BWRVIP-222NP: BWR Vessel and Internals Project

Accelerated Inspection Program for BWRVIP-75-A Category C Dissimilar Metal Welds Containing Alloy 182

1019055NP

Final Report, July 2009

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REPORT SUMMARY

This report provides guidance for utilities to plan and implement examinations of Category C dissimilar metal (DM) welds containing Alloy 182 exposed to the BWR environment that have not been inspected using ASME Section XI, Appendix VIII, Supplement 10 methods.

Background

Category C weldments in boiling water reactors (BWRs) are those not made of resistant materials that have been given a stress improvement (SI) process after more than two years of operation. Cracking in BWR Category C DM welds has been documented over a number of years; however, beginning in early 2007, several utilities reported indications in these welds. Improvements in inspection procedures and methods and in surface preparation of the weld region have contributed to the enhanced detection of flaws.

In 2008, the BWR Vessel and Internals Project (BWRVIP) developed and issued interim recommendations to utilities for reviewing previous examination records and determining the Category C DM welds that require further examination by June 2011. In parallel with that effort, activities were undertaken to develop an accelerated inspection program for Category C DM welds that have not been inspected in accordance with the requirements of ASME Section XI, Appendix VIII, Supplement 10.

Objectives

- To develop guidance on implementing the inspection of Category C DM welds containing Alloy 182 exposed to the BWR environment that have not been inspected in accordance with ASME Section XI, Appendix VIII, Supplement 10 methods
- To develop guidelines for preparing weld overlay repair relief requests

Approach

The project team compiled cracking experience of BWR Category C DM welds and determined the numbers of welds to be inspected. In addition, the team performed analytical evaluations of selected nozzle and nozzle-to-safe-end configurations and determined allowable flaw sizes to indicate available margins. The effectiveness of the SI processes in mitigating intergranular stress corrosion cracking (IGSCC) was assessed by comparing nozzle through-wall stress intensity profiles. The team also collected historical information, summarized the general requirements and application technology, and compiled recent relief requests related to weld overlays.

Results

The results of the flaw tolerance evaluation for the selected nozzles suggest that, at the DM weld locations, the nozzles possess substantial margin to crack instability for through-wall and 360° part-through-wall flaws. The report concludes that both the induction heating stress improvement (IHSI) and the mechanical stress improvement (MSIP) mitigation measures are effective against IGSCC initiation, although the MSIP measure may be more effective against IGSCC growth—particularly for thicker DM welds.

Inspection guidance is recommended for BWR DM welds based on the results of prior inspections and on the effectiveness of the stress mitigation measure against IGSCC initiation and growth. Guidance is also provided to assist utilities in the preparation of a relief request for the application of weld overlays.

EPRI Perspective

Advances in inspection techniques and proper weld surface preparation have significantly improved the reliability of nondestructive examination of BWR DM welds. Although IHSI and MSIP are roughly equivalent for treating DM welds not having preexisting flaws, application of these stress improvement methods after two years of operation leaves open the possibility that IGSCC could have gone undetected. To address this situation, BWRVIP will implement an accelerated inspection program to ensure that all Category C DM welds will receive an examination to ASME Section XI, Appendix VIII, Supplement 10, including criteria established by EPRI for flatness of the inspection region.

Keywords

BWR Vessel and Internals Project (BWRVIP)
BWR
Dissimilar metal welds
Mechanical stress improvement (MSIP)
Induction heating stress improvement (IHSI)
Stress corrosion cracking

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1 INTRODUCTION AND BACKGROUND

Cracking in boiling water reactor (BWR) dissimilar metal (DM) Alloy 182 butt welds has been reported since 1984, with the initial findings at Pilgrim in the reactor coolant system (RCS) outlet (N1) and inlet (N2) nozzle-to-safe end welds during safe end replacement [1, 2]. Other examples include indications found in 1999 and 2007 during inservice inspections of the Duane Arnold RCS inlet (N2) nozzle-to-safe end welds [2], and those found in the Hope Creek core spray nozzle (N5) safe end in 1997 and in the RCS inlet (N2) nozzle in 2004 [2]. More detailed descriptions of documented operating experience with cracking in BWR DM Alloy 182 butt welds are provided in Section 4 of this report. The reported indications have been limited to those welds classified as Category C and D [1]. Category C weldments are those not made of resistant materials that have been given a stress improvement (SI) process after more than two years of operation. Category D weldments are those that are not flawed, not made of resistant materials and not given an SI treatment.

As a consequence of examinations performed during the Spring 2007 outage at Duane Arnold that revealed indications in recirculation inlet piping nozzle-to-safe end welds, the Nuclear Regulatory Commission (NRC) was concerned with the potential for relatively large unidentified flaws to be present in Category D welds. Their belief was that examinations conducted prior to the owner's implementation of ASME Code, Section XI [3], Appendix VIII, Supplement 10 (hereinafter referred to as Supplement 10) might not, in all situations, be capable of detecting and sizing indications in DM welds.

The BWR Vessel and Internals Project (BWRVIP) issued letters 2007-051 [15], 2007-062 [16], and 2007-139 [17] to inform the BWRVIP members of the Duane Arnold event, and to recommend that utilities review and provide information on previous examinations of all Category D DM Alloy 182 welds [1]. This resulted in a compilation of DM weld information for weld Categories A through E which was transmitted to the NRC. This effort culminated in a July 19, 2007 letter to BWRVIP members identifying that 33 Category D welds needed to be examined using Supplement 10 methods. The affected utilities either agreed to examine the welds during their next refueling outage or established separate commitments with the NRC to inspect the welds. This resolved the concerns and open issues related to the inspection schedule for Category D welds.

On October 26, 2007, the BWRVIP issued letter 2007-321 [18] that described anomalous Category C DM weld examination results from the recently concluded outage at Hope Creek [1]. This event resulted in the BWRVIP issuing letter 2007-367 [19], which requested utilities to review previous examination records and determine those Category C welds containing Alloy 182 weld material exposed to the BWR environment, and all Category D welds that do not have examinations that were qualified in accordance with Supplement 10 examination methods. The completion date for this effort was December 31, 2008. It was also noted that the BWRVIP would assemble a team to review existing guidance, recommendations, and evaluations to determine if any changes were warranted.

In March 2008, a Focus Group (FG) was formed within the BWRVIP to assess the implications of the Hope Creek event [1]. The FG recommended that all Category C welds containing Alloy 182 weld material exposed to the environment should be inspected with Supplement 10 methods within 6 years. In essence, the aim is to adopt a Category D inspection frequency (100% within 6 years) for all Category C DM Alloy 182 butt welds that have not been inspected using Supplement 10 methods.

The purpose of this report is to provide inspection guidelines for utilities to plan and implement examinations of Category C DM welds containing Alloy 182 exposed to the BWR environment that have not been inspected using Supplement 10 methods. The interim guidance described herein is limited to examinations to be conducted by June 2015 and is based on the results of ultrasonic examination (UT) data reviews completed by February 2009.

1.1 Implementation Requirements

In accordance with the implementation requirements of Nuclear Energy Institute (NEI) 03-08, Guideline for the Management of Materials Issues, Section 9 is "needed" (unless otherwise noted) and the remaining sections are for information only.

2
OBJECTIVES

The objectives of this report are to provide inspection guidelines for utilities to plan and implement examinations of Category C welds, and to provide generic guidelines for weld overlay repair relief request preparation. The examination guidelines are limited to Category C welds containing Alloy 182 exposed to the BWR environment that have not been inspected using Supplement 10 methods, including criteria established by EPRI for flatness of the inspection region [1]. The interim guidance described herein is limited to examinations to be conducted by June 2015 and is based on the results of ultrasonic examination (UT) data reviews completed by February 2009.

3 SCOPE

Several different tasks are described within the scope of this report, including determining allowable flaw sizes to indicate available margins, assessing the effectiveness of the stress improvement processes in mitigating intergranular stress corrosion cracking (IGSCC), comparison of nozzles based on susceptibility, summarizing results of available UT data and DM weld cracking operating experience, and providing generic criteria and guidelines for weld overlay repair relief request preparation.

4
OPERATING EXPERIENCE RELATED TO DM WELD CRACKING

This section provides a summary of operating experience related to DM weld cracking, as well as descriptions of specific documented cases. Specific cases of operating experiences are documented in References 2, 5, 12, 13, and 22. Table 4-1 provides a summary of operating experiences followed by descriptions of specific cases [2, 5, 12, 13, and 22].

Table 4-1
Operating Experience

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Pilgrim—1984

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River Bend—1989

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Figure 4-1
River Bend Feedwater (N4) Safe End Cracking

Hope Creek—1997

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Perry—1999

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Duane Arnold—1999

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Nine Mile Point Unit 2—2000

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Pilgrim—2003

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Susquehanna Unit 1—2004

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Hope Creek—2004

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Duane Arnold—2007

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Nine Mile Point Unit 1—2007

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Pilgrim—2007

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Browns Ferry Unit 2 —2007

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Figure 4-2
Crack Initiating From a Geometric Discontinuity

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Figure 4-3
Crack Propagating Into Stainless Steel Filler Material

Hope Creek —2007

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Hatch Unit 1—2008

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Limerick 1—2008

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Brunswick—2008

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Oyster Creek—2008

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FitzPatrick—2008

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5
SUMMARY OF UT REVIEWS

BWRVIP letters 2007-367 [19] and 2008-096 [20] were issued to direct utilities to review previous examination records for all Category D DM welds (regardless of material), and for all Category C DM welds with Alloy 182 weld metal exposed to the environment, and determine those welds that do not have examinations that were qualified in accordance with the requirements of ASME Code, Section XI, Appendix VIII, Supplement 10. The results of the review for Category C DM welds are summarized in Table 5-1, which provides information on the review status, the number of remaining welds to be inspected with the Supplement 10 method, and the number of welds that do not have Alloy 182 exposed to the environment. Table 5-2 summarizes the Category C DM weld total population, the weld stress improvement processes applied to the welds, and the number of welds that have been, or have not been, examined with the Supplement 10 method. The data in Table 5-1 and in Table 5-2 are based on input as of February 2009 [4].

Table 5-1
Status of U.S. BWR Fleet Category C UT Data Review – February 2009

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Table 5-2
Summary of Category C DM Welds – February 2009

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Based on information summarized in Table 5-1 and Table 5-2, the following is summarized:

- Total U.S. fleet weld population = 359
- 264 welds contain Alloy 182, and 95 are other welds (e.g. SS)
- For welds containing Alloy 182, MSIP welds = 201 and IHSI welds = 63
- 127 of 264 (48%) welds with Alloy 182 have not been examined with a Supplement 10 examination method

As summarized in Table 5-3, as of February 2009, only 12 of 35 plants have additional Category C Supplement 10 examinations to perform on their Alloy 182 welds. The inspection guidelines for the welds in Table 5-3 are discussed in Section 9.

Table 5-3
Remaining Category C DM Welds to Inspect with an ASME Section XI, Appendix VIII, Supplement 10 Method

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6
ALLOWABLE CIRCUMFERENTIAL FLAWS FOR SERVICE LEVEL D CONDITIONS

In this section, allowable through-wall and 360° part through-wall flaws for faulted conditions are determined for selected nozzles in order to assess available margins. The allowable flaw results are used in the susceptibility ranking methodology, described in Section 8.

Eight nozzles of varying diameters were selected for allowable flaw evaluation. The selected nozzles have Category C DM welds at the nozzle-to-safe end, or nozzle-to-cap, or nozzle-to-flange joints. All eight nozzles have undergone stress improvement processes, and were selected based on easy accessibility of geometric and stress improvement parameters. Five (5) nozzles were selected from the Hope Creek Generating Station and three (3) from the Perry Nuclear Power Station. The selected nozzles were:

- Recirculation Outlet N1 (Perry)
- Recirculation Inlet N2 (Perry)
- Feedwater N4 (Perry)
- Recirculation Inlet N2 (Hope Creek)
- Core Spray N5 (Hope Creek)
- Head Spray N6A (Hope Creek)
- Jet Pump Instrument N8 (Hope Creek)
- Control Rod Drive Return Line N9 (Hope Creek)

6.1 Analytical Method

Allowable flaws were determined using the net section collapse techniques provided in Appendix C of the ASME Code, Section XI [3]. In all cases, flux welds were assumed, and allowable flaws were determined based upon a factor-of-safety that corresponds to Service Level D (Faulted) conditions.

The applicable equations for allowable flaws, based on Appendix C of Reference 3, are:

For $\theta + \beta \leq \pi$:

$$\beta = \frac{1}{2}\left(\pi - \frac{a}{t}\theta - \pi\frac{P_m}{3S_m}\right)$$

$$P_b' = \frac{6S_m}{\pi}\left(2\sin\beta - \frac{a}{t}\sin\theta\right)$$

$$P_b' = Z_1(SF)(P_m + P_b + P_e/SF) - P_m$$

$$Z_1 = 1.30[1 + 0.010(D - 4)]$$

For $\theta + \beta > \pi$:

$$\beta = \frac{\pi}{(2 - \frac{a}{t})}\left(1 - \frac{a}{t} - \frac{P_m}{3S_m}\right)$$

$$P_b' = \frac{6S_m}{\pi}\left(2 - \frac{a}{t}\right)\sin\beta$$

$$P_b' = Z_1(SF)(P_m + P_b + P_e/SF) - P_m$$

$$Z_1 = 1.30[1 + 0.010(D - 4)]$$

where:

a = allowable flaw depth
t = thickness
Θ = flaw length
Pm = primary membrane stress
Pb = primary bending stress
Pe = piping expansion stress
D = nominal pipe size
SF = emergency/faulted safety factor = 1.39
Sm = allowable stress intensity

6.2 Allowable Flaw Sizes

In order to determine the allowable flaw sizes, an iterative process was used. The results of the evaluation are summarized in Table 6-1 for through-wall flaws and in Table 6-2 for 360° part through-wall flaws. For through-wall flaws, the allowable lengths range from [[_____]] TS, as shown in Table 6-1. For 360° part through-wall flaws, the depth-to-thickness ratios range from [[_____]] TS, as shown in Table 6-2.

The results summarized in Table 6-1 and Table 6-2 are used in the IGSCC susceptibility study described in Section 8.

Table 6-1
Allowable Through-Wall Flaws

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Table 6-2
Allowable 360° Part Through-Wall Flaws

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6.3 Conclusions

The results of the of flaw tolerance evaluation for the selected nozzles suggest that, at the DM weld locations, the nozzles possess substantial margin to crack instability for through-wall and 360° part-through-wall flaws.

7 EFFECTIVENESS OF STRESS IMPROVEMENT PROCESSES

This evaluation was performed to assess the effectiveness of two methods of stress improvement processes applied to selected nozzles. As discussed previously in Section 6, the nozzles were of varying diameters, and have been selected based on easy accessibility of geometric and stress improvement parameters. The two methods of stress improvement processes evaluated were the mechanical stress improvement process (MSIP) and the induction heating stress improvement (IHSI) process. Both of these processes are used to mitigate intergranular stress corrosion cracking by inducing compressive stresses on the inner surface of the DM weld.

MSIP is a mechanical process of inducing localized radial contractions in the vicinity of the DM weld in a manner that compressive residual stresses are created at the inner surface of the DM weld region. IHSI relies on generating a temperature gradient between the inside and outside surfaces of the nozzle by heating the outer surface and by controlling water flow through the inside surface, creating compressive residual stresses at the inner surface of the DM weld region.

The eight selected nozzles have been subjected to MSIP. For a comparative study of IHSI effectiveness, two nozzles out of the eight were selected.

The evaluation uses finite element models, including a simulated inside diameter weld repair at the nozzle-to-safe end (or nozzle-to-cap, or nozzle-to-flange) DM weld. The ID weld repair was simulated to provide an unfavorable tensile stress condition (prior to applying the stress improvement process) due to the original fabrication of this weld, per the recommendations of MRP-139 [9]. Normal operating loads and stress improvement residual stress effects were considered. Stress intensity factors as a function of crack depth were calculated for a postulated circumferential flaw at the dissimilar metal weld location.

The results of the analyses were used in the IGSCC susceptibility study described in Section 8.

7.1 Finite Element Models

A typical two-dimensional axisymmetric model used for the evaluation includes a portion of the reactor pressure vessel (RPV), the nozzle, the safe end (where applicable), the cladding in the RPV and nozzle, the Alloy 182 DM weld and butter, the thermal sleeve (if present), the safe end extension (if present), and a portion of the attached piping (or flange, or cap, where applicable). A simulated ID weld repair was included at the DM weld location. Material properties included temperature-dependent elastic properties as well as bilinear elastic-plastic properties for residual stress analysis due to the simulated ID weld repair. Appropriate boundary conditions were applied to the model extremities. An example finite element model is shown in Figure 7-1.

For IHSI evaluations, two nozzles of different diameters and thicknesses were used in the study. A large diameter recirculation outlet nozzle and a medium size recirculation inlet nozzle were selected. For convenience, the finite element models developed in the MSIP evaluation for these nozzles were used. It should be noted that the IHSI study was performed using existing models and did not represent actual cases. The study was included for a qualitative evaluation.

7.2 Stress Analysis

A simulated ID weld repair was first performed, followed by a cooldown to room temperature and a hydrostatic test, followed by operating conditions of pressure and temperature. Stress improvement processes (MSIP or IHSI) were applied at room temperature and zero pressure, followed by operating conditions of pressure and temperature. Stresses due to mechanical piping loads during normal operating conditions were determined separately using elastic analyses.

MSIP was applied as an external pressure until the desired residual radial contraction for each nozzle was obtained using an iterative process.

In applying the IHSI process, the outside surface temperature was fixed and the heat transfer coefficient on the inside surface was varied until the desired through-wall temperature difference (ΔT) was obtained, using the minimum heating times and heated zones recommended in BWRVIP-61 [6]. The input parameters for the IHSI analysis met, or slightly exceeded, the minimum recommended parameters provided in BWRVIP-61. The through-wall temperature differences used were consistent with IHSI data reported for the Hatch, Unit 1 stress improvement program provided in Reference 11 for similar nozzle-to-safe end IHSI applications.

Through-wall stresses were extracted from the residual stress analysis and the mechanical piping loads analysis for calculation of applied stress intensity factors (K).

7.3 Stress Intensity Factor Calculation

Through-wall axial stresses were extracted through the DM weld center location, as shown in Figure 7-2. For stress intensity factor calculations, the fracture mechanics model for a circumferential flaw from the EPRI Ductile Fracture Handbook [10] was used, as shown in Figure 7-3. Stress intensity factors using this flaw model were calculated, and the resulting plots of stress intensity factor versus crack depth are shown in Figure 7-4 through Figure 7-11 for all the selected nozzles subjected to MSIP. Typical stress intensity factors versus crack depth plots for nozzles subjected to IHSI are shown in Figure 7-13 for the inlet nozzle and Figure 7-14 for the outlet nozzle. In all cases, the crack depth was normalized to the wall thickness at the DM weld center.

The results provided in Figure 7-4 through Figure 7-14 were used in Section 8 for the susceptibility study.

7.4 MSIP Sensitivity Study

The Hope Creek N2 nozzle was selected for a sensitivity study in which the circumferential contraction due to the MSIP was evaluated for values of [[________]] TS and [[________]] TS. All other parameters were identical for the two cases. A plot of the stress intensity factor versus crack depth for the two cases is shown in Figure 7-12. The results show that the nozzle with the larger circumferential change of [[________]] TS provides K-values that are more compressive. These results suggest that the depth and magnitude of the compressive residual stress distribution can be designed specifically for each nozzle.

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Figure 7-1
Typical Finite Element Model with ID Weld Repair Detail

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Figure 7-2
Location for Evaluation

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Figure 7-3
Circumferential Flaw Model

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Figure 7-4
Stress Intensity Factor versus Crack Depth due to MSIP, Hope Creek Nozzle N5

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Figure 7-5
Stress Intensity Factor versus Crack Depth due to MSIP, Hope Creek Nozzle N8

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Figure 7-6
Stress Intensity Factor versus Crack Depth due to MSIP, Hope Creek Nozzle N6

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Figure 7-7
Stress Intensity Factor versus Crack Depth due to MSIP, Hope Creek Nozzle N2

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Figure 7-8
Stress Intensity Factor versus Crack Depth due to MSIP, Hope Creek Nozzle N9

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Figure 7-9
Stress Intensity Factor versus Crack Depth due to MSIP, Perry Nozzle N1

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Figure 7-10
Stress Intensity Factor versus Crack Depth due to MSIP, Perry Nozzle N2

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Figure 7-11
Stress Intensity Factor versus Crack Depth due to MSIP, Perry Nozzle N4

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Figure 7-12
MSIP Sensitivity, Stress Intensity Factor versus Crack Depth, Hope Creek Nozzle N2

7.5 Comparative Study of IHSI Effectiveness

Results for the IHSI comparative study considered two nozzle geometries (one recirculation outlet and one recirculation inlet) having appropriate diameters and wall thicknesses typical of these nozzles. The finite element models and method of IHSI application are discussed in Section 7.1 and Section 7.2. Typical plots of the stress intensity factor versus crack depth that were developed for these cases are shown in Figures 7-13 and 7-14.

It is noted that the distribution of the stress intensities developed for assumed circumferential flaws is quite similar regardless of the size of the nozzle or regardless of the wall thickness. Both sizes of nozzles developed favorable conditions on the ID wetted surface that will provide resistance to IGSCC even though an ID weld repair has been assumed.

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Figure 7-13
Comparative Stress Intensity Factor for Inlet Nozzle as Function of Thickness versus Crack Depth Due to IHSI

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Figure 7-14
Comparative Stress Intensity Factor for Outlet Nozzle as Function of Thickness versus Crack Depth Due to IHSI

7.6 Conclusions

The evaluation of the selected nozzles indicates that both stress improvement remedies, MSIP and IHSI, achieve significant benefit, in spite of the assumption of an ID weld repair. The benefits are generally comparable for all nozzle types, with all cases showing similar residual stress benefit (i.e., negative stress intensity factor) at the ID surface. However, for the recirculation outlet nozzles, MSIP showed greater benefit than IHSI in arresting or retarding the growth of an existing crack.

8
SUSCEPTIBILITY RANKING

The analyses results that have been developed in Section 7 for the MSIP and IHSI mitigation processes and the effectiveness with which they impart compressive residual stress distributions for the nozzles are examined in this section. In all cases, an ID weld repair has been assumed for the analyses.

8.1 Susceptibility Ranking Overview

Susceptibility rankings have been developed to allow for inspection of 100% of the IGSCC Category C DM welds by June 2015. As presented in this report, the inspections shall be performed by June 2011, June 2013, and June 2015, as discussed in Section 9.

8.2 Residual Stress Mitigation

The stress mitigation methods evaluated include mechanical stress improvement (MSIP) and induction heating stress improvement (IHSI). The benefits of the MSIP and IHSI remedies have been discussed in Section 7 for typical nozzle-to-safe end configurations evaluated. The results provide a description of the effectiveness of the individual stress remedies, and in all cases have assumed the presence of a circumferential weld repair made from the ID surface. Both MSIP and IHSI are designed to provide residual stress mitigation (compression on the ID of the component and extending into the wall thickness) for the DM weld, butter and weld heat affected zone (HAZ). The details of the processes and the specific geometries of the nozzle configurations are used to estimate magnitudes of the improved (compressive) residual stress distributions including the assumption of an ID weld repair.

