays. There are no new or different approaches used in the overlay design, which are considered first-of-a-kind or inconsistent with previous approaches. The overlay is designed as a full structural overlay in accordance with the recommendations of NUREG-0313, Revision 2, which was forwarded by Generic Letter 88-01 and by ASME Code Case N-504 and Section XI of the ASME Boiler and Pressure Vessel Code, Paragraph IWB-3640.

Figure 2 on the following page depicts the final weld overlay design.



Notes

Water backing in nozzle/safe-end, flow not required. Forced flow is acceptable.

First layer thickness can be less than 0.075-inch if surface passes surface PT examination.

t = 0.425-inch minimum, +0.10", -0.0

t must be increased if the first overlay layer is greater than 0.075-inch. Amount of increase is equal to difference between the measured thickness and 0.075-inch.

Figure 2

The overlay is designed by assuming the weld to be completely cracked through the original pipe wall and the first layer of the overlay. In effect, credit was not taken for the first overlay layer, conservatively assuming that this layer remains susceptible to IGSCC due to possible dilution of the Alloy 52 weld overlay material from the underlying weld and base material. Thus, the first overlay layer is considered part of the original wall.

The thickness of the overlay was determined by comparing the weld overlay strength for a combination of dead weight, internal pressure, seismic stresses, and other loads such as water hammer, jet impingement, and safety relief valve discharge with the criteria contained in ASME Paragraph IWB-3641. Both normal operating and emergency/faulted conditions were considered in the evaluation (Reference 4).

The weld overlay application with water on the inside surface produces compressive stress or significantly reduced stress on the inner pipe wall. This results in significantly reduced or arrested crack growth. Although the structural reinforcement assured by the weld overlay is not impacted by the presence of the water, it is beneficial from the standpoint of crack growth (Reference 3).

Another benefit from the water backing is that shrinkage may be reduced as compared to weld overlay applied without water backing. The overlay is designed to meet the ASME Section XI safety margins and the ASME Section III stress limits for primary local and primary bending stresses.

The application of the weld overlay introduces additional weight at the nozzle location. This weight has been analyzed to be insignificant compared to the weight of the piping, safe-end and nozzle (Reference 4). Hence, the current stress analysis of the piping and nozzle will not be significantly impacted by the weld overlay. In addition, the stiffness of the piping will be insignificantly affected by the overlay and therefore the dynamic characteristics of the piping will be minimally affected.

Analysis has demonstrated that although the overlay length on the nozzle side of the overlay will not meet the ASME Code Case N-504 suggested length, the length is sufficient so that end effects will not occur (interaction of the weld overlay end and the cracked section stress fields) and primary membrane and primary bending stress limits are met (Reference 4).

The addition of the weld overlay will not have a significant impact on the fatigue condition of the fatigue critical locations. The conservatism within the existing fatigue evaluations bounds this minimal fatigue impact. Therefore, the existing conservative fatigue evaluations are considered to remain applicable with the weld overlay applied to the feedwater nozzle-to-safe-end location.

APPLICABLE ASME CODES AND CODE CASES

The rules for ASME Class 1 vessels shall apply to this repair. These rules are modified by the applicable documents listed in this section.

1. ASME Boiler and Pressure Vessel Code, Section III, 1989 Edition referenced for material properties and stress criteria.
2. ASME Boiler and Pressure Vessel Code, Section III, 1971 Edition up to and including Winter 1972 Addenda, the RPV construction code.
3. ASME Section III, 1992 Edition, no Addenda, for the surface NDE.
4. Welding materials will be in accordance with ASME Code Cases 2142 and 2143 as applicable.
5. ASME Section XI, 1989 Edition, no Addenda for the volumetric NDE.
6. ASME Code Case N-416-1 for the pressure testing except that the volumetric NDE will be performed in accordance with ASME Section XI rather than ASME Section III.
7. ASME Code Case N-504 - interpreted for welding of P-43 materials (Inconel) rather than P-8 material (stainless) as applicable.

REFERENCES

1. United States Nuclear Regulatory Commission, Generic Letter 88-01, "NRC Position on IGSCC in BWR Austenitic Stainless Steel Piping, January 1988, with Supplement 1," February 1992.
2. United States Nuclear Regulatory Commission, NUREG-0313, Revision 2, "Technical Report on Material Selection and Processing Guidelines for BWR Coolant Pressure Boundary Piping," January 1988.
3. EPRI NP-7103-D, Project T303-1, January 1991, "Justification for Extended Weld-Overlay Design Life."
4. Structural Integrity Associates, Report Number SIR-99-0038, "Weld Overlay Design and Thermal Sleeve Integrity Evaluation Feedwater Nozzle Weld 1B13-N4C-KB at the Perry Nuclear Power Plant," March 1999.
5. Structural Integrity Associates, **pc-CRACK™** for Windows, Version 3.1, February 1999.
6. ANSYS Linear plus Thermal, Revision 5.3, Second Release, October 1996.

7. Structural Integrity Associates, File (Nine Mile Point) NMPC-12Q-301, "Crack Growth and Fracture Mechanics of NMPC Nozzle-to-Safe-end Weld Butter Indication," June 1998.

8. EPRI NP-4720-LD, October 1986, "Examination of Weld-Overlayed Pipe Joints", as supplemented by EPRI TR-101681, December 1992, "Addendum to Examination of Weld-Overlayed Pipe Joints."

9. Transactions of the ASME, Journal of Pressure Vessel Technology, Pressure Vessel and Piping Codes, Evaluation of Flaws in Austenitic Piping, Section XI Task Group for Piping Flaw Evaluation, ASME Code, Volume 108, August 1986.

10. Letter, Shane Findlan to Dr. Wylie Childs, EPRI NDE Center, January 11, 1991, SI File GSU-01-103.

11. Structural Integrity Associates, Report SIR-91-054, "Weld Overlay Design and Thermal Sleeve Seal Integrity Evaluation for Weld 1B31*D001-N4A-2 at River Bend Nuclear Station," September 1991.