As has been discussed in the Section 8.1, it is desired to provide a generic evaluation of nozzles in BWRs for susceptibility to IGSCC for the purposes of establishing reasonable inspection intervals. An overriding consideration for this task is that no single generic set of nozzle conditions exists because each plant is different from the standpoint of design, fabrication, measures implemented for mitigation, water chemistry, and other conditions, (i.e. no two plants are the same). Originally, it was attempted to perform an evaluation of all these parameters by consideration of specific weighting factors for each condition and then to use these factors to establish a susceptibility index. The following conditions were encountered while attempting a susceptibility ranking:

1. Not all nozzles of a given type use the same material combinations
2. Not all nozzles of a given type are configured the same

3. Not all nozzles of a given type are fabricated the same
4. Not all nozzles of a given type have received the same stress mitigation
5. Not all nozzles of a given type used the same parameters to apply stress mitigation for either IHSI or MSIP.
6. Not all nozzles of a given type have the same history of water chemistry quality
7. Not all nozzles of a given type have the same effectiveness of hydrogen water chemistry (HWC) or NMCA water treatment mitigations

It was concluded that any numerical comparison must consider effects of multiple parameters, each of which can be the determining factor for IGSCC. Therefore, the following conservative assumptions are suggested.

1. The austenitic weld metal identified in NUREG 0313 [24] that is considered susceptible to IGSCC is Alloy 182. Consequently, the scope of this program is limited to Category C Alloy 182 welds.
2. All weldments are assumed to have some degree of inner surface smoothing by grinding and thus some degree of cold work – a factor known to be damaging to service lifetime.
3. All nozzle weldments are assumed to have been weld-repaired from the ID at some location around the circumference. This means that high tensile residual stresses will be present and this factor overrides any residual stress estimate for original construction.
4. Evaluation of flaw tolerance for each of the selected nozzles suggests that all of the nozzles evaluated possess a significant resistance to crack instability and this feature does not discriminate among the nozzles selected.
5. Evaluation of the residual stress benefits suggests that both stress improvement remedies for Category C DM welds (IHSI and MSIP) achieve significant benefit and are compressive at the ID surface to address the no-cracked condition. It is noted that if crevices or cracks exist then the MSIP technique is predicted to be more effective than the IHSI due to the increased depth of the compressive residual stress field. Therefore, differences in susceptibility for each selected nozzle configuration, and thus the inspection interval, should be determined by evaluation of the stress improvement applied both for crack initiation and crack propagation. The water chemistry history and the water chemistry mitigation applied (HWC and NMCA), and the specific water flow and/or creviced conditions while quite important in determining whether IGSCC will occur, will not be discriminators using this approach. Thus the resistance of the nozzles to SCC is determined by assessing the effectiveness of the application of a stress improvement remedy. As a result, the thicker nozzle components, such as the recirculation outlet nozzles, will have a similar residual stress benefit on the ID surface for the IHSI and MSIP remedies. However, the benefit in arresting or retarding growth of an existing crack will be greater for the MSIP residual stress treatment.

An evaluation of the stress improvement would then be used to determine inspection interval guidelines solely based upon the effectiveness of that remedy to crack initiation and to crack growth.

8.3 Summary and Conclusions

An examination of the nozzle DM welds in BWRs indicates that for all nozzles other than the recirculation outlet nozzle, the effectiveness of the IHSI and MSIP mitigation measures to crack initiation and to crack growth are similar. Therefore, the following inspection time line is recommended:

- For all nozzles except for recirculation outlet nozzles, it is recommended that the inspection be performed no later than June 2015.
- For the recirculation outlet nozzle DM welds, given the determination provided in Section 7 of this report that the IHSI mitigation is not as effective as the MSIP migration for crack growth, the inspection for these IHSI mitigated welds should be performed no later than June 2013.
- For MSIP mitigated recirculation outlet welds the inspection should be performed no later than June 2015.

9 ACCELERATED INSPECTION PROGRAM GUIDELINES

This section discusses the inspection guidelines for Category C DM Alloy 182 butt welds based on the results of UT reviews described in Section 5 and the susceptibility results described in Section 8. These guidelines apply to those Category C DM welds that have Alloy 182 exposed to the environment and have not received a Supplement 10 examination. These guidelines do not supersede relief requests. The affected welds are summarized in Section 5, Table 5-3.

Category B welds are not included in the program because 1) there is no operating experience which has revealed any relevant indications, and 2) the application of stress improvement processes within 2 cycles of plant operation is likely to reduce or eliminate the possibility for crack initiation and/or the potential for pre-existing IGSCC to propagate within the weld.

Category C weldments made without Alloy 182 weld material (stainless-to-stainless or stainless-to-carbon steel) are also not included in this program. This is based primarily on the fact that the operating experience for austenitic stainless steel weldments has revealed very little evidence of intergranular or interdendritic stress corrosion cracking. These welds are generally high in ferrite and, therefore, are more resistant to intergranular stress corrosion cracking than wrought austenitic stainless steel. Also, these welds are easier to examine due to the materials and locations of flaws being in heat affected zones. The procedures for examination of these locations were qualified prior to the DM welds, and the adequacy of pre-Appendix VIII examinations has been demonstrated. Only one recent case of cracking of a stainless-to-carbon steel weld occurred in a weld in the CRD system at Browns Ferry Unit 2 [21]. However, this cracking is not related to the present DM weld issue that is being addressed in this report.

9.1 Overall Inspection Program

The overall inspection program for Category C DM Alloy 182 butt welds is divided into two broad categories, as follows:

- Inspection by June 2011: These are interim inspections directed to be performed as per BWRVIP letter 2008-293, using the guidelines in Section 9.2. These are Category C DM Alloy 182 butt welds that:
    1. have not been inspected using procedures and personnel qualified according to Supplement 10, as summarized in Section 5, Table 5-3, and
    2. have a reasonable likelihood that existing stress corrosion cracking, if any, could have gone undetected or been incorrectly evaluated.

- Inspection by June 2013 and June 2015: These are inspections of Category C DM Alloy 182 butt welds to be performed based on generic analyses and results of the susceptibility evaluation described in Section 8, and have not been included in the interim inspection program by June 2011. These recommendations are described in Section 9.3.

Scope expansion is discussed in Section 9.4 for indications that are found in the initial population of welds. The purpose of the scope expansion is to ensure that, for those degraded locations, examinations are completed so that any common degradation can be identified.

9.2 Interim Accelerated Inspection Program Guidance

The following sections provide general guidance and factors that should be considered for determining DM welds that should be selected for Supplement 10 examination by June 2011. The number of welds affected by this examination is provided in Section 5, Table 5-3.

9.2.1 Automated UT Examinations

In general, the data generated from examinations conducted using automated UT (including manually encoded data) are reviewable because the information is encoded and stored in a digital format. BWRVIP Letter 2007-367 [19] and EPRI's guideline *Nondestructive Evaluation: Guideline for Conducting Ultrasonic Examinations of Dissimilar Metal Welds* [14] provide guidance on important aspects to consider when reviewing and assessing automated UT data. The reader is strongly encouraged to review these references.

Guidance for the selection of welds that should be examined by June 2011 falls into one of three categories and is discussed as follows:

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Figure 9-1
Example of Poor Probe Contact and/or Data Loss Resulting in Reduced Coverage

9.2.2 Manual UT Examinations

The data generated from examinations conducted using manual UT is very limited and in most cases is not reviewable. EPRI's guideline *Nondestructive Evaluation: Guideline for Conducting Ultrasonic Examinations of Dissimilar Metal Welds* [14] provides guidance for evaluation of manual UT.

Guidance is provided for selection of welds that should be inspected by June 2011:

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The following guidance is considered good practice:

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9.3 Guidance for Inspection After June 2011

The following guidance is provided for those Category C DM Alloy 182 butt welds that have not been inspected in accordance with the Supplement 10 inspection program, and have not been inspected by June 2011.

9.3.1 IHSI Treated Recirculation System Outlet Nozzle

The recirculation system outlet nozzles, for which the IHSI treatment has been applied, and for which all of the Category C DM Alloy 182 butt welds have not been inspected in accordance with the interim Supplement 10 inspection program by June 2011 as described in Section 9.2, shall be inspected no later than June 2013.

9.3.2 MSIP and IHSI Treated Nozzles

All MSIP and IHSI treated Category C DM Alloy 182 butt welds, other than the IHSI treated recirculation system outlet nozzles discussed in Section 9.3.1, that have not been inspected in accordance with the interim Supplement 10 inspection program by June 2011 as described in Section 9.2, shall be inspected no later than June 2015.

9.4 Scope Expansion

Scope expansion for this accelerated program applies only to those Category C DM welds containing Alloy 182 exposed to the BWR environment that have not been inspected with a Supplement 10 method. If all the Category C DM welds containing Alloy 182 exposed to the BWR environment have received a Supplement 10 examination, or are to receive a Supplement 10 examination in the current outage, no further scope expansion for the accelerated examination campaign is required.

If previously undetected planar flaws are detected in any weld as part of this accelerated examination campaign, scope expansion is required as outlined in the following three examples. The utility is expected to document the technical basis for scope expansion and weld selection. Note that if flaws are detected in welds that are scheduled for inspection to meet ASME Code and/or BWRVIP-75-A requirements, the scope expansion criteria of those documents must be followed as applicable.

Examples of scope expansion requirements are provided as follows:

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10
OVERVIEW OF WELD OVERLAY CRITERIA

Weld overlays (WOLs) have been applied successfully to hundreds of BWR pipe welds around the world – some having accumulated more than 20 years of successful service.

WOLs offer an excellent option for both mitigation and repair because of several beneficial characteristics, such as, providing structural reinforcement designed to sustain internal pressure and applied mechanical loads, providing favorable residual stress fields on the inside surface material that is exposed to the reactor environment, as well as the use of a weld filler material that is highly resistant to stress corrosion cracking.

WOLs have been applied preemptively in many cases for mitigation, but also as an effective repair for a defective condition. All WOLs are designed according to specific rules found in Section XI of the ASME Code. The rules also describe acceptance and subsequent in-service inspection requirements and any monitoring that may be required.

The application of WOLs to BWR dissimilar metal weldments is described in detail in Appendix A. This appendix also provides guidance and example relief request documentation.

11
CONCLUSIONS AND RECOMMENDATIONS

Inspection guidelines have been developed in order to prioritize inspection schedules for BWR Category C DM Alloy 182 butt welds subjected to the BWR environment. An inspection approach has been provided for BWR DM welds based upon the results of prior inspections, and the effectiveness of the stress mitigation measure against IGSCC initiation and growth.

This report concludes that IHSI and MSIP are roughly equivalent for treating nozzles not having preexisting defects such as IGSCC. This means that both methods of residual stress reversal are capable of eliminating the significant tensile stresses produced by weld repairs originating from the inner surface. The main objective is to place the wetted surface in some state of compression. It was noted that, in general, the MSIP method appears to generate a deeper compressive residual stress state so that preexisting defects can be mitigated up to depths as great at 60% of the wall thickness. It is noted in NUREG-0313 [24], that because the effectiveness of the stress improvement process is also related to the applied stress on the weldment, mitigation by stress improvement is not recommended for weldments with service stresses over S_m, cracks deeper than 30% of the wall, circumferential cracking longer than 10% of the circumference, and axial cracks of any extent, even though the MSIP is capable of producing compressive residual stresses for much greater depths of the wall thickness. This suggests that MSIP would be preferred over IHSI for nozzles having known or suspected IGSCC cracking, or some type of surface lack of fusion at the DM weld.

Based upon the results of this study, the following inspection guidelines are recommended:

- For those Category DM welds that have Alloy 182 exposed to the environment, have not had a Supplement 10 examination, and meet any of the conditions described in Section 9.2, the interim inspection program shall be completed by June 2011.
- All MSIP and IHSI treated Category C DM Alloy 182 butt welds, other than the IHSI treated recirculation system outlet nozzles, that have not been inspected in accordance with the interim Supplement 10 inspection program by June 2011, shall be inspected no later than June 2015.
- The recirculation system outlet nozzles, for which the IHSI treatment has been applied, and for which all of the Category C DM Alloy 182 butt welds have not been inspected in accordance with the interim Supplement 10 inspection program by June 2011, shall be inspected no later than June 2013.
- If previously undetected planar flaws are detected in any weld as part of this accelerated examination campaign, scope expansion is required as outlined in Section 9.4.

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A
EVALUATION OF ALLOY 82/182 CATEGORY C WELDS OVERVIEW OF WELD OVERLAY CRITERIA

A.1 Background

Dissimilar metal welds (DMWs) are welds that join two different materials using a compatible weld filler material. For example, the carbon or low alloy steel nozzles used in vessels of nuclear pressure equipment are often transitioned into stainless steel piping systems. The link between the two must be carried out either by joining different materials directly, or in many cases, by using a compatible transition piece (safe end) placed between the two components. The safe end material typically is a wrought nickel base material known as Alloy 600 or a stainless steel material that provides the interface between the low alloy steel nozzle and the stainless steel piping components. The weld joining the safe end to the nozzle (and sometimes to the piping) is made with a compatible nickel base filler material such as Alloy 82 for gas tungsten arc welding (GTAW) or Alloy 182 for shielded metal arc welding (SMAW). The SMAW process is also used to butter the end of the nozzle and tie into the nozzle ID cladding. There are multiple reasons for the use of a safe end and buttering, but the principal reason in nuclear power plant equipment is to avoid having to post weld heat treat (PWHT) the field weld between the low alloy steel nozzle and the piping. The use of a safe end facilitates the required PWHT of the nozzle and vessel shop welds, but avoids sensitizing the abutting end of the stainless steel piping. This sequence avoids one of the basic driving forces for stress corrosion cracking.

The weld overlay (WOL) was conceived and first applied in 1982 to repair intergranular stress corrosion cracking (IGSCC) in a stainless steel piping weld. The purpose of initial repair was to provide a new pressure boundary, essentially replacing the defective component in the area of the defect. The WOL repair technique for IGSCC flawed pipe welds was based upon application of weld metal to the outside pipe surface over and to either side of the flawed location, extending 360° circumferentially around the pipe. Although these repairs were accepted by the U.S. NRC as an effective IGSCC remedy, the initial regulatory position only recognized weld overlays as interim repair measures. Utilities were allowed to operate with weld overlay repairs so that they could develop and adequately plan for replacement.

After the initial applications of WOLs, significant field, analytical, and experimental evidence was assembled that clearly demonstrated WOLs to be effective long-term repairs. The technical basis includes:

1. weld metals used for weld overlay applications are inherently resistant to IGSCC [1 through 3],

2. weld overlays applied to a flawed component introduce a favorable compressive residual stress field beginning on the inner (wetted) surface [4, 5, 6],

3. advances in ultrasonic examination technology facilitated volumetric inspection of the weld overlay repaired components [7],

4. experimental work demonstrated the strength of weld overlays [8, 9].

The U.S. NRC recognized the value of the WOL option in NUREG-0313, Revision 2 [13]. Weld overlays have been applied successfully to hundreds of BWR pipe welds around the world – some having accumulated more than 25 years of successful service. The difference between the overlays discussed in NUREG-0313, Revision 2 and DMW overlays is that the Alloy 600 and the matching nickel base welds require nickel base fillers instead of the stainless steel fillers typically used over the stainless steel butt welds. Dilution of a stainless steel weld puddle with the nickel base substrate material will result in extensive hot cracking of the deposit. Therefore, nickel base filler materials are necessary for the WOLs placed over DMWs. Originally, for BWRs, Alloy 82 was used as the WOL filler, as it was identified in NUREG-0313, Revision 2 as an IGSCC resistant material. Recently, nickel base fillers having a nominal 30% Cr (approximately 10% greater than Alloy 82) have become used widely because of their excellent resistance to stress corrosion cracking in both the BWR and the PWR environments. This filler material is known as Alloy 52 (ERNiCrFe7), and the improved version formulated for oxide control is designated Alloy 52M (ERNiCrFe7A). Research has shown that recovery of Cr in the initial layer of as much as 20% is sufficient to resist IGSCC in the oxygenated BWR environment, and this level is easily achieved in all positions with current WOL technology using machine GTAW processes.

WOLs offer an excellent option for both mitigation and repair because more than one beneficial characteristic is provided:

- Structural reinforcement designed to sustain internal pressure and applied mechanical loads.
- Favorable residual stress fields are developed on the inside surface material that is exposed to the reactor coolant environment.
- Weld filler material applied is highly resistant to stress corrosion cracking.

Therefore, a "belt and suspenders" approach is achieved with the WOL. The ASME Code bodies and the U.S. NRC have recognized these benefits and have provided rules for implementation in Section XI of the ASME Code. These rules are studied over time and approved generically by the U.S. NRC via Regulatory Guide 1.147 (current revision). Specific implementations involving features not yet generically approved are evaluated via the relief request process provided through 10CFR50.55a(a)(3)(i) for specific requirements not yet approved generically by the U.S. NRC in Regulatory Guide 1.147 (current revision).

WOLs have been applied preemptively in many cases for mitigation, but also as an effective repair for a defective condition. One example is a condition having an indication of a size that is considered unacceptable by Section XI evaluation rules. All WOLs are designed according to specific rules found in Section XI of the ASME Code. The rules also describe acceptance and subsequent in-service inspection requirements and any monitoring that may be required.

This report describes the application of WOLs to BWR dissimilar metal weldments.

A.2 General Requirements and Applicable Technology

The rules for evaluating flaw indications are found in ASME Code, Section XI (IWB-3000 for Class 1 components). Should repairs be necessary based on the evaluation, they would be performed in accordance with the Section XI repair rules provided in IWA-4000. Weld overlays applied using the nominal 30% chromium filler materials (Alloy 52M solid bare wire for GTAW and Alloy 152 coated electrodes for SMAW) have become the method of choice for mitigation and repair of dissimilar metal welds in nuclear service [10].

The Section XI nuclear code case used for overlay repairs is N-504 (current revision is N-504-3 in Regulatory Guide 1.147). This code case was originally developed for overlaying butt welds joining stainless steel components in the BWR systems to mitigate IGSCC. Code Case N-504 has been specifically designed for such purposes, and describes the required materials, analyses, and examinations required for that purpose. Later it became necessary to repair dissimilar metal welds joining stainless steels or nickel base materials to ferritic carbon or low alloy steel nozzle materials. The ferritic materials required a post weld heat treatment (PWHT) to meet fabrication requirements of the Section III construction code. The application of PWHT necessitated draining the component to achieve PWHT temperatures. Draining is highly undesirable for many reasons related to worker exposure, component distortions and material sensitization. Therefore, an alternative temperbead technique was developed in lieu of the PWHT. This technique is currently incorporated into Section XI, Subsection IWA-4400 of the ASME Code. These rules were developed for the use of a manual shielded metal arc welding process that proved cumbersome, time consuming and inconsistent with ALARA principles.

Subsequently, Code Case N-432 was developed to substitute a machine GTAW process for the SMAW process. Elevated temperature preheat and post weld hydrogen bake-out techniques were continued in the new code case, the same as had been required by the earlier IWA-4400 temperbead technique. The ASME Code, Section XI Working Group on Welding and Special Processes recognized the need for use of automatic or machine welding and developed an improved temperbead welding method. This method, incorporated into a new code case identified as N-638, allows machine GTAW for similar and dissimilar metal welding of ferritic substrates. The code case was underpinned with a detailed white paper provided by EPRI that clearly demonstrated that elevated preheat was not necessary for the P-1 and P-3 materials [11]. The report further demonstrated that the machine GTAW process could be controlled to provide very effective tempering of the ferritic weld heat affected zones. In addition, the process produced inherently low levels of diffusible hydrogen such that the hydrogen control preheat measures required by the IWA-4400 method were unnecessary because they provided no additional measure of protection from hydrogen cracking. Code Case N-606 was also developed as a special application to address BWR CRD nozzles based upon the same technical considerations. The result was that Code Case N-638 permitted temperbead welding at ambient temperatures (no preheat) as an alternative to PWHT. Code Case N-638 has been revised four times, primarily to clarify the examination requirements and to increase the area of temperbead application to 500 in^2 – all based on specific EPRI research to fully justify these actions [14].

In recent years the technique has been applied to both BWR and PWR dissimilar metal welds to repair or mitigate IGSCC and primary water stress corrosion (PWSCC). As discussed earlier, the metallurgical compatibility of the stainless steel overlay deposit used for the stainless steel to stainless steel butt welds is not appropriate for overlay of nickel base dissimilar metal welds. In these cases a nickel base filler material such as the 30% Cr alloy filler Alloy 52 is required. This filler material has evolved over the past several years to improve weldability while continuing the important 30% Cr in the composition. The current version of this filler material is Alloy 52M(S) that improves the original formulation of the filler wire to minimize oxide floaters and facilitate a cleaner molten weld puddle. Implementation required relief from earlier rules and also provided the new Alloy 52 and Alloy 52M materials groupings for acceptable welding consumables.

The implementing relief requests that utilities have recently submitted to U.S. NRC have been based on one revision or another of Code Cases N-638 and N-504. Because these cases were originally intended for stainless steel overlays, several modifications are required to use them with the nickel base alloys for dissimilar metal weld overlays. The need for the U.S. NRC to specifically review each relief request individually in a timely fashion is a challenge for the regulators, and therefore the industry was encouraged to consolidate requirements into a single code case that provided all the features being requested on an individual basis. The result was nuclear Code Case N-740 (latest version approved by the ASME Code is Code Case N-740-2) that provides a single set of rules to design, qualify, implement and examine these overlays applied using ambient temperature temperbead welding. The code case addresses austenitic filler materials (both stainless steel and nickel base) for overlays having up to 500 in^2 deposited as temperbead, and includes a 48 hour hold time beginning after the third temperbead layer has been completed before examinations are begun. The machine GTAW process controls and requirements are also specified. The U.S. NRC Staff participates in the development of most of the new requirements; however, a Code Relief Request or Request for Alternative is required for each new application. The U.S. NRC Staff encourages detailed reference to prior relief requests or requests for alternatives that have already been reviewed to facilitate and accelerate regulatory review. The most recent DMW overlays have been based on the features embodied in Code Case N-740-2.

It is noted that the U.S. NRC has not at this time endorsed any version of Code Case N-740, but has approved relief requests having most of the features addressed therein. There are several open issues that still remain a concern to the regulators. These concerns are related primarily to definitions of material thickness used to determine whether PWHT is required for P1 plain carbon steel substrates, and thus, the need for ambient temperature temperbead controls. Second, the definition of a threshold for unacceptable material exposure to neutron irradiation is still being discussed. It should be noted that Code Case N-740 does not include provisions for the optimized weld overlay (OWOL) described in MRP-169. The optimized WOL is a thinner preemptive mitigation overlay having special design and inspection requirements. The need for OWOL rules will result in a new code case (currently under development) that will be designated Code Case N-754. This new case mirrors the latest Code Case N-740 revision, but addresses the design and examination of a thinner optimized overlay that can be applied as a preemptive mitigation or repair measure.

Automated GTAW using Alloy 52M is the welding method of choice for depositing the high quality structural overlays required for nuclear piping systems. A large number of successful overlays have been in service for many years. Considerable effort has been expended by utilities, service providers and EPRI in attempting to optimize the chemistry of filler materials and the welding parameters required to successfully overlay a variety of substrate materials. While great improvements in weldability have been achieved, Alloy 52M is still considered a challenge to weld and care is required to avoid unacceptable indications in the overlay deposit.

Alloy 52 and Alloy 52M weld filler materials are very sensitive to the welding process and require close control of demonstrated welding variables for satisfactory application. Both essential and nonessential variables for the welding procedure (defined in ASME Code, Section IX) must be carefully defined and controlled to address important issues of weld dilution, molten weld puddle management, heat input, tempering requirements, etc.

It is very important that the design of the overlay be completed by a knowledgeable organization having the capabilities and experience to evaluate the existing conditions so that the overlay can be designed to meet ASME Code and regulatory requirements. The same critical importance is assigned to the organization performing the nondestructive examination (NDE) for pre-service and in-service requirements.

Post overlay examination requirements include the weld overlay itself, plus the outer 25% of the original pipe wall thickness. This examination requirement applies to full structural weld overlays (FSWOLs), which use, as their design basis, a crack completely through the original pipe wall thickness. The 25% of original pipe wall thickness examination requirement is seen as providing added margin by verifying the arrest of an existing flaw and advanced warning in the unlikely case that the crack is not arrested before propagating into the WOL. In the special case of optimized weld overlays (OWOLs), a flaw would violate the design basis if it extended into the outer 25% of the pipe wall. Thus, the examination must provide additional coverage to preserve a similar "advanced warning" examination volume required by the FSWOL. Thus, since the OWOL design basis flaw is 75% of the original pipe wall, then the post-WOL examination (and subsequent inservice inspections) must cover the WOL material plus the outer 50% of the original wall thickness in the PWSCC susceptible material.

ASME Code, Section XI, 1995 Edition, and later, includes NRC accepted rules for inspection of welds in piping that require the procedures, equipment, and personnel to be qualified by a performance demonstration in accordance with Appendix VIII, Supplement 11. The utilities sponsored a performance demonstration initiative (PDI), implemented at the EPRI NDE Center, which satisfies these requirements, as amended for weld overlay repairs, and a number of organizations have successfully qualified personnel and techniques to inspect weld overlays under that program. Therefore, as has been the case for FSWOL repairs, ASME Section XI, Appendix VIII, Supplement 11 is currently in the process of being implemented for OWOLs. The overlay design, including surface preparation specifications, must be reviewed to confirm that an examination of the OWOL can be performed in accordance with the PDI qualification requirements. Phased array UT has proven to be an effective tool for examination of the weld overlay and underlying base metal.

The design of the full structural weld overlay repair provides sufficient reinforcement to the DM weld such that all structural design requirements are still met with full circumferential through-wall cracks in the weld. Overlay length and thickness are key parameters for achieving favorable compressive residual stress estimates on the inner surface. These analyses assure conservative estimates by assuming a previous hypothetical weld repair from the inner surface. In addition, end of life crack growth estimates from both fatigue and stress corrosion are evaluated.

The length of the overlay design also must be sufficiently long to meet requirements providing for effective inspection coverage of any welds located underneath the overlay. In some instances, the design length is increased to meet this requirement. In many cases, the inspection coverage is improved after the overlay is applied, and especially when the phased array UT technology is to be applied.

Some of the critical issues important for both design and implementation that must be addressed prior to and during the overlay process are discussed below.

A.2.1 Parent Material

The base composition of the parent material including impurity levels is an important consideration for quality welding. ASME Code, Section IX identifies the requirements necessary to qualify a welding procedure. In addition, the Code recognizes that it is acceptable to group similar materials and welding consumables such that one qualified procedure would cover that grouping. Therefore, such groupings establish the need for procedure qualification and whether preheat or PWHT would be required. The material condition of cast or wrought is an important consideration with regard to impurity content, level of segregation, and inspectability due to grain size. It is essential that the original certified mill test reports be available to evaluate weldability. In some cases a physical welding test is appropriate to make the evaluation.

The nickel base filler materials, and in particular Alloys 52M and 152, are very sensitive to low levels of sulfur, phosphorus, silicon and low melting point materials such as tin and lead. All austenitic filler materials are susceptible to impurity driven solidification cracking to varying degrees, but Alloys 52M or 152 tend to be in the highly sensitive category. As a result, careful consideration of weld dilution is required to make crack free welds. Dilution of the molten weld puddle with the parent material containing or contaminated with quantities of these elements at the high end of the permissible limits for the base material likely will result in solidification cracking of the weld during cooling [12]. Welding parameters can be varied to control the percentage dilution from the base material through use of a control parameter known as the Power Ratio. Numerically the Power Ratio is computed according to the following formula.

$$\text{Power ratio} = \frac{\text{Amperage} \times \text{Voltage}}{\left[\dfrac{\text{Wire-feed speed}}{\text{Travel speed}} \times \begin{array}{c}\text{Cross-sectional}\\ \text{area of filler}\end{array}\right]}$$

Power Ratio is computed from current, voltage, travel speed and wire feed speed. This control is needed because the wire feed is independent of welding power in the GTAW process. Without controlling the combination of these parameters, one cannot control dilution.

In essence, Power Ratio partitions the base metal melted versus the weld filler wire added for a given molten weld puddle. Weld dilution is a function of Power Ratio for any given combination of welding materials and conditions. By operating at a low Power Ratio, the weld dilution will be low. A high Power Ratio produces higher dilution and the variation is significant. Therefore, weld overlays of nickel base fillers, such as Alloy 52M, placed over stainless steel substrates should have a Power Ratio as low as practical within the boundaries of the weld procedure qualification. If the weld impurities are significant, a buffer layer may be needed to counter the high impurity levels. The buffer layer would be deposited with a material more tolerant to impurity elements (primarily sulfur and phosphorus). Typically ER308L or ER309L filler materials are used for this purpose because they are known to resist solidification cracking due to impurities. The buffer layer material is selected to have low sulfur and phosphorus content so as to provide a buffer on which the Alloy 52/52M overlay material can be deposited without cracking. Care must be taken with the tie-in to the crown of the DMW, because the iron dilution into the nickel base DMW will also result in solidification cracking. From a practical standpoint, the buffer layer is stopped just short of the DMW fusion line and a bridge bead(s) applied to make the tie-in using a compatible filler material. Alloy 52M has been used for this purpose; however recent applications have found that Alloy 82 is more tolerant to the impurity content and most vendors are using this filler material for the bridge bead(s).

It is essential that the parent material be free of surface contamination such as oil, grease, paint, moisture or other contaminants that might decompose under the heat of welding to generate nascent hydrogen. Hydrogen can be absorbed into the molten weld and weld heat affected zone of P-1 and P-3 materials creating a potential for delayed hydrogen cracking in these regions. The code cases used for welding address this issue by requiring a 48 hour delay prior to surface and volumetric examinations that will detect this type of cracking. The temperbead technique reduces the susceptibility to this type of damage. The tempering effect has been accomplished by the completion of the third temperbead layer (third layer of the overlay deposit), and a hold time of 48 hours is initiated before inspection is begun. Code Case N-740 has addressed this aspect of the WOL implementation. This improvement greatly reduces the span time for the overlay examination.

Thick oxides on the surface of the parent material will also affect the quality of the final deposit. The GTAW process is not designed to accommodate the oxides that will melt or distribute over the molten weld puddle, and can cause fusion, trapped oxide, and porosity defects. It is essential that the surface be cleaned to bright metal by grinding or other aggressive cleaning methods.

A.2.2 Filler Material

As noted above, the filler material has been improved to reduce its susceptibility to various problems, such as hot cracking, ductility dip cracking and oxide floaters that can lead to fusion defects in the deposited weld [10, 12]. The material must be purchased to meet the requirements of the applicable edition and addenda of the construction code and ASME Code, Section II, Part C. The current generation of filler materials (Alloy 52M for GTAW since 2006) is relatively consistent for low restraint applications such as overlays; however, it does exhibit some heat-to-heat variability that must be understood and accommodated by adjusting the welding machine variables. This accommodation requires that the service supplier test and develop experience with each heat of filler material to verify that it is weldable using his equipment and process. Various suppliers have developed different tests that will give an indication of the acceptability of a heat of material.

A.2.3 Process Validation

Acceptance of the heat of filler material is only a preliminary indication of the ability to make a sound weld. Prior to field implementation, an engineering mockup simulating the field conditions, including equipment, weld parameters, operator, configuration, cleaning and access restrictions, must be examined and evaluated as the field weld will be examined and evaluated. It is essential that the testing include NDE identical to that to be used for examination of the field welds. Orientation of the weld (2G, 5G, 6G, etc.) and weld progression (double up or orbital) are key variables. Generally, it has been shown that double up progression is less likely to result in defects in the overlay. The reason is that the nickel base filler is sluggish (viscous) and tends to roll over when welding with a downhill progression—a characteristic that promotes oxide entrapment. An engineering mockup should be designed to accurately simulate the condition that will be encountered in the field so that acceptable weld quality can be demonstrated. In addition, the mockup is valuable to demonstrate the acceptable level of Cr recovery achieved in the first overlay layer. Anything less is considered a buffer layer.

The mockup should be witnessed by knowledgeable utility representatives for comparison to field conditions. The importance of consistent application of welding good practices cannot be overemphasized. In addition to verification of the process parameters by visual observation, all documentation of process qualification and process control must be reviewed and validated by the utility representatives.

A.2.4 Field Implementation

If the mockup and documentation have been thoroughly and completely reviewed for appropriate representation of the field conditions, then implementation consists of assuring that the pre-approved plan is followed. It is essential that everyone who can affect weld quality be fully trained not only on the specific application of the equipment and processes, but also on the importance of each of the variables. They must be committed to following the plan and be empowered to stop work whenever they feel conditions warrant.

Welding equipment continues to evolve in the direction of improved programmability and more precise control of voltage, amperage, travel, wire feed and other critical parameters. Processes using higher deposition GTAW are being evaluated and implemented for overlay applications. In addition, the use of other high deposition processes such as hot wire GTAW, dual wire GTAW, plasma welding, and gas metal arc welding (GMAW) may become the future processes of choice for overlay applications because of improved deposition rates. It is noted that increased deposition rates are beneficial provided the larger molten puddles are physically manageable without introducing unacceptable defects, and that the other application features of a WOL are maintained, such as appropriate tempering of weld heat affected zones.

A.3 Recent Relief Requests and Requests for Additional Information

Relief requests for dissimilar metal weld overlays are quite similar for BWR and PWR applications. Generally, the request is technically a request for alternative pursuant to 10CFR50.55a(a)(3)(i), which states that proposed alternatives may be used when authorized by the Director of the Office of Nuclear Reactor Regulation, provided that the proposed alternatives provide an acceptable level of quality and safety. If the alternative includes use of an ASME code case, the case should be listed in Regulatory Guide 1.147 as follows:

The code cases addressed by this regulatory guide are listed in five tables:

1. Table 1, "Acceptable Section XI Code Cases," lists the code cases that are acceptable to the U.S. NRC for implementation in the Inservice Inspection (ISI) of light-water-cooled nuclear power plants.

2. Table 2, "Conditionally Acceptable Section XI Code Cases," lists the code cases that are acceptable, provided that they are used with the identified limitations or modifications (i.e., the code case is generally acceptable but the U.S. NRC has determined that the alternative requirements must be supplemented in order to provide an acceptable level of quality and safety).

3. Table 3, "Annulled Unconditionally Approved Section XI Code Cases," lists code cases annulled by the ASME that the U.S. NRC previously determined to be fully acceptable.

4. Table 4, "Annulled Conditionally Acceptable Section XI Code Cases," lists code cases that the U.S. NRC determined to be acceptable, provided that they were used with the identified limitations or modifications, but were subsequently annulled by the ASME.

5. Table 5, "Section XI Code Cases That Have Been Superseded by Revised Code Cases," lists code cases that have been superseded through revision. Code cases that the U.S. NRC determined to be unacceptable are listed in Regulatory Guide 1.193, "ASME Code Cases Not Approved for Use".

If the code case is not approved or conditionally approved by the U.S. NRC, then the parts that will be used must be copied into and justified in the relief request. There have been a number of recent requests to permit the use of Alloy 52/52M for temperbead welding over the ferritic portion of the dissimilar metal weld joint. Concurrent with this action, relief to use the PDI implementation of Supplement 11 to Appendix VIII of ASME Code, Section XI is requested. Once accepted by the U.S. NRC, relief requests become public records and can be found in the Agencywide Document Access and Management System (ADAMS) database of the U.S. NRC reading room at http://www.nrc.gov/reading-rm.html. The latest issuance of Regulatory Guide 1.147 is likewise found on this site.

Some typical examples that elicited Requests for Additional Information (RAIs) are offered below.

A.3.1 Recent PWR Relief Request Summaries

June 1, 2007, ADAMS Accession No. ML071550420
Virgil C. Summer Nuclear Station (VCSNS)
Request To Use Alternatives to ASME Code, Section XI Requirements For Application Of Weld Overlay Repairs (RR-III-05)

This relief request, based on Code Case N-740 and covering multiple welds, resulted in only a few RAIs. The most notable one is the request to specify the material for the buffer layer material and address the ferrite content of the buffer layer. This particular RAI has appeared in other relief requests, so the utility is advised to pay particular attention to explaining why a buffer layer is needed, how it differs from a structural overlay, and why the ferrite need not be controlled as in a structural stainless steel overlay.

September 28, 2007, ADAMS Accession No. ML073190511
FirstEnergy Nuclear Operating Company Davis-Besse Nuclear Power Station Third 10-Year Interval Request RR-A30, Revision 2

This relief request, based on Code Case N-740, resulted in a number of requests for additional information. The issues were primarily related to lack of detail in the relief request. The RAIs also point out the need for careful handling of code cases that have not yet been approved by the U.S. NRC. While an unapproved code case may be referenced as source material, the requirements of the code case must be duplicated into the relief request and justified on their technical merits.

March 21, 2007, ADAMS Accession No. ML070860369
Request for Alternative ANO2-R&R-005, Request for Proposed Alternative to ASME Code Requirements for Weld Overlay Repairs

Based on Code Case N-740, this request covers several carbon steel to stainless steel transition welds on the hot leg. As noted in several other relief requests, the duration of the request was not clearly stated so there was an RAI on this topic. This unit also has cast stainless steel safe ends which, at this time, cannot be ultrasonically inspected with a qualified procedure. The U.S. NRC required the utility to further explain the inspection plan for these safe ends. The last RAI dealt with issues associated with the stainless steel buffer layer. As noted in other relief requests, separating this buffer layer from the concept that it is a structural weld overlay is essential.

A.3.2 Compilation of Recent BWR Relief Requests, RAIs and Safety Evaluation Reports

December 2004
Section A.7:

- Hope Creek HC-RR-12-W01 for N2K Recirculation Inlet Nozzle
- RAI Responses for HC-RR-12-W01
- SER for HC-RR-12-W01

October 2007
Section A.8:

- Hope Creek HC-RR-12-W02 for N2A Recirculation Inlet Nozzle
- RAI Responses for HC-RR-12-W02
- SER for HC-RR-12-W02

February 2007
Section A.9:

- Duane Arnold Relief Request for N2C and N2F Recirculation Inlet Nozzles
- First RAI Response for Duane Arnold N2C and N2F
- Second RAI Response for Duane Arnold N2C and N2F
- SER for Duane Arnold N2C and N2F

April 2007
Section A.10:

- Pilgrim PRR-15, Rev. 1 & RAIs for Six RPV Nozzle Overlays (N2 and N9)
- SER for Pilgrim PRR-15
- Pilgrim LER for N2K Nozzle

March 2005
Section A.11:

- Pilgrim PRR-39, Rev. 2 for a Number of Overlays in Various Locations
- Pilgrim PRR-39, Rev. 1 & RAIs
- SER for Pilgrim PRR-39

February 2008
Section A.12:

- Hatch Relief Request For Overlay of Capped CRD Nozzle N9
- RAI Response for Hatch Relief Request For Overlay of Capped CRD Nozzle

October 2008
Section A.13:

- Fitzpatrick Relief Request for Overlay of N-2C" Nozzle Dissimilar Metal Weld including RAI response

A.4 Relief Requests Referencing Nuclear Code Case N-740

It has been noted above that the U.S. NRC does not have an internal mechanism for reviewing relief requests based on code cases that have not received generic approval by the Commission. As a result there is no straightforward mechanism whereby relief requests may be based on Code Case N-740 even though it was developed specifically to include all of the key features for weld overlays using temperbead welding rules that are embodied in a combination of N-504-3 and N-638-1 (the latest versions approved in Regulation Guide 1.147 Revision 15). What has been done is to identify N-740 (or soon to be published N-740-2) so that the methodology of the new code case can be identified. Normally a table is prepared to compare the N-740 code case features with N-504-3 and N-638-1. Entergy has applied this approach for their last 6 relief requests (5 PWR and 1 BWR). The BWR relief request for Fitzpatrick is provided in Appendix G and the PWR relief request example of VC Summer is provided in Appendix H. It is noted that the Fitzpatrick final SER has not been issued at this time.

A.5 General Considerations for Preparation of Relief Requests

It is highly desirable to have the overlay design near complete prior to submitting the relief request. Quite often the U.S. NRC reviewer will require design information prior to completing his review. If possible, the relief request should be submitted early enough to meet the U.S. NRC guidelines for required review time. If early submittal is not possible, the U.S. NRC is usually amenable to negotiating a verbal approval to meet the utility needs. It is essential that the details be covered in the body of the relief request. Review of other utility relief requests for similar components along with the RAIs for the relief request is a recommended practice. Following is a list of the sections of a typical relief request associated with a preemptive or repair weld overlay.

I. COMPONENTS

A detailed description of each component including:

- Size (ID, OD, thickness),
- Material of construction including the code description of the material
- Code class of the component.

II. CODE REQUIREMENTS

- Construction code for the component (note that this can vary for different parts of the system and may have been updated since the unit went into service)
- ISI Code for the current interval

Note: Section II includes Code requirements for current operation. Code requirements for the proposed alternative should be included as references.

III. PROPOSED ALTERNATIVE

A. Background

Background may be included as an introduction to the proposed alternative. If it is included as a separate section, it will generally consist of a history of the component leading up to the need for a repair and a repair alternative. That is, it will conclude with a paragraph indicating that the current codes listed in Section II do not contain the appropriate rules for the required repair or preemptive mitigation.

B. Proposed Alternative

In general code cases referenced in this section will not have been approved by the U.S. NRC (not listed as approved in Regulatory Guide 1.147), thus the requirements of the code cases will be duplicated into the relief request. As noted in the example relief requests above, it is essential that all details be covered within the body of the relief request or as attachments to the main document. The content of this section should be limited to "what we will do" statements; why the proposed alternative is acceptable is covered in the next section.

IV. BASIS FOR PROPOSED ALTERNATIVE

Justification for using the alternative methods is detailed in this section along with technical references supporting the conclusions. Each of the deviations from the codes governing current operation must be explained.

V. CONCLUSION

Usually this simply reiterates the statement that the proposed alternative meets the 10CFR50.55a(a)(3)(i) requirement to provide an acceptable level of quality and safety.

VI. DURATION

Duration relates to the relief request, not the repair. Most repairs or mitigations are intended to remain in place for the life of the plant. The U.S. NRC will generally approve a relief request to be applicable only for the current inspection interval. The rationale is that inspection requirements may change when a new version of ASME Code, Section XI becomes the controlling document for ISI.

VII. REFERENCES

Technical references supporting the use of the alternative, as well as code edition and addenda, and code cases that will apply to the alternative, are included here. The code of construction and current ISI code need not be referenced again in this section as they are already defined in Section II discussed previously.

A.6 References for Appendix A

1. EPRI Document NP-5881-LD, "Assessment of Remedies for Degraded Piping," June 1988.
2. ANL Document NUREG/CR-4667, "Environmentally Assisted Cracking in Light Water Reactors: Semiannual Report – October 1985 – March 1986," Volume II.
3. ANL Document NUREG/CR-4667, "Environmentally Assisted Cracking in Light Water Reactors: Semiannual Report – April – September 1986," Volume III.
4. Structural Integrity Associates Report SIS-88-002, Revision 0, "Technical Requirements for the Application of Weld Overlay Repairs," July 1988.
5. J. Park, D. Kupperman, and W. Shack, "Examination of Overlay Pipe Weldments Removed from Hatch-2 Reactor," Argonne National Laboratory, September 1984, presented at the 8th International Conference on Structural Mechanics in Reactor Technology, Brussels, Belgium, August 19-23, 1985.
6. Structural Integrity Associates Report SIR-84-030, Revision 0, "Extended Lifetime Test Program for Weld Overlays at Hatch Unit 1," September 1984.
7. EPRI Document IR-2005-84, "A Summary of Technical Information Related To The Application, and Ultrasonic Examination of Weld-Overlaid Components," Internal Report August 2005.
8. Battelle Memorial Institute Document NUREG/CR-4877, "Assessment of Design Basis for Load-Carrying Capacity of Weld Overlay Repairs," April 1987.
9. Battelle Memorial Institute Document NUREG/CR-4082, Vol 3, "Degraded Piping Program, Phase 2 – Semiannual Report, April 1985 – September 1985," NUREG/CR-4082, Vol. 3, September 1985.
10. *Overlay Handbook:* Part 1: Welding Procedures, EPRI, Palo Alto, CA, 2007, TR-1014554.
11. EPRI Report GC-111050, "Ambient Temperature Preheat for Machine GTAW Temperbead Applications," November 1998.
12. R. E. Smith, et al, "Effectiveness of Stainless Steel Buffer Layer to Address Hot Cracking During Weld Overlay Repair of Dissimilar Metal Alloy 82/182 Welds with Stainless Steel Piping," Proceedings of PVP2008, 2008 ASME Pressure Vessels and Piping Division Conference, July 27-31, 2008 Chicago, IL.
13. "Technical Report on Material Selection and Processing Guidelines for BWR Coolant Pressure Boundary Piping", NUREG-0313, Revision 2, January 1988, and its implementing Generic Letter 88-01, "NRC Position on IGSCC of Austenitic Piping", January 25, 1988.
14. EPRI Report: "RRAC Code Justification for the Removal of the 100 Square Inch Temper Bead Weld Repair Limitation", 1011898, 2005.

A.7 Hope Creek Nozzle N2K (RR, RAI, and SER)

PSEG Nuclear LLC
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DEC 0 1 2004

LR-N04-0533

PSEG
Nuclear LLC

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

RELIEF REQUEST HC-RR-I2-W01
PROPOSED ALTERNATIVE REPAIR METHOD
HOPE CREEK GENERATING STATION
FACILITY OPERATING LICENSE NO. NPF-57
DOCKET NO. 50-354

In accordance with 10 CFR 50.55a, Codes and Standards, paragraph (a)(3)(i), PSEG Nuclear LLC (PSEG) is submitting a proposed alternative to the requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI, Rules for Inservice Inspection of Nuclear Power Plant Components. This proposed alternative would permit the use of a full structural weld overlay repair for an indication identified in the N2K recirculation inlet nozzle safe-end to nozzle weld joint.

The Hope Creek Unit 1 Second Ten-Year Interval Inservice Inspection (ISI) Program complies with the requirements of the ASME Code Section XI, 1998 Edition, including Addenda through 2000. The second 10-year interval began at the end of Refueling Outage, RFO7 in November 1997 and is projected to end May 2006 (RFO13).

Due to the need to obtain approval of this alternative prior to startup of the unit from the current outage, we are requesting your review and approval prior to Operational Condition 2, which is currently scheduled to occur on December 24, 2004.

No new commitments are identified in this letter. If you have any questions or require additional information, please contact Mr. Michael Mosier at (856) 339-5434.

Sincerely,

Christina L. Perino
Director – Licensing and Nuclear Safety

Enclosure - Overview
Attachment - Relief Request HC-RR-I2-W01

A047

95-2168 REV. 7/99

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LR-N04-0533

DEC 0 1 2004

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Document Control Desk **Enclosure**
LR-N04-0533

Overview of
Alternative Repair for the N2K Recirculation Inlet Nozzle Safe-end to Nozzle Weld

Introduction

During Refueling Outage (RFO) 12 Inservice Inspection (ISI) ultrasonic examinations (UT), the dissimilar weld metal joint at the N2K recirculation inlet nozzle safe-end to nozzle weld was examined as part of scheduled ISI population. This weld is a Code examination category B-F, Item No. B5.10 weld. The N2K weld was examined during RFO12 in accordance with Generic Letter 88-01, Category 'C', in conjunction with Risk Informed classification RA. This ASME Section II, Part C, SFA-5.14 ERNiCr-3 UNS N06082 (commercially known as Alloy 82) weld connects an approximately 14 inch outside diameter (OD) by 11 inch inside diameter (ID) stainless steel SA-182 Grade F316L safe-end buttered with ASME Section II, Part C, SFA-5.11 ENiCrFe-3, UNS W86182 (commercially known as Alloy 182) to the SA-508 Class 2 low alloy steel nozzle buttered with Alloy 182.

The weld was examined with an ASME Section XI, Appendix VIII qualified, Electric Power Research Institute (EPRI) - Performance Demonstration Initiative (PDI) procedure. The inspection was performed using automated UT with 45° longitudinal waves scanning in the clockwise (CW) and counter-clockwise (CCW) directions, which detected the flaw. As a result of this examination, an axial indication was identified at approximately 90° clockwise (3 o'clock) from top dead center looking into the nozzle and toward the Reactor Vessel (RV). Based on the UT data, the axial indication was classified as an ID connected planar flaw, contained solely within the safe-end to nozzle weld and buttering.

The flaw is believed not to extend through wall as verified by no observed leakage of the entire OD weld surface and adjacent areas. Estimates on indication depth provided from information available from the detection and length sizing examination data indicates that the flaw size estimates would exceed the acceptance criteria stated in IWB-3514-2.

Degradation Mechanism

Even though the apparent cause evaluation has not been completed, experience at the same joint on the core spray nozzle at Hope Creek in 1997 and at other Boiling Water Reactors (BWRs) in the last few years lead one to believe that the cause of the flaw is most likely due to stress corrosion cracking (SCC).

The original Construction Code for the reactor vessel is ASME Section III, 1968 Edition, including Addenda through Summer 1970 and Paragraph NB-3338.2(d)(4) of the Winter 1971 Addenda supersedes Paragraph I-613(d) of the 1968 Edition.

The original Construction Code for the safe-end is ASME Section III, 1977 Edition, including Addenda through Winter 1978.

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LR-N04-0533

Overview of
Alternative Repair for the N2K Recirculation Inlet Nozzle Safe-end to Nozzle Weld

The existing safe-end to nozzle weld is Alloy 82 and connects a stainless steel SA-182 Grade F316L safe-end buttered with Alloy 182, to the SA-508 Class 2 low alloy steel nozzle, also buttered with Alloy 182. A portion of the original Alloy 82/182 safe-end to nozzle weld remains on the nozzle side as a result of installing a modified safe-end with an integrally attached thermal sleeve prior to going into service (see Attachment 1, Figures 1 and 2). The N2K weld underwent Mechanical Stress Improvement Process (MSIP) treatment during RFO8 (1999).

The function of the N2K nozzle is to connect a portion of the recirculation system inlet piping to the reactor vessel (RV).

SCC Mitigation by Weld Overlay Repairs

PSEG Nuclear has decided to mitigate the flaw employing a weld overlay repair using machine gas tungsten arc welding (GTAW) and Alloy 52 weld metal. Weld overlay repairs have been used in the BWR industry since the late 1970s to repair flaws due to SCC, including safe-end to nozzle welds. The experience with weld overlays in the BWR industry has been excellent. It is approved as an effective SCC mitigating technique in USNRC Generic Letter 88-01/ NUREG-0313, Rev. 2.

Although MSIP was performed, as a further preventative measure, implementation of an overlay at the N2K safe-end to nozzle weld will provide further mitigation as discussed below:

1. The overlay is designed as a standard (full structural) overlay per the structural requirements in ASME Code Case N-504-2 using paragraph IWB-3640 of ASME Section XI. In the design of a standard overlay, a 360° degree "through the thickness" circumferential flaw is assumed and, therefore, no credit is taken for any portion of the original pipe wall. Hence, all the weld material, where flaw initiation is believed to have occurred, is essentially assumed to be completely flawed. The full ASME Section XI safety margins are restored after the application of a standard overlay.

2. The application of the overlay results in a favorable residual stress field on the inside of the component, which arrests further flaw growth. This is because the overlay establishes compressive residual stresses on the inner half of the pipe, which prevents further SCC.

3. The nickel based Alloy 52 weld rod / wire (ASME Section II, Part C, SFA-5.14, ERNiCrFe-7, UNS N06052), which is used for the GTAW overlay repair, has been shown to be highly resistant to SCC and has properties comparable to those of austenitic stainless steels. This alloy, containing nominally 30 wt. % chromium, and its corresponding wrought material, Alloy 690, have been

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LR-N04-0533

Overview of
Alternative Repair for the N2K Recirculation Inlet Nozzle Safe-end to Nozzle Weld

demonstrated in laboratory testing, in modeling studies, and in the field, to be highly resistant to SCC initiation and growth in the BWR environment. Alloy 152 electrode (ASME Section II, Part C, SFA-5.11, ENiCrFe-7, UNS W86152, containing the same amount of chromium, may also be utilized for local repairs to the underlying weld metal, if required for unexpected through wall defects.

Similar BWR Experience
The observed flaw at Hope Creek, Unit 1 is consistent with the documented SCC observed at Hope Creek in 1997 on the core spray safe-end to nozzle (N5B) weld. Similar flaws have been observed at other BWRs, including Duane Arnold, Perry, Nine Mile Point 2 and Susquehanna 1.

Document Control Desk **Attachment**
LR-N04-0533

10 CFR 50.55a Relief Request HC-RR-I2-W01

Proposed Alternative In Accordance with 50.55a(a)(3)(i)
-Alternative Provides Acceptable Level of Quality and Safety-

1. ASME Code Components Affected

Code Class:	1
References:	ASME Section XI, 1998 Edition, including and through the 2000 Addenda ASME Section XI, Case N-504-2 ASME Section XI, Case N-638 NUREG-0313 Rev 2 Generic Letter 88-01
Examination Category:	B-F
Item Number:	B5.10
Description:	Alternative Repair for the N2K Recirculation Inlet Nozzle Safe-end to Nozzle Weld
Component Number:	N2K Recirculation Inlet Nozzle

2. Applicable Code Edition and Addenda

The Hope Creek Unit 1 Second Ten-Year Interval Inservice Inspection (ISI) Program complies with the requirements of the ASME Code Section XI, 1998 Edition, including Addenda through 2000. The second ten-year interval began November 1997 and is projected to end May 2006.

3. Applicable Code Requirements

The following information is from ASME Boiler and Pressure Vessel Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," 1998 Edition, including Addenda through 2000, which identifies the specific requirements included in this alternative:

IWA-4421(a) and IWA-4611.1(a) require removal of the detected flaw.

IWA-4610(a) requires that the area to be welded shall be preheated to 300°F minimum for GTAW.

IWA-4610(a) requires that thermocouples (TCs) shall be used to monitor process temperatures.

Document Control Desk **Attachment**
LR-N04-0533

10 CFR 50.55a Relief Request HC-RR-I2-W01

Proposed Alternative In Accordance with 50.55a(a)(3)(i)
-Alternative Provides Acceptable Level of Quality and Safety-

IWA-4631(b) specifies that the surface of the completed weld on the ferritic steel shall not exceed 100 square inches.

IWA-4632(b) specifies the base material and heat affected zone (HAZ) shall meet IWA-4622. IWA-4622 specifies that the average lateral expansion of the three HAZ impact tests shall be equal to or greater than the average of the three base metal tests.

IWA-4633.2(c) specifies that the first six layers of the weld shall be deposited with heat inputs within ±10% of that used in the procedure qualification test. Subsequent layers shall be deposited using heat input equal to or less than that used for layers beyond the sixth in the procedure qualification.

IWA-4633.2(c) also specifies that at least one layer of weld reinforcement shall be deposited and then this reinforcement shall be removed substantially flush with the surface surrounding the weld using mechanical means.

4. Reason for Request

The request is based on restoring the structural integrity of the N2K recirculation inlet nozzle safe-end to nozzle weld joint using technically sound welding practices and non-destructive examination (NDE), while limiting repair personnel exposure to the maximum extent practical. The following cited Code articles identify the actions that would be required if the repair were conducted in accordance with the Code without exception.

IWA-4421(a) and IWA-4611.1(a) require defect removal in this case. The repair cavity would extend through wall since OD removal would be required. ID removal of the indication would be impractical since it would require the removal of the thermal sleeve and jet pump from the reactor interior.

IWA-4610(a) requires the area to be welded shall be preheated to 300°F minimum for GTAW. Since the nozzle will remain full of water, establishing the 300°F minimum preheat temperature cannot be achieved.

IWA-4610(a) also requires the use of TCs to monitor process temperatures. Due to the personnel exposure associated with the installation and removal of the TCs, the nozzle configuration, and since the nozzle will be full of water, a contact pyrometer will be used in lieu of TCs to verify preheat and interpass temperature limits are met.

IWA-4631(b) specifies the surface of the completed weld on the ferritic steel shall not exceed 100 square inches. Restoring the structural integrity of the safe-end to nozzle

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weld with the weld overlay will require welding on more than 100 square inches of surface on the low alloy steel base material.

IWA-4632(b) specifies the base material and HAZ shall meet IWA-4622. IWA-4622 specifies that the average lateral expansion of the three HAZ impact tests shall be equal to or greater than the average of the three base metal tests. The welding procedure qualification supporting the welding procedure specification for this weld overlay requires a 5°F increase to the RT_{NDT} for the low alloy steel nozzle base material.

IWA-4633.2(c) specifies the first six layers of the weld shall be deposited with heat inputs within ±10% of that used in the procedure qualification test. Subsequent layers shall be deposited using heat input equal to or less than that used for layers beyond the sixth in the procedure qualification. Sound welds and their HAZ on low alloy steel P-No.3 Group No. 3 base material can be achieved using machine gas tungsten arc welding (GTAW) with three layers (≥ 0.125 inches thick) using heat inputs within ±10% of that used in the procedure qualification test, with subsequent layers beyond the third using heat inputs that are equal to or less than the heat inputs used beyond the third layer in the procedure qualification test.

IWA-4633.2(c) also specifies that at least one layer of weld reinforcement shall be deposited and then this reinforcement shall be removed substantially flush with the surface surrounding the weld using mechanical means. The weld reinforcement will not removed flush to the surface.

Pursuant to 10 CFR 50.55a(a)(3)(i), an alternative is requested on the basis that the proposed repair will provide an acceptable level of quality and safety.

5. Proposed Alternative and Basis for Use

A full structural weld overlay repair is proposed for the safe-end to nozzle weldments. The nozzle material is SA-508 Class 2 low alloy steel. The safe-end is austenitic stainless steel SA-182 Grade F316L. The existing weld material is Alloy 82 with Alloy 182 buttering.

The weld overlay will be designed consistent with the requirements of NUREG-0313, Revision 2 (which was implemented by Generic Letter 88-01), Code Case N-504-2 "Alternative Rules for Repair of Classes 1, 2, and 3 Austenitic Stainless Steel Piping", Code Case N-638 "Similar and Dissimilar Metal Welding Using Ambient Temperature GTAW Temper Bead Technique", and IWB-3640, ASME SECTION XI 1998 Edition, including Addenda through 2000 with Appendix C.

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Welder Qualification And Welding Procedures

All welders and welding operators will be qualified in accordance with ASME Section IX and any special requirements of ASME XI or applicable code cases. Qualified personnel under the AREVA Framatome ANP Welding Program will perform the weld overlay repair.

Welding Procedure Specification (WPS) No. 55-WP3/8/43/F43OLTBSCa3 (machine GTAW with cold wire feed) for welding SFA-5.14, ERNiCrFe-7, UNS N06052, F-No. 43 (commercially known as Alloy 52) will be used.

If repairs to the overlay are required, manual GTAW for welding SFA-5.14, ERNiCrFe-7, UNS N06052, F-No. 43 (commercially known as Alloy 52) or shielded metal arc welding (SMAW), for welding SFA-5.11, ENiCrFe-7, UNS W86152, F-No. 43 (commercially known as Alloy 152), will be used.

Welding Wire and Electrodes

A consumable welding wire highly resistant to SCC was selected for the overlay material. Alloy 52 contains a nominal 30 wt% Cr that imparts excellent resistance to SCC. Where localized repairs are required, Alloy 52 or Alloy 152 will be used. Alloy 152 also contains a nominal 30 wt% Cr that imparts excellent resistance to SCC.

Weld Overlay Design

The weld overlay will extend around the full circumference of the safe-end to nozzle weldment location in accordance with NUREG-0313, Rev. 2, Code Case N-504-2 and Generic Letter 88-01. The overlay length will extend across the projected flaw intersection with the outer surface beyond the extreme axial boundaries of the flaw. The design thickness and length has been computed in accordance with the guidance provided in Code Case N-504-2 and ASME Section XI, IWB-3640, 1998 Edition including Addenda through 2000 and Appendix C. The overlay will completely cover the area of the flaw and other Alloy 182 susceptible material with the highly resistant Alloy 52 weld filler material.

To provide the necessary weld overlay geometry, it will be necessary to weld on the low alloy steel nozzle base material. A temper bead welding approach will be used for this purpose following the guidance of ASME Section XI Code Case N-638 "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique". This Code Case provides for machine GTAW temper bead weld repairs to P-No. 3 Group No. 3 nozzle base material at ambient temperature. The temper bead approach was selected because temper bead welding supplants the requirement for post weld heat treatment (PWHT) of the HAZ in welds on low alloy steel material. Also, the temper bead welding technique produces excellent toughness and ductility as demonstrated by welding procedure qualification in the HAZ of welds on low alloy steel materials, and, in this case, results in compressive residual stresses on the inside surface, which assists in inhibiting SCC. This approach provides a comprehensive weld overlay repair and increases the volume under the overlay that can be examined.

The overlay length conforms to the guidance of Code Case N-504-2, which satisfies the stress requirements.

Examination Requirements

The examination requirements for the weld overlay repair are summarized in Table 1. No final post weld examinations will be performed until 48 hours has elapsed after completion of welding. This is required to detect any possible hydrogen induced cracking that may occur in the low alloy steel nozzle HAZ.

NUREG-0313, Rev. 2, and Code Case N-504-2, specify UT using methods and personnel qualified in accordance with ASME Section XI, Appendix I. The UT techniques to be used for the final post-weld examination have been qualified through the EPRI NDE Center, which satisfies the requirements of ASME Section XI, Appendix I. Furthermore, NUREG-0313 states that the UT be performed in accordance with the requirements of the applicable Edition and Addenda of ASME Section XI. ASME Section XI, 1998 Edition including Addenda through 2000 is the Code of record for the 10-year Inservice Inspection Interval. Therefore the acceptance criteria that will be used for the UT will be IWB-3130, Inservice Volumetric and Surface Examinations and ASME Section XI Nonmandatory Appendix P, Weld Overlay Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping Weldments as clarified on page 13 under Exceptions to Code Case N-638 Paragraph 4.0(b).

Pressure Testing

The completed repair shall be given a system leakage test in accordance with ASME Section XI, IWA-5000, since the pressure boundary has not been penetrated (no leakage has occurred). In the event an unexpected through wall defect is identified, either before or during the repair, relief is requested from the hydrostatic pressure test requirements defined in Code Case N-504-2 and IWA-5000. A system leakage test will be performed in accordance with ASME Section XI, IWA-5000. Precedence

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for use of a leak test at normal operating temperature and pressure in lieu of a hydrostatic test has been set with Code Case N416-1 that has been incorporated in the 2000 Addenda of ASME Section XI.

Preheat and PWHT Requirements

Preheat and PWHT are typically required for welding on low alloy steel material. ASME Section III specifies PWHT on P-No. 3 Group No. 3 base materials unless temper bead welding is performed under limited restrictions (area and depth limits). ASME SECTION XI, 1998 Edition including Addenda through 2000, specifies 300°F minimum preheat be used for temper bead welding. PWHT cannot be performed and the preheat requirements would necessitate draining the RV and a portion of the recirculation system piping. This would create unacceptable levels of airborne contamination. Therefore, consistent with ALARA practices and prudent utilization of outage personnel, the RV will not be drained for this activity. The nozzle and connected piping will be full of water.

Alternatives to Code Case N-504-2

Code Case N-504-2 Applicability to Nickel Based Austenitic Steel

Code Case N-504-2 was prepared specifically for austenitic stainless steel material. An alternate application for nickel based austenitic materials (Alloy 52 and Alloy 152) is needed due to the specific materials and configuration of the existing nickel based alloy weld and buttering.

Exception to Code Case N-504-2, Requirement (b)

Code Case N-504-2, Requirement (b) requires the weld overlay shall be low carbon (0.035% maximum) austenitic stainless steel. A nickel-based filler is required and Alloy 52 has been selected to be used.

Exception to Code Case N-504-2, Requirement (e)

Code Case N-504-2, Requirement (e) requires the first two layers of the weld overlay to have a ferrite content of at least 7.5 FN (Ferrite Number). These measurements will not be performed for this overlay since the nickel alloy filler is a fully austenitic material.

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Exception to Code Case N-504-2, Requirement (h)

Code Case N-504-2, Requirement (h) specifies that a system hydrostatic test shall be performed in accordance with IWA-5000 if the flaw penetrates the pressure boundary. In the event the flaw becomes through wall, leak testing only, in accordance with ASME Section XI, IWA-5000, will be performed.

Alternatives to Code Case N-638

Exception to Code Case N-638 Paragraph. 1.0(a)

Code Case N-638 paragraph 1.0(a) specifies that the maximum weld area on the finished surface shall be 100 square inches. Restoring the structural integrity of the safe-end to nozzle weld with the weld overlay will require welding on more than 100 square inches of surface on the low alloy steel base material.

Exception to Code Case N-638 Paragraph. 2.0(j)

Code Case N-638 paragraph 2.0(j) specifies that the average lateral expansion of the three HAZ impact tests shall be equal to or greater than the average of the three unaffected base metal tests. This will not be met. The welding procedure qualification supporting the welding procedure specification for this weld overlay requires a 5°F increase to the RT_{NDT} for the low alloy steel nozzle base material.

Exception to Code Case N-638 Paragraph. 4.0(b)

Code Case N-638 paragraph 4.0(b) specifies that the final weld surface and band area (1.5T width) shall be examined using a surface and ultrasonic methods when the completed weld has been at ambient temperature for at least 48 hours. The ultrasonic examination shall be in accordance with ASME SECTION XI Appendix I. Full ultrasonic examination of the 1.5T band will not be performed.

Exception to Code Case N-638 Paragraph. 4.0(c)

Code Case N-638 paragraph 4.0(c) specifies that the area from which weld-attached thermocouples are used have been removed shall be ground and examined using a surface examination method. Thermocouples will not be used.

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Basis For The Alternative

IWA-4421(a) and **IWA-4611.1(a)** require defect removal in this case. The repair cavity would extend through wall since OD removal would be required. The ID is inaccessible due to the thermal sleeve. Therefore the flaw will not be removed. Structural weld overlays covering flaws are permitted by Code Case N-504-2, provided the necessary weld overlay geometry is used. Therefore, this alternative provides an acceptable level of quality and safety.

IWA-4610(a) requires the area to be welded shall be preheated to 300°F minimum for GTAW. Since the nozzle will remain full of water, establishing the 300°F minimum preheat temperature cannot be achieved. Code Case N-638, paragraph 1.0(b) provides for machine gas tungsten arc welding (GTAW) temper bead weld repairs to P-No. 3 Group No. 3 nozzle base material at ambient temperature. The ambient temperature temper bead approach was selected because temper bead welding supplants the requirement for PWHT of the heat-affected zones in welds on low alloy steel material. Also, the temper bead welding technique produces excellent toughness and ductility, as demonstrated by welding procedure qualification, in HAZ of welds on low alloy steel materials. AREVA Framatome ANP welding procedure qualifications have been successfully performed using Alloy 52 welds on P-No. 3 Group No. 3 base material using the ambient temperature temper bead technique. Therefore, this alternative provides an acceptable level of quality and safety.

IWA-4610(a) also requires the use of TCs to monitor process temperatures. Due to the personnel exposure associated with the installation and removal of the TCs, the nozzle configuration, and since the nozzle will be full of water, TCs will not be used to verify that preheat and interpass temperature limits are met. In lieu of TCs, a contact pyrometer will be used to verify preheat temperature and interpass temperature compliance with the WPS requirements. The use of a contact pyrometer provides equivalent temperature monitoring capabilities and is recognized as acceptable calibrated measuring and test equipment (M&TE). Therefore, this alternative provides an acceptable level of quality and safety.

IWA-4631(b) specifies the surface of the completed weld on the ferritic steel shall not exceed 100 square inches. Restoring the structural integrity with the weld overlay of the safe-end to nozzle weld will require welding on more than 100 square inches of surface on the low alloy steel base material. If this limit were maintained the length of weld overlay extension on the nozzle base material would be limited to approximately 2.25 inches, including the taper. This distance could be justified as sufficient to provide load redistribution from the weld overlay back into the nozzle without violating ASME III stress limits for primary local and bending stresses, and secondary and peak stresses. However, this length would not permit a complete UT of the outer 25% of the nozzle and safe-end thickness as specified by Code Case N-504-2. The overlay will extend to the transition taper of the low alloy steel nozzle so that qualified UT of the required volume can be performed. Therefore this alternative provides an acceptable level of quality and safety.

There have been temper bead weld overlay repairs applied to safe-end to nozzle welds in the nuclear industry. Some safe-end to nozzle welds have exceeded the 100 square inch limit. At V. C. Summer, the safe-end to nozzle repair was buttered using a temper bead machine GTAW process, and resulted in an overlay of approximately 300 square inches. At Three Mile Island, primary piping to pressurizer surge nozzle repair resulted in an overlay of approximately 200 square inches.

Code Case N-432 has always allowed temper bead welding on low alloy steel nozzles without limiting the temper bead weld surface area. The two additional conditions required by N-432 that are not required by Code Case N-638 are that temper bead welds have preheat applied and that the procedure qualification be performed on the same specification, type, grade and class of material. As previously discussed, elevated preheat necessitates draining of the RV and a portion of the recirculation system piping. This would create unacceptable levels of airborne contamination.

The ASME Code committees have recognized that the 100 square inches restriction on the surface area is excessive and a draft code case is currently in process with ASME Section XI to increase the surface area limit to 500 square inches. The code case attempts to combine the features of Code Case N-432 and N-638 into a single code case. The supporting analysis for the draft code case (EPRI Technical Report 1008454, Proposed Code Case, Expansion of Temper Bead Repair) concluded that the residual stresses are not detrimentally changed by increasing the surface area of the repair and increasing the HAZ tempering is unaffected by the weld overlay application. Therefore, this alternative provides an acceptable level of quality and safety.

IWA-4632(b) specifies the base material and HAZ shall meet IWA-4622. IWA-4622 specifies that the average lateral expansion of the three HAZ impact tests shall be equal to or greater than the average of the three base metal tests. The welding procedure qualification supporting the welding procedure specification for this overlay requires a 5°F increase to the RT_{NDT} for the low alloy steel nozzle base material at the nozzle HAZ location due to the overlay. This methodology is consistent with ASME Section III. Since the HAZ due to the weld overlay is on the nozzle outside surface and outside the core region where fluence effects degrade impact properties over time, the RT_{NDT} increase required for the nozzle base material will not be a plant operational limitation. This conclusion assumes the nozzle base material initial RT_{NDT} value is consistent with the initial RT_{NDT} values of the low alloy steel material used in the core region pressure boundary. Therefore this alternative provides an acceptable level of quality and safety.

IWA-4633.2(c) specifies the first six layers of the weld shall be deposited with heat inputs within ±10% of that used in the procedure qualification test. Subsequent layers shall be deposited using heat input equal to or less than that used for layers beyond the sixth in the procedure qualification. Sound welds and their HAZ on low alloy steel P-No.3 Group No. 3 base material can be achieved using machine GTAW with three layers (≥0.125 inch thick) using heat inputs within ±10% of that used in the procedure qualification test with subsequent layers beyond the third using heat inputs that are equal to or less than the heat inputs used beyond the third layer in the procedure qualification test. Code Case N-638, paragraph 3.0(c) specifies this technique for machine GTAW temper bead welding on P-No. 3 Group No. 3 nozzle base material at ambient temperature. AREVA Framatome ANP procedure qualifications have been successfully performed using Alloy 52 welds on P-No. 3 Group No. 3 base material using the ambient temperature temper bead technique. Therefore, this alternative provides an acceptable level of quality and safety.

IWA-4633.2(c) also specifies that at least one layer of weld reinforcement shall be deposited and then this reinforcement shall be removed substantially flush with the surface surrounding the weld using mechanical means. The weld overlay is austenitic and there is no need to remove the final layer. Also, overlays cannot be substantially flush with the surrounding surface, and overlays are permitted per Code Case N-504-2. The toe of the weld on the low alloy steel nozzle shoulder will be indexed between layers such that proper HAZ tempering will result. Therefore, this alternative provides an acceptable level of quality and safety.

Code Case N-638 was approved for generic use in Regulatory Guide 1.147, Revision 13, and was developed for similar and dissimilar metal welding using ambient temperature machine GTAW temper bead technique. The welding methodology of Code Case N-638 will be followed for the overlay when within the 0.125-inch minimum distance from the low alloy steel nozzle base material.

Code Case N-504-2 was approved for generic use in Regulatory Guide 1.147, Revision 13, and was developed for welding on and using austenitic stainless steel material. An alternate application for nickel-based and low alloy steel materials is proposed due to the specific configuration of this weldment. The weld overlay

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proposed is austenitic material having a mechanical behavior similar to austenitic stainless steel. It is also compatible with the existing weld and base materials. The methodology of Code Case N-504-2 is to be followed, except for the following:

Exception to Code Case N-504-2, Requirement (b)

A consumable welding wire highly resistant to SCC was selected for the overlay material. This material, designated as UNS N06052, F-No. 43, is a nickel based alloy weld filler material, commonly referred to as Alloy 52 and will be deposited using the machine GTAW process with cold wire feed. Alloy 52 contains about 30 wt% chromium, which imparts excellent corrosion resistance to the material. By comparison, Alloy 82 is identified as a SCC resistant material in NUREG-0313 Revision 2 and contains nominally 20 wt% chromium while Alloy 182 has a nominal chromium content of 15 wt%. With its higher chromium content than Alloy 82, Alloy 52 provides an even higher level of resistance to SCC consistent with the requirements of the Code Case. Therefore, this alternative provides an acceptable level of quality and safety.

Exception to Code Case N-504-2, Requirement (e)

The composition of nickel-based Alloy 52 is such that delta ferrite does not form during welding. Delta ferrite measurements will not be performed for this overlay because Alloy 52 welds are 100% austenitic and contain no delta ferrite due to the high nickel composition (approximately 60 wt% nickel). Therefore, this alternative provides an acceptable level of quality and safety.

Exception to Code Case N-504-2, Requirement (h)

Code Case N-504-2 requirement (h) specifies a system hydrostatic test shall be performed in accordance with IWA-5000 if the flaw penetrates the pressure boundary. Leak testing in accordance with ASME Section XI, IWA-5000, will be performed. Precedence for use of a leak test at normal operating temperature and pressure in lieu of a hydrostatic test has been set with Code Case N416-1 that has been incorporated in the 2000 Addenda of ASME Section XI. Therefore, this alternative provides an acceptable level of quality and safety.

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Exception to Code Case N-638 Paragraph. 1.0(a)

Code Case N-638 paragraph 1.0(a) specifies that the maximum weld area on the finished surface shall be 100 square inches. Restoring the structural integrity with the weld overlay of the safe-end to nozzle weld will require welding on more than 100 square inches of surface on the low alloy steel base material. The weld overlay will cover approximately 180 square inches of the low alloy steel nozzle.

There have been temper bead weld overlay repairs applied to safe-end to nozzle welds in the nuclear industry. Two safe-end to nozzle welds have exceeded this limit. These include the safe-end to nozzle repair at V. C. Summer, where the end of the nozzle (approximately 30 inches OD x 3 inches thick wall) was buttered using a temper bead machine GTAW process (approximately 300 square inches) and to the Three Mile Island primary piping to pressurizer surge nozzle (approximately 200 square inches).

Code Case N-432 allows temper bead welding on low alloy steel nozzles without limiting the temper bead weld surface area. The two additional conditions required by N-432 that are not required by Code Case N-638 are that temper bead welds have preheat applied and that the procedure qualification be performed on the same specification, type, grade and class of material. As previously discussed, elevated preheat necessitates draining of the RV and a portion of the recirculation system piping. This would create unacceptable levels of airborne contamination.

The ASME Code committees have recognized that the 100 square inches restriction on the surface area is excessive and a draft code case is currently in process with ASME Section XI to increase the surface area limit to 500 square inches. The code case attempts to combine the features of Code Case N-432 and N-638 into a single code case. The supporting analysis for the draft code case (prepared by EPRI) concluded that the residual stresses are not detrimentally changed by increasing the surface area of the repair and increasing the HAZ tempering is unaffected by the weld overlay application. Therefore, this alternative provides an acceptable level of quality and safety.

Exception to Code Case N-638 Paragraph. 2.0(j)

Code Case N-638 Paragraph 2.0(j) specifies that the average lateral expansion of the three HAZ impact tests shall be equal to or greater than the average of the three unaffected base metal tests. The welding procedure qualification supporting the welding procedure specification for this weld overlay requires a 5°F increase to the RT_{NDT} for the low alloy steel nozzle base material. This methodology is consistent with ASME Section III. Since the HAZ due to the weld overlay is on the nozzle outside surface and outside the core region where fluence effects degrade impact properties over time, the RT_{NDT} increase required for the nozzle base material will not be a plant operational limitation. This conclusion assumes the nozzle base material initial RT_{NDT} value is consistent with the initial RT_{NDT} values of the low alloy steel material used in the core region pressure boundary. Therefore, this alternative provides an acceptable level of quality and safety.

Exception to Code Case N-638 Paragraph. 4.0(b)

Code Case N-638 Paragraph 4.0(b) specifies that the final weld surface and band area (1.5T width) shall be examined using surface and ultrasonic methods when the completed weld has been at ambient temperature for at least 48 hours. The ultrasonic examination shall be in accordance with ASME SECTION XI, Appendix I. Surface exams will be performed. Full ultrasonic examination of the 1.5T band will not be performed. IWA-4634 requires UT of the weld only. Any laminar flaws in the weld overlay will be evaluated in accordance with ASME SECTION XI Nonmandatory Appendix P, except that as allowed by IWB-3132.3, any flaws that exceed the acceptance standards of Table IWB-3410-1 are acceptable for continued service without repair if an analytical evaluation, as described in IWB-3600, meets the acceptance criteria of IWB-3600. Therefore, this alternative provides an acceptable level of quality and safety.

Exception to Code Case N-638 Paragraph. 4.0(c)

Code Case N-638 paragraph 4.0(c) specifies that the area from which weld-attached thermocouples have been removed shall be ground and examined using a surface examination method. Due to the personnel exposure associated with the installation and removal of the TCs, the nozzle configuration, and since the nozzle will be full of water, TCs will not be used to verify that preheat and interpass temperature limits are met. In lieu of TCs, a contact pyrometer will be used to verify preheat temperature and interpass temperature compliance with the WPS requirements. Therefore, this alternative provides an acceptable level of quality and safety.

The use of overlay filler material that provides excellent resistance to SCC develops an effective barrier to flaw extension. Also, temper bead welding techniques produce excellent toughness and ductility in the weld HAZ low alloy steel materials, and in this case result in compressive residual stresses on the inside surface that help to inhibit SCC. The design of the overlay for the safe-end to nozzle weldment uses methods that are standard in the industry. There are no new or different approaches in this overlay design which are considered first of a kind or inconsistent

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with previous approaches. The overlay will be designed as a full structural overlay in accordance with Code Case N-504-2. The temper bead welding technique that will be implemented in accordance with Code Case N-638 will produce a tough, ductile, corrosion-resistant overlay.

Use of Code Cases N-504-2 and N-638 has been accepted in Regulatory Guide 1.147, Revision 13, as providing an acceptable level of quality and safety.

PSEG concludes that the alternative repair approach described above presents an acceptable level of quality and safety to satisfy the requirements of 10CFR50.55a(a)(3)(i).

6. Duration of Proposed Alternative

This alternative repair is requested for the remainder of the plant life.

7. Precedents

The observed flaw at Hope Creek Unit 1 is consistent with the documented SCC observed at Hope Creek in 1997 on the core spray safe-end to nozzle (N5B) weld. Similar flaws have been observed at other BWRs including Duane Arnold (TAC NO. MA8663), Perry, Nine Mile Point 2 and Susquehanna 1.

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TABLE 1
Examination Requirements

Exam Description	Method	Technique	Reference
As Found Flaw Detection	Auto UT	PDI Qualified Implementing ASME SECTION XI Appendix VIII Supplement 11	IWB-3514
Pre-weld UT Thickness	Manual UT	0°	N-504-2
Surface Prior to Welding	PT	Color Contrast (Visible) Penetrant	IWA-4611.1(a) N-504-2(c) N-638-4.0(a)
Final Weld Overlay Surface	PT	Color Contrast (Visible) Penetrant	IWA-4634 N-504-2(j) N-638-4.0(b)
Final Weld Overlay for Thickness	UT	0°	IWA-4634 N-504-2(j) N-638-4.0(b)
Final Weld Overlay and Outer 25% of the Underlying Wall Thickness Volumetric Preservice	Auto UT	PDI Qualified Implementing ASME SECTION XI Appendix VIII Supplement 11	IWA-4634 IWB-3514 N-504-2(j) N-638-4.0(b) Appendix P

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Figure 1

N2K Recirculation Inlet Nozzle/Safe-end Configuration with Structural Overlay

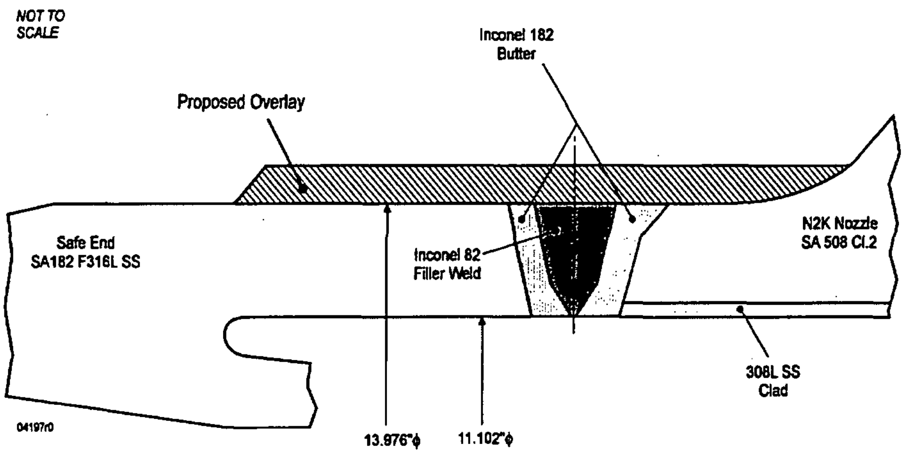

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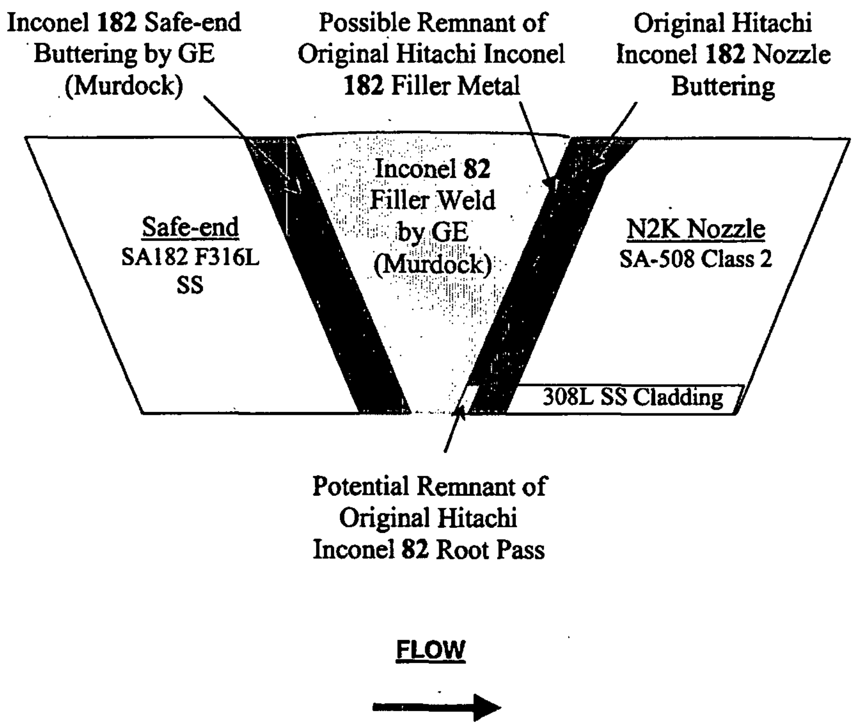
Figure 2

N2K Nozzle to Safe-End Field Configuration
(As Determined from Historical Documentation Research)



NOTE: Not to Scale

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**REQUEST FOR ADDITIONAL INFORMATION
REGARDING PROPOSED ALTERNATIVES TO
AMERICAN SOCIETY OF MECHANICAL ENGINEERS
BOILER AND PRESSURE VESSEL CODE REQUIREMENTS
HOPE CREEK GENERATING STATION
FACILITY OPERATING LICENSE NO. NPF-57
DOCKET NO. 50-354**

Reference: LR-N04-0587, Request For Additional Information Regarding Relief Request HC-RR-I2-W01, Proposed Alternative Repair Method, Hope Creek Generating Station, dated December 16, 2004

The referenced letter provided the response to a December 14, 2004 draft request for additional information from the NRC. On December 27, 2004, the NRC staff granted verbal approval of both proposed alternatives. By letter dated January 19, 2005, the NRC staff determined that additional information was necessary to properly document all issues discussed prior to granting verbal approval. Attachment 1 to this letter contains the NRC questions and PSEG's response. Additional or revised information not contained in the December 16, 2004 letter is denoted by marginal markings on the right side of the page.

If you have any questions, please contact Michael Mosier at (856) 339-5434.

Sincerely,

Christina L. Perino
Director – Regulatory Assurance

Attachment

A047

95-2168 REV. 7/99

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LR-N05-0072

C: Mr. S. Collins, Administrator - Region I
U. S. Nuclear Regulatory Commission
475 Allendale Road
King of Prussia, PA 19406

Mr. D. Collins, Project Manager – Hope Creek/Salem
U.S. Nuclear Regulatory Commission
Mail Stop 08C2
Washington, DC 20555-0001

USNRC Senior Resident Inspector – Hope Creek (X24)

Mr. K. Tosch
Manager IV
Bureau of Nuclear Engineering
P. O. Box 415
Trenton, NJ 08625

Document Control Desk **Attachment 1**
LR-N05-0072

**REQUEST FOR ADDITIONAL INFORMATION
REGARDING PROPOSED ALTERNATIVES TO
AMERICAN SOCIETY OF MECHANICAL ENGINEERS
BOILER AND PRESSURE VESSEL CODE REQUIREMENTS
HOPE CREEK GENERATING STATION
DOCKET NO. 50-354**

By letters dated December 1, 2004, PSEG Nuclear LLC (PSEG) submitted two relief requests for Hope Creek Generating Station (Hope Greek). The applications requested approval of a proposed alternative to the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) requirements in the repair and subsequent inspection of the N2K reactor vessel nozzle. On December 14, 2004, the Nuclear Regulatory Commission (NRC) staff faxed draft questions to Mr. Michael Mosier of your staff in order to support a conference call that occurred on December 22, 2004. On December 27, 2004, the NRC staff granted verbal approval of both the proposed alternatives. The NRC staff has determined that a response to the enclosed questions, letter dated January 19, 2005, is necessary to properly document all issues discussed prior to granting verbal approval.

Questions Applicable to HC-RR-I2-W01

NRC Question 1:

In the enclosure of your December 1, 2004, submittal, you stated that the root cause evaluation has not been completed. Describe the plan and schedule for completion of your root cause evaluation.

PSEG Response to Question 1:

An Apparent Cause Evaluation (ACE) was completed on December 14, 2004 in accordance with PSEG Nuclear's Corrective Action Program. The N2K weld flaw is attributed to stress corrosion cracking. A cause and effect analysis, review of operating experience (OE), and summary of the well documented Boiling Water Reactor (BWR) industry history relative to BWR pipe cracking was used to determine this apparent cause.

NRC Question 2:

When was hydrogen water chemistry and NobleChem implemented at Hope Creek? In view of the detected flaw at the subject weld (N2K), discuss its effectiveness in mitigating intergranular stress-corrosion cracking (IGSCC) initiation and propagation.

1

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PSEG Response to Question 2:

Noble Chemical Addition has not been implemented at Hope Creek; however, it is being considered for implementation in the near future. Hydrogen Water Chemistry (HWC) has been implemented since 1991 and was initially injected at a rate of approximately 21 scfm. Hydrogen injection levels were increased in 1999 to about 35 scfm in order to mitigate IGSCC initiation and propagation with the belief that full mitigation was chieved for recirculation piping. However, ongoing evaluations of Hope Creek operating data and industry experience suggest that the hydrogen injection levels may not be high enough to fully mitigate IGSCC in recirculation piping.

ERPI BWR Water Chemistry Guidelines (BWRVIP-130) dated October 2004, states in part, "Mitigation of recirculation piping is very plant specific and may require low-to-high HWC." Quad Cities for example requires 2.3 ppm hydrogen in order to reach the electrochemical potential (ECP) required to mitigate cracking in the recirculation piping. This is above the present capability and specification of Hope Creek, which limits the hydrogen concentration in the feed to <2 ppm.

NRC Question 3:

Provide ultrasonic testing (UT) inspection history of weld N2K. Was IGSCC detected in any other dissimilar metal welds at Hope Creek?

PSEG Response to Question 3:

The N2K nozzle to safe-end weld was examined using automated UT techniques in Refueling Outages 2, 4, 6, 8, 9, and 12. The results of these exams are summarized in Table 1. The UT data was reviewed by the Electric Power Research Institute (EPRI) Non Destructive Examination (NDE) Center. The axial flaw detected during RFO 12 was not seen in the previous UT results.

Table 1 – N2K Nozzle-Safe-End Weld Ultrasonic Examination History

Examination Date	Type of Examination (Automated/Manual)	Results
1985 Note 1	Automated SWRI (Amdata Introspect)	Acoustic Interface
1989 (RFO 2)	Automated (Axial Scans) SWRI (Amdata I/PC-2)	Interface and Counterbore
1989 (RFO 2)	Manual (Circ Scans) SWRI (Amdata I/PC-2)	No Recordable Indications
1992 (RFO 4)	Automated (GE Smart 2000)	Acoustic Interface, Root Geometry, and Non-Relevant Indications

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1995 Note 2 (RFO 6)	Automated (GE Smart 2000)	Acoustic Interface and Non-Relevant Indications
1999 Note 3 (RFO 8)	Automated (Framatome Accusonex)	Acoustic Interface, Non-Relevant Indications, and two Fabrication Type Indications Outside Inner 1/3T Note 4
2000 (RFO 9)	Automated (Framatome Accusonex)	Acoustic Interface, Non-Relevant Indications, and three Fabrication Type Indications Outside Inner 1/3T Note 4
2004 Note 5 (RFO 12)	Automated (by Framatome) RD Tech's Tomoscan System	Acoustic Interface, Clad Roll, Non-Relevant Indications, Non-geometric (Axial Flaw)

Note 1. Preservice ultrasonic examination.
Note 2. Pre-Mechanical Stress Improvement Process (MSIP) ultrasonic examination.
Note 3. Post-MSIP ultrasonic examination.
Note 4. Indications evaluated as weld noise/interface in 2004 with PDI qualified procedure. Also, in different circumferential location as 2004 axial.
Note 5. RFO 12 examination using PDI qualified procedures.

A through wall flaw was detected in 1997 in the N5B Core Spray nozzle to safe-end dissimilar metal weld. This flaw was attributed to IGSCC.

NRC Question 4:

You stated that the N2K weld was examined in part in accordance with risk-informed classification RA. Describe the risk-informed classification RA and the inspection frequency associated with this weld classification. What is the basis for this frequency?

PSEG Response to Question 4:

The alternative risk-informed inservice inspection (RI-ISI) program for piping was described in PSEG Nuclear's Relief Request (LR-N04-0036, dated March 1, 2004) titled, "Request For Authorization To Use A Risk-Informed Inservice Inspection Alternative To The ASME Boiler And Pressure Vessel Code Section XI Requirements For Class 1 And 2 Piping At Hope Creek Generating Station". The relief request was prepared in accordance with EPRI Report TR-112657, "Revised Risk-Informed Inservice Inspection Evaluation Procedure", that provides the requirements for defining the relationship between the RI-ISI Program and the remaining unaffected portions of ASME Section XI. The NRC granted this relief on December 8, 2004 (TAC NO. MC2221).

The EPRI TR-112657 describes the RI-ISI process for identification and selection of RI-ISI components. ASME Code Case N-578 was the mechanism used to assign the ASME XI RI-ISI category (R-A) and item number to remain consistent with ASME XI ISI Program practices and assist calculating Inspection Program B percentage - requirements for ASME XI tables IWB-2412-1 and IWC-2412-1.

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The N2K weld RI-ISI classification is:

Exam Category: R-A
Item No. R1.14-2

Failure Mechanism	Risk Ranking	Failure Potential	Consequence	Risk Category
CC IGSCC	High/High	Medium	High	2

Hope Creek Generating Station incorporated the guidance contained in BWR Vessel and Internals Project (BWRVIP) Report No. BWRVIP-75. BWRVIP-75 provides alternative criteria to NRC Generic Letter 88-01 for the examination of welds susceptible to intergranular stress corrosion cracking (IGSCC). Both Generic Letter 88-01 and BWRVIP-75 specify examination extent and frequency requirements for austenitic stainless steel welds that are classified as Categories "A" through "G", dependent upon their susceptibility to IGSCC. In accordance with EPRI TR-112657, piping welds identified as Category "A" were considered resistant to IGSCC and are assigned a low failure potential provided no other damage mechanisms are present. As such, the examination of welds identified as Category "A" inspection locations is subsumed by the RI-ISI Program. The existing plant augmented inspection program for the other piping welds such as the N2K nozzle to safe-end weld susceptible to IGSCC at the Hope Creek Generating Station (Categories "C" and "E") remained unaffected by the RI-ISI Program submittal.

It is noted that in some cases, the sample size required to be examined in BWRVIP-75 is smaller than that required by ASME Section XI. This is the case for weld overlays, where BWRVIP-75 specifies an inspection frequency of "25% every 10 years" for Category "E" welds (cracked-reinforced by weld overlay). The inspection frequency for the N2K weld overlay will be once every 10 years, which is consistent with ASME Section XI.

NRC Question 5:

You stated in page 3 of your December 1, 2004, submittal and page 4 of its attachment that an Alloy 152 electrode may also be utilized for local repairs to the underlying weld metal. Please confirm that ASME Code Case N638 will not be applied to the repair welding using Alloy 152 since the subject Code Case is limited to the welding using gas tungsten arc welding temper bead technique.

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PSEG Response to Question 5:

Any localized repair using manual shielded metal arc welding (SMAW) temper bead welding would have been done with preheat in accordance with the rules of ASME Section XI. This was planned as a contingency in the unlikely case of a through wall defect. SMAW would have only been used to seal any defect if it were greater than 0.125 inch from the P-3 nozzle material before beginning the structural weld overlay using GTAW. This contingency as well as the aforementioned limitations was noted on the AREVA job traveler. This contingency was not needed.

NRC Question 6:

Clarify the acceptance criteria in ASME Section XI Nonmandatory Appendix P that you propose to use for UT examination of weld overlay. It should be noted that Appendix P has not been incorporated in ASME Code nor endorsed by NRC.

PSEG Response to Question 6:

The acceptance criteria in paragraph P-4100(c) of the proposed ASME Code Section XI states that Appendix P will be used for UT inspection of the weld overlay. Any laminar flaws in the weld overlay will be evaluated in accordance with P-4100(c). As allowed by IWB-3132.3, any flaws that exceed the acceptance standards of Table IWB-3514 (per Table IWB-3410-1) will be evaluated per IWB-3600 to determine if they are acceptable for continued operation without additional repairs having to be made to the completed structural overlay.

NRC Question 7:

For the relief from system hydrostatic test, you referenced Code Case N416-1. Please confirm that you will not take any exception to the subject Code Case such as in item (b) which states that nondestructive examination is required to be performed in accordance with that of the applicable Subsection of the 1992 Edition of Section III.

PSEG Response to Question 7:

Code Case N-416 is noted within the relief request only as a reference for clarification purposes and to denote that the provisions of this Code Case had been incorporated into the 1998 Edition with 2000 Addenda of ASME Section XI, specifically IWA-4540. Included in IWA-4540 are all of the limitations of the original Code Case, including which editions of ASME Section III shall be used for the selection of NDE methodology and acceptance criteria, prior to the conduct of a system leakage test. The Hope Creek ISI program is based upon the 2000 Addenda of ASME XI and the planned repair for the N2K nozzle is also based upon the 2000 Addenda. Consequently, the provisions of the Code Case and its attendant limitations are already contained within IWA-4540, was used for the post overlay pressure-testing requirements.

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NRC Question 8:

In support of the exception to ASME Code Case N-638 Paragraph 1.0(a) regarding the maximum allowable weld area, you referenced the conclusion of an Electric Power Research Institute Technical Report 1008454. Please provide a summary description of how the conclusion was reached including any testing data or analytical evaluation being performed.

PSEG Response to Question 8:

The draft Code Case prepared by EPRI is found in the referenced EPRI Technical Report 1008454. The technical basis that justifies exceeding of the 100 square inches surface area for repair welds is found in EPRI Technical Report, 1003616, Additional Evaluations to Expand Repair Limits for Pressure Vessels and Nozzles. The conclusion described in the RAI and this technical report was reached by using an ANSYS Finite Element Analysis (FEA) conducted on the Nine Mile Point 2 feedwater nozzle weld overlay repair. The analysis consisted of modeling the welding processes for both thermal and mechanical respects. Two overlays were modeled, one was 100 square inches, the other was extended to blend into the nozzle radius to achieve greater than the 100 square inches surface area repair currently permitted by ASME Code requirements. Comparison of the residual stresses of the two overlays showed that the affect of extending the overlay to the nozzle radius minimally impacted the residual stress profile and in some cases slightly increased the beneficial compressive stresses on the nozzle inner diameter.

NRC Question 9:

To support the exception to ASME Code Case N-638 Paragraph 2.0(i), which requires that the average lateral expansion of the three heat-affected zone impact, tests shall be equal to or greater than the average of the three unaffected base metal tests, please provide the following additional information:

a. What is the RT_{NDT} value for the N2K nozzle base material?

b. Provide justification for your assumption that the nozzle base material initial RT_{NDT} value is consistent with the initial RT_{NDT} value of the low alloy steel material used in the core region pressure boundary. Is there test data to support the assumption?

c. Provide reasons for why the referenced requirement in Paragraph 2.0(i) cannot be met.

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PSEG Response to Question 9:

The exception to ASME Code Case-638 Paragraph 2.0(i), which requires that the average lateral expansion of the three heat-affected zone impact tests shall be equal to or greater than the average of the three unaffected base metal tests is withdrawn. The AREVA procedure qualification record (PQR) No. 7164 meets this requirement, and is one of the supporting PQR's for the AREVA welding procedure qualification (WPS) used for the temperbead weld overlay. Therefore, no exception to this code requirement is necessary.

NRC Question 10:

On page 8 of the Attachment to your December 1, 2004, submittal, under IWA-4610(a), you stated that AREVA Framatome ANP welding procedure qualification have been successfully performed using Alloy 52 Alloy welds on P-No. 3 Group No. 3 base material using the ambient temperature temper bead technique. However, in your submittal you are seeking exception to ASME Code Case N-638 Paragraph 2.0(i) because the results of welding procedure qualification failed to meet the requirement specified in the subject paragraph. Please clarify this apparent discrepancy.

PSEG Response to Question 10:

See response to Question 9.

NRC Question 11:

Provide technical justification to support the acceptance of not performing UT of the band area as required in ASME Code Case N-638 Paragraph 4.0(b).

PSEG Response to Question 11:

The weld overlay will extend into the blend radius of the nozzle beyond the length required by Code Case N-504-2 for structural reinforcement. This extension onto the blend radius is for the purpose of eliminating a stress riser on the nozzle and providing additional OD surface area for UT examination of the defect in the nozzle to safe end weld or weld heat affected zone (HAZ). UT examination on the nozzle beyond the overlay will not provide any information regarding the defect that required the repair. Additionally, such UT would likely be unsatisfactory when applied to the nozzle blend radius, where the toe of the weld overlay resides, as the UT return signal would be difficult to obtain, and to interpret. Alternatively, surface examination will assure that no defects have been created at the toe of the weld overlay.

The major concern associated with temperbead welding on low alloy steels is related to hydrogen cracking. Additional actions were taken during the weld overlay application to minimize the potential for this type of cracking. These include the following:

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- The welding technique used is the gas tungsten arc process (GTAW), which provides a very high quality weldment, without the presence of moisture (that can create conditions conducive to hydrogen damage). This process utilizes a shielding gas to minimize the presence of contaminants on the surface. Intermediate cleaning is performed to further reduce the possibility of contamination or moisture on the surface.

- Prior studies have illustrated that the high hardness produced by the temperbead welding at the toe region in the low alloy steel is a very short range phenomenon. One such study examining the effect of a weld overlay repair on the core spray nozzle at Vermont Yankee (EPRI Report NP-7085-D, January, 1991) revealed that while the hardness in the low alloy steel near the surface was as great as Rockwell C 36, at a depth of 40 mils it had been reduced to less than Rockwell C 29. At a depth approaching 100 mils, the hardness was less than Rockwell B 100, nearly that of the unaffected base metal. Based upon the above, the clear concern associated with temperbead welding is the toe of the overlay in the low alloy steel near the OD surface. That region was extensively interrogated by surface NDE techniques after a post-welding 48-hour hold period.

NRC Question 12:

Describe how the contact pyrometer will be calibrated in the temperature range that it will be used. If it has already been calibrated and its accuracy demonstrated, describe the results.

PSEG Response to Question 12:

The AREVA calibration serial number for the pyrometer used for this repair is an Omega Digital Thermometer, VH-9103. This pyrometer was calibrated with an Omega Temperature Calibrator, VH-3911, which was calibrated by SIMCO electronics. The certificate from SIMCO shows National Institute of Standards & Technology (NIST) traceability.

NRC Question 13:

You requested the approval of the proposed alternative for the remainder of the plant life. The current staff position is that the staff will approve such alternative no longer than the remainder of the current in-service inspection l0-year interval because the need for the proposed alternative may change with the improvement of the technology and the change of the regulation including ASME Code. Please provide a justification of why the requested duration is appropriate or revise the requested duration to the end of the current l0-year interval.

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PSEG Response to Question 13:

The request for approval of the proposed alternative repair for the remainder of the plant life only applies to the weld overlay repair to nozzle to safe-end weld, RPV1-N2KSE. The structural weld overlay is intended to remain in-situ on the N2K nozzle for the remainder of plant life. Request for approval for use of a structural weld overlay for repair to any other component would be submitted to the NRC under a separate relief request.

NRC Question 14:

Provide details of flaw characterization, such as the length and the depth of the flaw, and provide a sketch to show the location of the flaw. On page 1of the Enclosure to your December 1, 2004, submittal, you stated that, based on the UT data, the axial indication was contained solely within the safe-end to nozzle weld and buttering. However, during a conference call, you indicated that the axial indication was contained within the butter. This is consistent with the known IGSCC resistant property associated with Alloy 82 material. Please clarify this in your response.

PSEG Response to Question 14:

The ultrasonic inspection data, obtained prior to application of the weld overlay, indicated that weld RPV1-N2KSE contained an axial flaw having approximate dimensions of 0.75 inches long by 0.343 inches deep.

Prior to initial plant start-up, the safe-end was replaced with a tuning fork style safe-end. The documentation revealed the following operations for the safe-end replacement:

a. The original safe-end was removed by cutting the original (Hitachi) nozzle to safe-end weld on the safe-end side of the weld centerline.
b. The new weld end-prep/bevel was machined on the remaining weld metal, which consisted of both the original Alloy 182 butter and remaining Alloy 182/82 butt weld. The replacement documentation does not indicate the thickness of the remaining/original Alloy 182 butt weld.
c. The new safe-end, which was also buttered with Alloy 182, was welded to the nozzle-side end prep using machine Gas Tungsten Arc Welding (GTAW) and Alloy 82 filler metal.

Based on the RFO12 ultrasonic inspection data and the above weld joint configuration, there is no evidence suggesting that the suspect flaw in weld RPV1-N2KSE extends into the machine GTAW Alloy 82 weld metal. Figure RAI 14-1 (attached) provides a schematic of the flaw.

The ultrasonic inspection of the completed weld overlay identified an indication within the outer 25% of the safe-end wall thickness, which is part of the required weld overlay inspection volume. While this indication is located in approximately the same circumferential position as the original reported flaw, the axial position of this indication does not correspond to the axial position of the original flaw. In fact, this indication is located on the opposite side (safe-end side) of the weld. This indication will be monitored as part of the required inservice weld overlay inspections, as it is within the outer 25% of the safe-end wall thickness.

Questions Applicable to Both HC-RR-I2-W01 and HC-RR-I2-30

NRC Question 1:

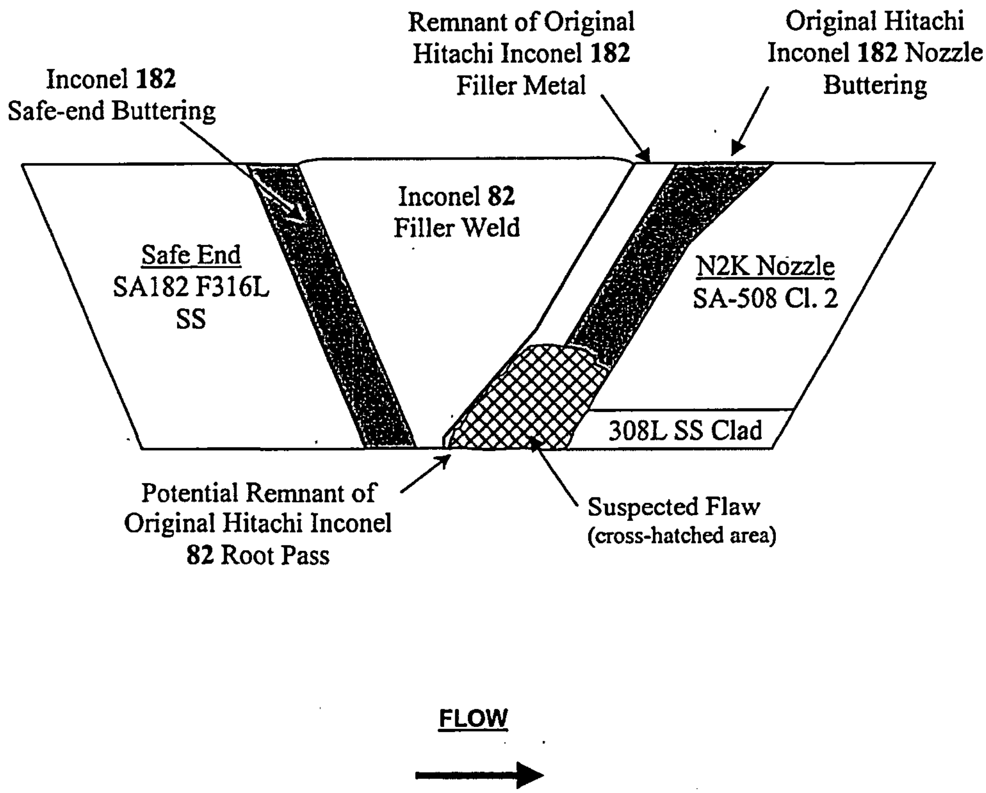
By letter dated December 23, 2004, the NRC approved an update of the ASME Code of record for Hope Creek to the 1998 Edition with 2000 Addenda. Please clarify the ASME Code of record that these proposed alternatives are applicable to.

PSEG Response to Question 1:

The proposed alternatives apply to the 1998 Edition with 2000 Addenda.

Document Control Desk **Attachment 1**
LR-N05-0072

FIGURE RAI 14-1
N2K Nozzle to Safe-end Field Configuration
(As Determined from Historical Documentation Research)



NOTE: NOT to Scale

August 29, 2005

Mr. William Levis
Senior Vice President & Chief Nuclear Officer
PSEG Nuclear - X15
P.O. Box 236
Hancocks Bridge, NJ 08038

SUBJECT: HOPE CREEK GENERATING STATION - EVALUATION OF RELIEF REQUEST HC-RR-I2-W01 (TAC NO. MC5173)

Dear Mr. Levis:

By letter dated December 1, 2004, as supplemented by letters dated December 16, 2004, and February 18, 2005, PSEG Nuclear, LLC (PSEG) submitted a proposed alternative to the requirements of Section XI of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code relating to a full-structural weld overlay repair of a degraded recirculation inlet nozzle to the safe-end weld (N2K) at the Hope Creek Generating Station. An ultrasonic examination of the Hope Creek N2K weld was performed during the fall 2004 refueling outage and identified an axial indication. PSEG performed the weld overlay repair but required timely Nuclear Regulatory Commission (NRC) approval of the proposed alternative to support completion of repair activities. On December 27, 2004, the NRC staff granted verbal authorization to PSEG for the proposed alternative, to be followed up by the NRC staff's final review and written evaluation. The December 16, 2004, and February 18, 2005, letters were submitted to formally docket information previously given in a teleconference by PSEG in support of verbal authorization of the proposed alternative.

Based on the information provided, the NRC staff concludes that the proposed alternative, as described in Relief Request HC-RR-I2-W01, will provide an acceptable level of quality and safety. Therefore, the NRC staff authorizes the proposed alternative, pursuant to Title 10 of the *Code of Federal Regulations*, Section 50.55a(a)(3)(i), for the remainder of the plant life.

The NRC staff's Safety Evaluation is enclosed. If you have any questions, please contact G. Edward Miller, at 301-415-2481.

Sincerely,

/RA/

Darrell J. Roberts, Chief, Section 2
Project Directorate I
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-354

Enclosure: As stated

cc w/encl: See next page

August 29, 2005

Mr. William Levis
Senior Vice President & Chief Nuclear Officer
PSEG Nuclear - X15
P.O. Box 236
Hancocks Bridge, NJ 08038

SUBJECT: HOPE CREEK GENERATING STATION - EVALUATION OF RELIEF REQUEST HC-RR-I2-W01 (TAC NO. MC5173)

Dear Mr. Levis:

By letter dated December 1, 2004, as supplemented by letters dated December 16, 2004, and February 18, 2005, PSEG Nuclear, LLC (PSEG) submitted a proposed alternative to the requirements of Section XI of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code relating to a full-structural weld overlay repair of a degraded recirculation inlet nozzle to the safe-end weld (N2K) at the Hope Creek Generating Station. An ultrasonic examination of the Hope Creek N2K weld was performed during the fall 2004 refueling outage and identified an axial indication. PSEG performed the weld overlay repair but required timely Nuclear Regulatory Commission (NRC) approval of the proposed alternative to support completion of repair activities. On December 27, 2004, the NRC staff granted verbal authorization to PSEG for the proposed alternative, to be followed up by the NRC staff's final review and written evaluation. The December 16, 2004, and February 18, 2005, letters were submitted to formally docket information previously given in a teleconference by PSEG in support of verbal authorization of the proposed alternative.

Based on the information provided, the NRC staff concludes that the proposed alternative, as described in Relief Request HC-RR-I2-W01, will provide an acceptable level of quality and safety. Therefore, the NRC staff authorizes the proposed alternative, pursuant to Title 10 of the *Code of Federal Regulations*, Section 50.55a(a)(3)(i), for the remainder of the plant life.

The NRC staff's Safety Evaluation is enclosed. If you have any questions, please contact G. Edward Miller, at 301-415-2481.

Sincerely,
/RA/
Darrell J. Roberts, Chief, Section 2
Project Directorate I
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-354

Enclosure: As stated

cc w/encl: See next page

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ADAMS ACCESSION NUMBER: ML051520177

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DATE	8/26/05	8/26/05	8/26/05	5/20/05	8/08/05	8/29/05

OFFICIAL RECORD COPY

Hope Creek Generating Station

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

REQUEST FOR RELIEF HC-RR-I2-W01

SECOND 10-YEAR INSERVICE INSPECTION INTERVAL

HOPE CREEK GENERATING STATION

PSEG NUCLEAR, LLC

DOCKET NO. 50-354

1.0 INTRODUCTION

By letter dated December 1, 2004, as supplemented by letters dated December 16, 2004, and February 18, 2005, PSEG Nuclear, LLC (PSEG or the licensee) submitted a proposed alternative to the requirements of Section XI of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) relating to a full-structural weld overlay repair of a degraded recirculation inlet nozzle to the safe-end weld (N2K) at the Hope Creek Generating Station (Hope Creek). This relief request (RR) was pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.55a(a)(3)(i).

An ultrasonic examination of the Hope Creek N2K weld was performed during the fall 2004 refueling outage. That exam identified an axial indication. PSEG performed the weld overlay repair but required timely Nuclear Regulatory Commission (NRC or the Commission) approval of the proposed alternative to support completion of the repair activities. On December 27, 2004, the NRC staff granted verbal authorization to PSEG for the proposed alternative, to be followed up by the NRC staff's final review and written evaluation.

Authorization of the request allowed the licensee to perform the weld overlay repair with Alloy 52 filler material utilizing the machine gas tungsten arc welding (GTAW) process and an ambient temperature temper bead method with 50 °F minimum preheat temperature and no post-weld heat treatment (PWHT).

2.0 REGULATORY EVALUATION

Pursuant to 10 CFR 50.55a(a)(3), alternatives to the ASME Code requirements may be authorized by the NRC if the licensee demonstrates that: (i) the proposed alternatives provide an acceptable level of quality and safety, or (ii) compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

PSEG submitted the subject request pursuant to 10 CFR 50.55(a)(3)(i), as a proposed alternative to certain ASME Code requirements for the performance of a weld overlay repair of a nozzle to safe-end weld (N2K) for the remaining portion of the plant life.

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The Hope Creek second 10-year ISI program complies with the requirements of the ASME Code Section XI, 1998 Edition, including Addenda through 2000. The second 10-year ISI interval began November 1997 and is projected to end May 2006.

3.0 TECHNICAL EVALUATION

3.1 ASME Code components affected:

The specific components that are affected by this RR are as follows:

Class 1, Examination Category B-F, Item Number B5.10, N2K recirculation inlet nozzle to safe-end weld.

3.2 ASME Code requirements for which an alternative is proposed:

In its submittal, the licensee identified the following paragraphs of the ASME Code for which alternatives are proposed:

- IWA-4421(a) and IWA-4611.1(a), which require removal of the detected flaw
- IWA-4610(a), which requires that the area to be welded be preheated to 300°F for GTAW and requires that thermocouples (TCs) shall be used to monitor process temperatures
- IWA-4631(b), which specifies that the surface of the completed weld on the ferritic steel shall not exceed 100 square inches.
- IWA-4633.2(c), which specifies that the first six layers of the weld shall be deposited with heat inputs within ±10% of that used in the procedure qualification test. Subsequent layers shall be deposited using heat input equal to, or less than, that used for layers beyond the sixth in the procedure qualification. Additionally, the paragraph specifies that at least one layer of weld reinforcement shall be deposited and then this reinforcement shall be removed substantially flush with the surface surrounding the weld using mechanical means.

3.3 Licensee Proposed Alternative

A full structural weld overlay repair is proposed for the subject safe-end to nozzle weld. The nozzle material is SA-508 Class 2 low alloy steel. The safe-end is austenitic stainless steel SA-182 Grade F316L. The existing weld material is Alloy 82 with Alloy 182 buttering.

The weld overlay will be designed consistent with the requirements of NUREG-0313, Revision 2 (which was implemented by Generic Letter (GL) 88-01), ASME Code Case 504-2, "Alternative Rules for Repair of Classes 1, 2, and 3 Austenitic Stainless Steel Piping," ASME Code Case 638, "Similar and Dissimilar Metal Welding Using Ambient Temperature GTAW Temper Bead Technique," and IWB-3640, ASME Code, Section XI 1998 Edition, including Addenda through 2000, with Appendix C.

All welders and welding operators will be qualified in accordance with ASME Code, Section XI and any special requirements of ASME Code, Section XI or applicable ASME Code Cases. Qualified personnel under the AREVA Framatome ANP Welding Program will perform the weld overlay repair.

Welding Procedure Specification (WPS) No. 55-WP3/8/43/F43OLTBSCa3 (machine GTAW with cold wire feed) for welding SFA-5.14, ERNiCrFe-7, UNS N06052, F-No. 43 (commercially known as Alloy 52) will be used. Alloy 52 contains a nominal 30 wt% Cr that imparts excellent resistance to stress-corrosion cracking (SCC). Where localized repairs are required, Alloy 52 or Alloy 152 will be used.

The weld overlay will extend around the full circumference of the safe-end to nozzle weldment location in accordance with NUREG-0313, Revision 2, ASME Code Case 504-2 and GL 88-01. The overlay length will extend across the projected flaw intersection with the outer surface beyond the extreme axial boundaries of the flaw. The design thickness and length has been computed in accordance with the guidance provided in ASME Code Case 504-2 and ASME Code Section XI, IWB-3640, 1998 Edition including Addenda through 2000 and Appendix C. The overlay will completely cover the area of the flaw and other Alloy 182 susceptible material with the highly-resistant Alloy 52 weld filler material.

To provide the necessary weld overlay geometry, it will be necessary to weld on the low alloy steel nozzle base material. A temper bead welding approach will be used for this purpose following the guidance of ASME Code Section XI, ASME Code Case 638. This ASME Code Case provides for machine GTAW temper bead weld repairs to P-No. 3 Group No. 3 nozzle base material at ambient temperature.

The temper bead approach was selected because temper bead welding supplants the requirement for PWHT of the heat-affected zone (HAZ) in welds on low alloy steel material. Also, the temper bead welding technique produces excellent toughness and ductility as demonstrated by welding procedure qualification in the HAZ of welds on low alloy steel materials, and, in this case, results in compressive residual stresses on the inside surface, which assists in inhibiting SCC. This approach provides a comprehensive weld overlay repair and increases the volume under the overlay that can be examined.

The examination requirements for the weld overlay are summarized in Table 1 of the licensee's December 1, 2004 submittal. In a separate submittal dated December 1, 2004, the licensee submitted RR HC-RR-I2-30, as a proposed alternative to the implementation of ASME Code Section XI, Appendix VIII, Supplement 11, "Qualification Requirements for Full Structural Overlaid Wrought Austenitic Piping Welds.

The completed repair shall be given a system leakage test in accordance with ASME Code Section XI, IWA-5000, since the pressure boundary has not been penetrated (no leakage has occurred). In the event an unexpected through-wall defect is identified, either before or during the repair, relief is requested from the post-repair hydrostatic pressure test requirements defined in ASME Code Case 504-2 and IWA-5000. A system leakage test will be performed in accordance with ASME Code Section XI, IWA-5000. Precedence for use of a leak test at normal operating temperature and pressure in lieu of a hydrostatic test has been set with ASME Code Case N416-1 that has been incorporated in the 2000 Addenda of ASME Code Section XI.

Preheat and PWHT are typically required for welding on low alloy steel material. ASME Code

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Section III specifies PWHT on P-No. 3 Group No. 3 base materials unless temper bead welding is performed under limited restrictions (area and depth limits). ASME Code Section XI, 1998 Edition including Addenda through 2000, specifies 300 °F minimum preheat be used for temper bead welding. PWHT cannot be performed and the preheat requirements would necessitate draining the reactor vessel and a portion of the recirculation system piping. This would create unacceptable levels of airborne contamination. Therefore, consistent with as low as reasonably achievable practices and prudent utilization of outage personnel, the reactor vessel will not be drained for this activity. The nozzle and connected piping will be full of water.

Alternatives to ASME Code Case 504-2

ASME Code Case 504-2 was prepared specifically for austenitic stainless steel material. An alternate application for nickel-based austenitic materials (Alloy 52 and Alloy 152) is needed due to the specific materials and configuration of the existing nickel-based alloy weld and buttering.

Exception to ASME Code Case 504-2. Requirement (b)

ASME Code Case 504-2, Requirement (b) requires the weld overlay shall be low carbon (0.035% maximum) austenitic stainless steel. A nickel-based filler is required and Alloy 52 has been selected to be used.

Exception to ASME Code Case 504-2. Requirement (e)

ASME Code Case 504-2, Requirement (e) requires the first two layers of the weld overlay to have a ferrite content of at least 7.5 FN (ferrite number). These measurements will not be performed for this overlay since the nickel alloy filler is a fully austenitic material.

Exception to ASME Code Case 504-2. Requirement (h)

ASME Code Case 504-2, Requirement (h) specifies that a system hydrostatic test shall be performed in accordance with IWA-5000 if the flaw penetrates the pressure boundary. In the event the flaw becomes through wall, post-repair leak testing only, in accordance with ASME Code Section XI, IWA-5000, will be performed.

Alternatives to ASME Code Case 638

Exception to ASME Code Case 638 Paragraph. 1.0(a)

ASME Code Case 638 paragraph 1.0(a) specifies that the maximum weld area on the finished surface shall be 100 square inches. Restoring the structural integrity of the safe-end to nozzle weld with the weld overlay will require welding on more than 100 square inches of surface on the low alloy steel base material.

Exception to ASME Code Case 638 Paragraph. 4.0(b)

ASME Code Case 638 paragraph 4.0(b) specifies that the final weld surface and band area (1.5T width) shall be examined using surface and ultrasonic methods when the completed weld has been at ambient temperature for at least 48 hours. The ultrasonic examination shall be in accordance with ASME Code Section XI Appendix I. Full ultrasonic examination of the 1.5T band will not be performed.

Exception to ASME Code Case 638 Paragraph. 4.0(c)

ASME Code Case 638 paragraph 4.0(c) specifies that the area from which weld-attached TCs are used and have been removed shall be ground and examined using a surface examination method. Thermocouples will not be used.

3.4 NRC Staff's Evaluation

During Refueling Outage 12 at Hope Creek, an axial flaw resulting from intergranular stress-corrosion cracking (IGSCC) was found by ultrasonic testing (UT) in a dissimilar metal weld joint at the 'A' recirculation inlet nozzle to safe-end weld (N2K). The licensee submitted RR HC-RR-I2-W01 to support the weld overlay repair of the degraded N2K weld. In its submittal, PSEG proposed a repair plan which consists of the use of ASME Code Cases 504-2 and 638 with exceptions for a full structural weld overlay repair of the N2K weld. The weld overlay repair is proposed as an alternative to the ASME Code requirements in IWA-4421(a), IWA-4611.1, IWA-4610(a), IWA-4631(b) and IWA-4633.2(c). The staff has evaluated the licensee's bases for the proposed alternative as provided in the licensee's submittals. The staff notes that both ASME Code Cases are approved for use by the NRC in Regulatory Guide 1.147 without limitations or modifications. Both ASME Code cases provide acceptable alternatives to the ASME Code requirements. The details of the exceptions to the two ASME Code cases and the licensee's proposed alternative are described in Section 3.3 of this safety evaluation. The staff's evaluation of the licensee's proposed alternatives relating to the exceptions to ASME Code Cases 504-2 and 638 are provided below.

Exceptions to ASME Code Case 504-2

ASME Code Case 504-2 allows the use of weld overlay repair by deposition of weld reinforcement on the outside surface of the pipe in lieu of mechanically reducing the defect to an acceptable flaw size. However, the subject ASME Code case is designed for repairing austenitic stainless steel piping. Therefore, the material requirements of the carbon content limitation (0.035% maximum) and the delta ferrite content of at least 7.5 FN as delineated in ASME Code Case-504-2 paragraphs (b) and (e) apply only to austenitic stainless steel materials to ensure its resistance to IGSCC. These requirements are not applicable to Alloy 52, a nickel-based material which the licensee will use for weld overlay repair. For material compatibility in welding, the staff considers Alloy 52 to be a better choice of filler material than austenitic stainless steel material for this weld joint configuration.

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Alloy 52 contains about 30% chromium which would provide excellent resistance to IGSCC in a reactor coolant environment. This material is identified as F-No. 43 Grouping for Ni-Cr-Fe, classification UNS N06052 Filler Metal, and has been previously approved by the NRC staff for similar applications. Therefore, the licensee's proposed use of Alloy 52 for the weld overlay repair as an alternative to the requirements of AMSE Code Case 504-2 paragraphs (b) and (e) are acceptable as it will provide an acceptable level of quality and safety.

AMSE Code Case 504-2, paragraph (h) requires a system hydrostatic test to be performed in accordance with IWA-5000 if the flaw penetrated the pressure boundary prior to welding or during welding. Instead, the licensee proposed that a system leakage test be performed if the pressure boundary is penetrated. However, the staff notes that the axial flaw detected in weld N2K is not a through-wall flaw and, in the licensee's February 18, 2005 response to the staff's request for additional information (RAI), the licensee stated that no leak was observed during overlay repair of the subject weld. Since the pressure boundary of weld N2K was not penetrated before or during the repair, the licensee's proposed alternative to the system hydrostatic test requirement is not needed.

<u>Exceptions to ASME Code Case 638</u>

ASME Code Case 638 paragraph 1(a) limits the size of the repair to 100 square inches maximum. However, because of the diameter of the N2K nozzle (14 inches), this restriction would limit the weld overlay length to 2.25 inches on the low alloy steel nozzle material. This distance could be justified as an adequate axial length to provide for load redistribution from the weld overlay back into the nozzle without violating the applicable stress limits of Section III for primary, local and bending stresses and secondary peak stresses. However, this axial length will not permit a complete ultrasonic inspection of the area involving the crack region from the nozzle side of the weld as required by Paragraph 4.0(b) of ASME Code Case 504-2. Therefore, the axial length of the overlay on the low alloy steel nozzle will be extended to encompass an area of approximately 180 square inches for the temper bead weld.

ASME Code Case 638 limits the size of the repair to 100 square inches maximum and a depth not greater than half of the ferritic base metal thickness. Some of the reasons for these limits are: distortion of weld and base metal, cracking in weld and base metal, and large residual stresses. The final weld surface area requested in this RR is significantly larger than that allowed by the ASME Code.

Since the girth weld and butter, and the weld overlay are fabricated from austenitic materials, with inherent toughness, no cracking in the overlay is expected to occur due to the shrinkage associated with the weld overlay. With respect to the low alloy steel, many temper bead weld overlays have been applied in the boiling-water reactor industry to these nozzle to safe end locations. In no instance has there been any reported cracking due to the weld overlay application. The stiffness and high toughness inherent in the low alloy steel nozzle is expected to protect against any cracking and limit any distortion that might occur in the low alloy steel nozzle. The licensee will measure and evaluate axial shrinkage for impact on the nozzle and safe end materials and piping system in accordance with ASME Code Case 504-2. Also, any cracking which might occur should be detected by the final non-destructive examination (NDE) of the weld overlay.

Since laboratory testing and field experience have been documented qualifying the temper bead weld overlay repair for safe end to nozzle welds and these efforts and experience have demonstrated that the remedy provides a quality and sound repair to these joints, the staff concludes that the nozzle to safe end weld overlay repair discussed in the subject RR can be applied to the nozzle without detrimental effects.

ASME Code Case 638 Paragraph, 4.0(b) specifies that the final weld surface and band area (1.5T width) shall be examined using surface and ultrasonic methods when the completed weld has been at ambient temperature for at least 48 hours. The licensee proposed not to perform the full ultrasonic examination of the 1.5T band around the weld overlay. This was discussed during the conference call on December 27, 2004, and documented by the licensee on February 18, 2005, as summarized below:

(1) The weld overlay will extend into the blend radius of the nozzle for the purpose of eliminating a stress riser on the nozzle and providing additional outside-diameter (OD) surface area for UT examination of the defect in the nozzle to safe end weld or weld HAZ. UT examination of the nozzle blend radius would likely be unsatisfactory as the UT return signal would be difficult to obtain and to interpret.

(2) The concern of hydrogen cracking associated with temper bead welding on low alloy steels is minimized with the use of the GTAW technique. Shielding gas is used and intermediate cleaning is performed to minimize the presence of contaminants or moisture on the surface.

(3) Prior studies have illustrated that the high hardness produced by the temper bead welding at the toe region in the low alloy steel is a very short range phenomenon. The area of concern is the toe of the overlay in the low alloy steel near the OD surface. This area will be extensively interrogated by surface NDE technique after a post-welding 48-hour holding period.

Based on the above, the staff concludes that the licensee's proposal of not performing UT of the 1.5T band is acceptable. The conclusion is based on the consideration that the UT inspection of the 1.5T band area will not be meaningful and surface examination of the susceptible area will be performed.

ASME Code Case 638 Paragraph 4.0(c) specifies that the area from which weld-attached TCs have been removed shall be ground and examined using a surface examination method. To minimize the personnel exposure associated with the installation and removal of the TCs, the licensee proposed to use a contact pyrometer to verify preheat temperature (50 °F, minimum) and interpass temperature (350 °F, maximum). In the licensee's February 18, 2005, response to the NRC staff's RAI, the licensee stated that the pyrometer used for this repair was calibrated with an Omega Temperature Calibrator, VH-3911, which was calibrated by SIMCO electronic. The certificate from SIMCO shows National Institute of Standards and Technology traceability. The staff concludes that the licensee's use of this contact pyrometer in lieu of TC is acceptable because the contact pyrometer used in this repair has the capability of monitoring the process temperatures and was properly calibrated.

Based on the above evaluation, the staff has determined that the licensee's proposed

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alternative relating to weld overlay repair of the subject weld is acceptable, because it will provide an acceptable level of quality and safety.

4.0 CONCLUSION

The NRC staff has reviewed the licensee's submittal and determined that, in accordance with 10 CFR 50.55a(a)(3)(i), the proposed alternative program will provide an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the staff authorizes the proposed alternative for the remainder of the Hope Creek plant life.

All other ASME Code, Section XI requirements for which relief was not specifically requested and approved in this RR remain applicable, including third-party review by the Authorized Nuclear Inservice Inspector.

Principal Contributor: W. Koo

Date: August 29, 2005

A.8 Hope Creek Nozzle N2A (RR, RAI, and SER)

PSEG Nuclear LLC
P.O. Box 236, Hancocks Bridge, New Jersey 08038-0236

10CFR50.55a

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LR-N07-0273

PSEG
Nuclear LLC

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

HOPE CREEK GENERATING STATION
FACILITY OPERATING LICENSE NO. NPF-57
DOCKET NO. 50-354

SUBJECT: RELIEF REQUEST HC-RR-I2-W02
PROPOSED ALTERNATIVE REPAIR METHOD

In accordance with 10 CFR 50.55a, Codes and Standards, paragraph (a)(3)(i), PSEG Nuclear LLC (PSEG) is submitting a proposed alternative to the requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI, Rules for Inservice Inspection of Nuclear Power Plant Components. This proposed alternative described in the attachments would permit the use of a full structural weld overlay repair for an indication identified in the N2A recirculation inlet nozzle safe-end to nozzle weld joint.

The Hope Creek Unit 1 Second Ten-Year Interval Inservice Inspection (ISI) Program complies with the requirements of the ASME Code Section XI, 1998 Edition, including Addenda through 2000. The Second 10-year interval began on December 13, 1997 and is currently projected to end December 12, 2007.

Due to the need to obtain approval of this alternative prior to startup of the unit from the current outage, we are requesting your review and approval prior to Operational Condition 2, which is currently scheduled to occur on October 30, 2007. No new commitments are identified in this letter.

If you have any questions or require additional information, please contact Mr. Philip J. Duca at (856) 339-1640.

Sincerely,

George P. Barnes
Site Vice President – Hope Creek

Attachment 1 - Overview
Attachment 2 - Relief Request HC-RR-I2-W02

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Attachment 1

Overview of Alternative Repair for the
N2A Recirculation Inlet Nozzle Safe end-to-nozzle Weld

Introduction

During Hope Creek's Refueling Outage (RFO) 14 Inservice Inspection (ISI) ultrasonic examinations (UT), the dissimilar metal joint at the N2A recirculation safe end-to-nozzle is receiving an unscheduled inspection in response to OE24381, "Circumferential Flaw in Reactor Recirculation Riser Nozzle to Safe End Weld." This is a Code examination category R-A, Item R1.14 (formerly classified as B-F, Item No. B5.10) weld. This Alloy 82 weld connects an approximately 13.976 inches outside diameter (OD) by 11.102 inches inside diameter (ID) stainless steel SA-182 Grade F316L safe-end buttered with Alloy 182 to the SA-508 Class 2 low alloy steel nozzle buttered with Alloy 182.

This weld is also contained within the Intergranular Stress Corrosion Cracking (IGSCC) augmented examination program as a category C weld. Accordingly, this re-examination is being performed in accordance with the requirements of Generic Letter 88-01," NRC Position on IGSCC in BWR Austenitic Piping", and BWRVIP-75-A: BWR Vessel and Internals Project, Technical Bases for Revisions to GL 88-01 Inspection Schedules." The weld will be examined with an ASME Section XI, Appendix VIII, Supplement 10 qualified, Electric Power Research Institute (EPRI) – Performance Demonstration Initiative (PDI) procedure. The inspection will use ultrasonic (UT) refracted longitudinal waves in the axial and circumferential directions. Results of the examination will be available upon its completion.

PSEG Nuclear will employ a weld overlay repair using machine gas tungsten arc welding (GTAW) and Alloy 52M weld metal. Weld overlay repairs have been used in the Boiling Water Reactor (BWR) industry since the 1980s to repair flaws due to SCC, including safe end-to-nozzle welds. The experience with weld overlays in the BWR industry has been excellent. Weld overlays have been approved as an effective SCC mitigating technique in USNRC Generic Letter 88-01/ NUREG-0313, Rev. 2 and BWRVIP-75-A.

Degradation Mechanism

Experience at similar joints on recirculation inlet nozzle (N2K) at Hope Creek in 2004, and at other BWRs in the last few years identified the cause of such flaws were due to stress corrosion cracking (SCC).

The original Construction Code for the reactor vessel is ASME Section III, 1968 Edition, including Addenda through Summer 1970, and Paragraph NB-3338.2(d)(4) of the Winter 1971 Addenda supersedes Paragraph I-613(d) of the 1968 Edition.

The current Construction Code for the safe-end is ASME Section III, 1974 Edition, including Addenda through Summer 1976. The existing safe end-to-nozzle weld is Alloy 82 and connects a stainless steel SA-182 Grade F316L safe-end buttered with Alloy

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182, to the SA-508 Class 2 low alloy steel nozzle, also buttered with Alloy 182 (see Attachment 2, Figure 1). A portion of the original Alloy 82/182 safe end-to-nozzle weld remains on the nozzle side as a result of installing a modified safe-end with an integrally attached thermal sleeve prior to going into service. The N2A weld underwent Mechanical Stress Improvement Process (MSIP) treatment during RFO8 (1999).

The function of the N2A nozzle is to connect a portion of the recirculation system inlet piping to the reactor vessel (RV).

SCC Mitigation by Weld Overlay Repairs

PSEG Nuclear has decided to mitigate the flaw employing a weld overlay repair using machine GTAW and Alloy 52M weld metal. Weld overlay repairs have been used in the BWR industry since the 1980s to repair flaws due to SCC, including safe end-to-nozzle welds. The experience with weld overlays in the BWR industry has been excellent. It is approved as an effective SCC mitigating technique in USNRC Generic Letter 88-01/ NUREG-0313, Rev. 2 and BWRVIP-75-A.

Although MSIP was performed, as a further preventative measure, implementation of an overlay at the N2A safe end-to-nozzle weld will provide further mitigation as discussed below:

1. The overlay is designed as a standard (full structural) overlay per the structural requirements in ASME Code Case N-504-3 and Nonmandatory Appendix Q using paragraph IWB-3640 of ASME Section XI. In the design of a standard overlay, a 360 degree "through the thickness" circumferential flaw is assumed and, therefore, no credit is taken for any portion of the original pipe wall. Hence, all the weld material, where flaw initiation is believed to have occurred, is essentially assumed to be completely flawed. The full ASME Section XI safety margins are restored after the application of a standard overlay.

2. The application of the overlay results in a favorable residual stress field on the inside of the component, which arrests further flaw growth. This is because the overlay establishes compressive residual stresses on the inner half of the pipe, which prevents further SCC.

3. The nickel based Alloy 52M weld wire (ASME Section II, Part C, SFA-5.14, ERNiCrFe-7A, UNS N06054), which is used for the GTAW overlay repair, has been shown to be highly resistant to SCC. This alloy, containing nominally 30 wt. % chromium, and its corresponding wrought material, Alloy 690, have been demonstrated in laboratory testing, in modeling studies, and in the field, to be highly resistant to SCC initiation and growth in the BWR environment.

Overview of Alternative Repair for the
N2A Recirculation Inlet Nozzle Safe end-to-nozzle Weld

Inservice Inspection

Subsequent inservice examinations of the overlay will be performed in accordance with the requirements of BWRVIP-75-A.

Similar Plant Experience

The requested alternatives for the repair at Hope Creek Unit 1 are consistent with the documented safety evaluation reports (SER) previously issued for Hope Creek in 2004 on the recirculation inlet safe end-to-nozzle (N2K) weld, as well as other plants including Duane Arnold (TAC No. MA8663), Perry, Nine Mile Point 2 and Susquehanna 1.

The SER for Palo Verde Units 1, 2, and 3 issued June 21, 2007 (TAC Nos. MD4272, M4273, MD4274, MD5579, MD5580, and MD55810) encompasses the requested alternatives for starting the 48-hour hold period at the completion of the third layer, crediting the first dilution layer based on chromium content, and the use of alloy 52M rather than low carbon austenitic stainless steel.

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Attachment 2

10 CFR 50.55a Relief Request HC-RR-I2-W02

Proposed Alternative In Accordance with 50.55a(a)(3)(i)
Alternative Provides Acceptable Level of Quality and Safety-

1. ASME Code Components Affected

Code Class:	1
References:	ASME Section XI, 1998 Edition, including and through the 2000 Addenda ASME Section XI, Case N-504-3 ASME Section XI, Case N-638-1 NUREG-0313 Rev 2 Generic Letter 88-01 BWRVIP-75-A
Examination Category:	R-A (formerly B-F)
Item Number:	R1.14 (formerly B5.10)
Description:	Alternative Repair for the N2A Recirculation Inlet Nozzle, Safe end-to-Nozzle Weld
Component Number:	N2A Recirculation Inlet Nozzle

2. Applicable Code Edition and Addenda

The Hope Creek Unit 1 Second Ten-Year Interval In-service Inspection (ISI) Program complies with the requirements of the ASME Code Section XI, 1998 Edition, including Addenda through 2000. The Second 10-year interval began on December 13, 1997 and is currently projected to end December 12, 2007.

3. Applicable Code Requirements

The following information is from ASME Boiler and Pressure Vessel Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," 1998 Edition, including Addenda through 2000, which identifies the specific requirements included in this alternative:

IWA-4421(a) and IWA-4611.1(a) require removal of the detected flaw.

IWA-4610(a) requires that the area to be welded shall be preheated to 300°F minimum for gas tungsten arc welding (GTAW).

IWA-4610(a) requires that thermocouples (TCs) shall be used to monitor process temperatures.

IWA-4631(b) specifies that the surface of the completed weld on the ferritic steel shall not exceed 100 square inches.

4. Reason for Request

The request is based on restoring the structural integrity of the N2A recirculation inlet nozzle, safe end-to-nozzle weld joint using technically sound welding practices and non-destructive examination (NDE), while limiting repair personnel radiological exposure to the maximum extent practical. The following cited Code articles identify the actions that would be required if the repair were conducted in accordance with the Code without exception.

IWA-4421(a) and IWA-4611.1(a) require defect removal in this case. The repair cavity would extend through wall since OD removal would be required. ID removal of the indication would be impractical since it would require the removal of the thermal sleeve.

IWA-4610(a) requires the area to be welded shall be preheated to 300°F minimum for GTAW. Since the nozzle will remain full of water, establishing the 300°F minimum preheat temperature cannot be achieved.

IWA-4610(a) also requires the use of TCs to monitor process temperatures. Due to the personnel radiological exposure associated with the installation and removal of the TCs, the nozzle configuration, and since the nozzle will be full of water, a calibrated contact pyrometer will be used in lieu of TCs to verify preheat and interpass temperature limits are met.

IWA-4631(b) specifies the surface of the completed weld on the ferritic steel shall not exceed 100 square inches. Restoring the structural integrity of the safe end-to-nozzle weld with the weld overlay may require welding on more than 100 square inches of surface on the low alloy steel base material.

Pursuant to 10 CFR 50.55a(a)(3)(i), an alternative is requested on the basis that the proposed repair will provide an acceptable level of quality and safety.

5. Proposed Alternative and Basis for Use

A full structural weld overlay repair is proposed for the safe end-to-nozzle weldments. The nozzle material is SA-508 Class 2 low alloy steel. The safe-end is austenitic stainless steel SA-182 Grade F316L. The existing weld material is Alloy 82 with Alloy 182 buttering.

The weld overlay will be implemented consistent with the requirements of NUREG-0313, Revision 2 (which was implemented by Generic Letter 88-01), BWRVIP-75-A, Code Case N-504-3 "Alternative Rules for Repair of Classes 1, 2, and 3 Austenitic Stainless Steel Piping", Nonmandatory Appendix Q, Code Case N-638-1 "Similar and Dissimilar Metal Welding Using Ambient Temperature GTAW Temperbead Technique", and IWB-3640, ASME Section XI 1998 Edition, including Addenda through 2000 with Appendix C.

Welder Qualification And Welding Procedures

All welders and welding operators will be qualified in accordance with ASME Section IX and any special requirements of ASME XI or applicable code cases.

Machine GTAW with cold wire feed for welding SFA-5.14, ERNiCrFe-7A, UNS N06054, F-No. 43 (commercially known as Alloy 52M) will be used.

Welding Wire

A consumable welding wire highly resistant to SCC was selected for the overlay material. Alloy 52M contains a nominal 30 wt% Cr that imparts excellent resistance to SCC.

Weld Overlay Design

The weld overlay will extend around the full circumference of the safe end-to-nozzle weldment location in accordance with NUREG-0313, Rev. 2, BWRVIP-75-A, Code Case N-504-3, Nonmandatory Appendix Q, and Generic Letter 88-01. The overlay length will extend across the projected flaw intersection with the outer surface beyond the extreme axial boundaries of the flaw. The design thickness and length has been computed in accordance with the guidance provided in Code Case N-504-3, Nonmandatory Appendix Q, and ASME Section XI, IWB-3640, 1998 Edition including Addenda through 2000 and Appendix C. The overlay will completely cover the area of the flaw and the Alloy 82 and 182 materials with the highly resistant Alloy 52M weld filler material.

To provide the necessary weld overlay geometry, it will be necessary to weld on the low alloy steel nozzle base material. A temperbead welding approach will be used for this purpose following the guidance of ASME Section XI Code Case N-638-1

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Alternative Provides Acceptable Level of Quality and Safety-

"Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temperbead Technique". This Code Case provides for machine GTAW temperbead weld repairs to P-No. 3 Group No. 3 nozzle base material at ambient temperature. The temperbead approach was selected because temperbead welding supplants the requirement for post weld heat treatment (PWHT) of the heat-affected zone (HAZ) in welds on low alloy steel material. Also, the temperbead welding technique produces excellent toughness and ductility as demonstrated by welding procedure qualification in the HAZ of welds on low alloy steel materials. This results in compressive residual stresses on the inside piping surface in addition to those imparted by MSIP which assists in inhibiting SCC initiation and growth.

The overlay length conforms to the guidance of Code Case N-504-3 and Nonmandatory Appendix Q, which satisfies the stress requirements.

Examination Requirements

Table 1 summarizes the examination requirements for the weld overlay repair.

Code Case N-504-3, and Nonmandatory Appendix Q, specify UT using methods and personnel qualified in accordance with ASME Section XI, Appendix VIII. The UT techniques to be used for the final post-weld examination have been qualified through the Performance Demonstration Initiative (PDI) which satisfies the requirements of ASME Section XI, Appendix VIII. Therefore, the acceptance criteria that will be used for the UT will be ASME Section XI Nonmandatory Appendix Q, Weld Overlay Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping Weldments as clarified under Exceptions to Code Case N-638-1 Paragraph 4.0(b).

Pressure Testing

The completed repair shall be given a system leakage test in accordance with ASME Section XI, IWA-5000.

Preheat and Post Weld Heat Treatment (PWHT) Requirements

Preheat and PWHT are typically required for welding on low alloy steel material. ASME Section III specifies PWHT on P-No. 3 Group No. 3 base materials unless temperbead welding is performed under limited restrictions (area and depth limits). ASME Section XI, 1998 Edition including Addenda through 2000, specifies 300°F minimum preheat be used for temperbead welding. PWHT cannot be performed and the preheat requirements would necessitate draining the reactor vessel (RV) and a portion of the recirculation system piping. This would create unacceptable levels of airborne contamination. Therefore, consistent with ALARA practices and prudent utilization of outage personnel, the RV will not be drained for this activity. The nozzle and connected piping will be full of water.

Alternatives to Code Case N-504-3

Code Case N-504-3 Applicability to Nickel Based Austenitic Steel

Code Case N-504-3 was prepared specifically for austenitic stainless steel material. An alternate application for nickel based austenitic materials (Alloy 52M) is needed due to the specific materials and configuration of the existing nickel based alloy weld and buttering.

Exception to Code Case N-504-3, Requirement (b)

Code Case N-504-3, Requirement (b) requires the weld overlay shall be low carbon (0.035% maximum) austenitic stainless steel. A nickel-based filler Alloy 52M will be used.

Exception to Code Case N-504-3, Requirement (e)

Code Case N-504-3, Requirement (e) requires the first two layers of the weld overlay to have a ferrite content of at least 7.5 FN (Ferrite Number). These measurements will not be performed for this overlay since the nickel alloy filler is a fully austenitic material.

Exception to Code Case N-504-3, Requirement (h)

Code Case N-504-3, Requirement (h) specifies that a system hydrostatic test shall be performed in accordance with IWA-5000 if the flaw penetrates the pressure boundary. In the event the flaw becomes through wall, a system leakage test in accordance with ASME Section XI, IWA-5000, will be performed in lieu of the system hydrostatic test.

Alternatives to Code Case N-638-1

Exception to Code Case N-638-1 Paragraph 1.0(a)

Code Case N-638-1 paragraph 1.0(a) specifies that the maximum weld area on the finished surface shall be 100 square inches. Restoring the structural integrity of the safe end-to-nozzle weld with the weld overlay may require welding on more than 100 square inches of surface on the low alloy steel base material.

Exception to Code Case N-638-1 Paragraph 4.0(b)

Code Case N-638-1 paragraph 4.0(b) specifies that the final weld surface and band area (1.5T width) shall be examined using a surface and ultrasonic methods when the completed weld has been at ambient temperature for at least 48 hours. The ultrasonic examination shall be in accordance with ASME Section XI Appendix I. Full ultrasonic examination of the 1.5T band will not be performed and the examination will be performed no sooner than 48 hours after completion of the third temperbead layer over the ferritic base material. UT examinations will be performed in accordance with ASME Section XI Appendix VIII Supplement 11.

Exception to Code Case N-638-1 Paragraph 4.0(c)

Code Case N-638-1 paragraph 4.0(c) specifies that the area from which weld-attached thermocouples have been removed shall be ground and examined using a surface examination method. Thermocouples will not be used.

Basis For The Alternative to ASME Section XI

IWA-4421(a) and **IWA-4611.1(a)** require defect removal in this case. The repair cavity would extend through wall since OD removal would be required. The ID is inaccessible due to the thermal sleeve. Therefore the flaw will not be removed. Structural weld overlays covering flaws are permitted by Code Case N-504-3, provided the necessary weld overlay geometry is used. Therefore, this alternative provides an acceptable level of quality and safety.

IWA-4610(a) requires the area to be welded shall be preheated to 300°F minimum for GTAW. Since the nozzle will remain full of water, establishing the 300°F minimum preheat temperature cannot be achieved. Code Case N-638-1, paragraph 1.0(b) provides for machine GTAW temperbead weld repairs to P-No. 3 Group No. 3 nozzle base material at ambient temperature. The ambient temperature temperbead approach was selected because temperbead welding eliminates the requirement for PWHT of the heat-affected zones in welds on low alloy steel material. Also, the temperbead welding technique produces excellent toughness and ductility, as demonstrated by welding procedure qualification, in HAZ of welds on low alloy steel materials. Therefore, this alternative provides an acceptable level of quality and safety.

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Proposed Alternative In Accordance with 50.55a(a)(3)(i)
Alternative Provides Acceptable Level of Quality and Safety-

IWA-4610(a) also requires the use of TCs to monitor process temperatures. Due to the personnel radiological exposure associated with the installation and removal of the TCs, the nozzle configuration, and since the nozzle will be full of water, TCs will not be used to verify that preheat and interpass temperature limits are met. In lieu of TCs, the preheat and interpass temperatures will be measured using a contact pyrometer. In the first three layers, the interpass temperature will be measured every three to five passes. After the first three layers, interpass temperature measurements will be taken every six to ten passes for the subsequent layers. Contact pyrometers will be calibrated in accordance with approved calibration and control program documents. The use of a contact pyrometer provides equivalent temperature monitoring capabilities and is recognized as acceptable calibrated measuring and test equipment (M&TE). Therefore, this alternative provides an acceptable level of quality and safety.

IWA-4631(b) specifies the surface of the completed weld on the ferritic steel shall not exceed 100 square inches. Restoring the structural integrity with the weld overlay of the safe end-to-nozzle weld may require welding on more than 100 square inches of surface on the low alloy steel base material.

EPRI Technical Report 1003616, "Additional Evaluations to Expand Repair Limits for Pressure Vessels and Nozzles" provides technical justification for exceeding the size of the temperbead repairs up to a finished area of 500 square inches over the ferritic material. The area of the finished overlay over the ferritic material will be substantially less than this. The weld overlay will extend over the ferritic material so that qualified UT of the required volume can be performed. There have been a number of temperbead weld overlay repairs applied to safe end-to-nozzle welds in the nuclear industry, and a weld overlay repair having a 300 square inches surface area was recently approved for Susquehanna Steam Electric Station and D.C. Cook.

Results of industry analyses and testing performed to date have indicated that there is no direct correlation of amount of surface area repaired when comparing residual stresses using temperbead welding. Residual stresses associated with larger area repairs (>100 square inches) remain compressive at an acceptable level. Therefore, this alternative provides an acceptable level of quality and safety.

Basis for the Alternative to the Code Cases Applied

<u>Exception to Code Case N-504-3, Requirement (b)</u>

A consumable welding wire highly resistant to SCC was selected for the overlay material. This material, designated as UNS N06054, F-No. 43, is a nickel based alloy weld filler material, commonly referred to as Alloy 52M and will be deposited using the machine GTAW process with cold wire feed. Alloy 52M contains nominally 30 wt% chromium, which imparts excellent corrosion resistance to the material. By comparison, Alloy 82 is identified as a SCC resistant material in NUREG-0313 Revision 2 and contains nominally 20 wt% chromium while Alloy 182 has a nominal chromium content of 15 wt%. With its higher chromium content than Alloy 82/182, Alloy 52M provides an even higher level of resistance to SCC consistent with the requirements of the Code Case. Therefore, this alternative provides an acceptable level of quality and safety.

Exception to Code Case N-504-3, Requirement (e)

The composition of nickel-based Alloy 52M is such that delta ferrite does not form during welding. Delta ferrite measurements will not be performed for this overlay because Alloy 52M welds contain no delta ferrite due to the high nickel composition (nominally 60 wt% nickel).

The weld overlay is deposited using Nickel Alloy 52M filler metal instead of austenitic stainless steel filler metals. The basis for crediting the first layer towards the required design thickness will be based on the chromium content of the nickel alloy filler metal. For BWR applications, a diluted layer may be credited toward the required thickness provided the portion of the layer over the austenitic base material, austenitic filler material weld, and the associated dilution zone from an adjacent ferritic base material contain at least 20% chromium, and the chromium content of the deposited weld metal is determined by chemical analysis of the production weld or of a representative coupon taken from a mockup prepared in accordance with the welding procedure specification (WPS) for the production weld.

Structural Integrity Associates report SI-05-030, Rev. 0, "Effect Of Chromium Content On Nickel-Base Alloy SCC Resistance," is available on the ASME website in support of crediting the first overlay layer toward design thickness for both BWR and PWR applications. The report concludes that a minimum of 20% chromium must be present in the first overlay layer to be considered resistant to IGSCC in the BWR environment.

Therefore, this alternative provides an acceptable level of quality and safety.

10 CFR 50.55a Relief Request HC-RR-I2-W02

Proposed Alternative In Accordance with 50.55a(a)(3)(i)
Alternative Provides Acceptable Level of Quality and Safety-

Exception to Code Case N-504-3, Requirement (h)

Code Case N-504-3 requirement (h) specifies a system hydrostatic test shall be performed in accordance with IWA-5000 if the flaw penetrates the pressure boundary. System leakage testing in accordance with ASME Section XI, IWA-5000, will be performed. Therefore, this alternative provides an acceptable level of quality and safety.

Exception to Code Case N-638-1 Paragraph 1.0(a)

Code Case N-638-1 paragraph 1.0(a) specifies that the maximum weld area on the finished surface shall be 100 square inches. Restoring the structural integrity with the weld overlay of the safe end-to-nozzle weld may require welding on more than 100 square inches of surface on the low alloy steel base material.

EPRI Technical Report 1003616 provides technical justification for exceeding the size of the temperbead repairs up to a finished area of 500 square inches over the ferritic material. The area of the finished overlay over the ferritic material will be substantially less than this. The weld overlay will extend over the ferritic material so that qualified UT of the required volume can be performed. There have been a number of temperbead weld overlay repairs applied to safe end-to-nozzle welds in the nuclear industry, and a weld overlay repair having a 300 square inches surface area was recently approved for Susquehanna Steam Electric Station and D.C. Cook.

Results of industry analyses and testing performed to date have indicated that there is no direct correlation of amount of surface area repaired when comparing residual stresses using temperbead welding. Residual stresses associated with larger area repairs (>100 square inches) remain compressive at an acceptable level. Therefore, this alternative provides an acceptable level of quality and safety.

Exception to Code Case N-638-1 Paragraph 4.0(b)

Code Case N-638-1 Paragraph 4.0(b) specifies that the final weld surface and band area (1.5T width) shall be examined using surface and ultrasonic methods when the completed weld has been at ambient temperature for at least 48 hours. The required liquid penetrant examination of 4.0 (b) will be performed. In lieu of the ultrasonic examination in accordance with Appendix I, the ultrasonic examination will be in accordance with Code Case N-504-3, and Nonmandatory Appendix Q which states to perform UT examinations in accordance with ASME Section XI Appendix VIII. Examination of the weld overlay covering the ferritic base material shall be

10 CFR 50.55a Relief Request HC-RR-I2-W02

Proposed Alternative In Accordance with 50.55a(a)(3)(i)
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performed no sooner than 48 hours after completion of the third temperbead layer over the ferritic base material.

For the application of the weld overlay repair addressed in this request the appropriate examination methodologies and volumes are provided in Code Case N-504-3 and Nonmandatory Appendix Q. Code Case N-638-1 applies to any type of welding where a technique is to be employed and is not specifically written for a weld overlay repair. EPRI research (Technical Report 1013558, *Temperbead Welding Applications – 48 Hour Hold Requirement for Ambient Temperature Temperbead Welding*) has shown that it is not necessary to wait until ambient temperature is reached before initiating the 48-hour hold in order to assure adequate hydrogen removal. No further tempering or potential hydrogen absorption effects will occur after deposition of the third overlay layer. The described approach has previously been reviewed and approved by the NRC (*Safety Evaluation By the Office of Nuclear Reactor Regulation Related To ASME Code, Section XI, Alternatives for Union Electric Company Callaway Plant, Unit 1, Docket No. 50-483, July 10, 2007*). Therefore, this alternative provides an acceptable level of quality and safety.

<u>Exception to Code Case N-638-1 Paragraph 4.0(c)</u>

Code Case N-638-1 paragraph 4.0(c) specifies that the area from which weld-attached thermocouples have been removed shall be ground and examined using a surface examination method. Due to the personnel radiological exposure associated with the installation and removal of the TCs, the nozzle configuration, and since the nozzle will be full of water, TCs will not be used to verify that preheat and interpass temperature limits are met. In lieu of TCs, a calibrated contact pyrometer will be used to verify preheat temperature and interpass temperature compliance with the WPS requirements. Therefore, this alternative provides an acceptable level of quality and safety.

Summary

The use of the 52M overlay filler material provides excellent resistance to IGSCC and develops an effective barrier to flaw growth. Also, temperbead welding techniques produce excellent toughness and ductility in the weld HAZ low alloy steel materials, and in this case result in compressive residual stresses on the inside surface that help to inhibit SCC. The design of the overlay for the safe end-to-nozzle weldment uses methods that are standard in the industry. There are no new or different approaches in this overlay design which are considered first of a kind or inconsistent with previous approaches. The overlay will be designed as a full structural overlay in accordance with Code Case N-504-3. The temperbead welding technique that will be implemented in accordance with Code Case N-638-1 will produce a tough, ductile, corrosion-resistant overlay.

Use of Code Cases N-504-3 and N-638-1 has been conditionally accepted in Regulatory Guide 1.147, Revision 15, as providing an acceptable level of quality and safety.

PSEG concludes that the alternative repair approach described above provides an acceptable level of quality and safety to satisfy the requirements of 10CFR50.55a(a)(3)(i).

6. Duration of Proposed Alternative

This alternative repair is requested for the remainder of the plant life.

7. Precedents

The requested alternatives for the repair at Hope Creek Unit 1 are consistent with the documented safety evaluation reports (SER) previously issued for Hope Creek in 2004 on the recirculation inlet safe end-to-nozzle (N2K) weld, as well as other plants including Duane Arnold (TAC NO. MA8663), Perry, Nine Mile Point 2 and Susquehanna 1.

The SER for Palo Verde Units 1, 2, and 3 issued June 21, 2007 (TAC Nos. MD4272, M4273, MD4274, MD5579, MD5580, and MD55810) encompasses the requested alternatives for starting the 48-hour hold period at the completion of the third layer, crediting the first dilution layer based on chromium content, and the use of alloy 52M rather than low carbon austenitic stainless steel.

Document Control Desk **Attachment 2**
LR-N07-0273

10 CFR 50.55a Relief Request HC-RR-I2-W02

Proposed Alternative In Accordance with 50.55a(a)(3)(i)
-Alternative Provides Acceptable Level of Quality and Safety-

TABLE 1
Examination Requirements

Exam Description	Method	Technique	Reference
As Found Flaw Detection	UT	PDI Qualified Implementing ASME Section XI Appendix VIII Supplement 10	IWB-3514*
Surface Prior to Welding	PT	Color Contrast (Visible) Penetrant	N-504-3(c) Appendix Q*
Final Weld Overlay Surface	PT	Color Contrast (Visible) Penetrant	N-504-3(j) Appendix Q*
Final Weld Overlay for Thickness (as-built dimensional verification)	Manual Mechanical	Pre and post overlay outside diameter and profile measurement	Appendix Q
Final Weld Overlay and Outer 25% of the Underlying Wall Thickness Volumetric Preservice	Manual UT	PDI Qualified Implementing ASME Section XI Appendix VIII Supplement 11	Appendix Q*

* Acceptance Criteria

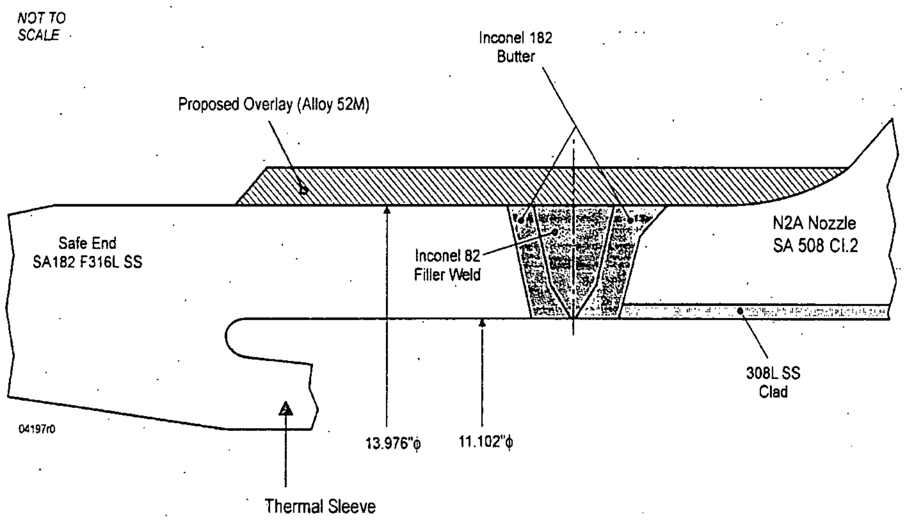
Document Control Desk **Attachment 2**
LR-N07-0273

10 CFR 50.55a Relief Request HC-RR-I2-W02

Proposed Alternative In Accordance with 50.55a(a)(3)(i)
-Alternative Provides Acceptable Level of Quality and Safety-

Figure 1

N2A Recirculation Inlet Nozzle/Safe-end Configuration with Structural Overlay



PSEG Nuclear LLC
P.O. Box 236, Hancocks Bridge, New Jersey 08038-0236

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10CFR50.55a

LR-N07-0281

PSEG
Nuclear LLC

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

HOPE CREEK GENERATING STATION
FACILITY OPERATING LICENSE NO. NPF-57
DOCKET NO. 50-354

Subject: **RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION, RELIEF REQUEST HC-RR-I2-W02 PROPOSED ALTERNATIVE REPAIR METHOD**

References: (1) PSEG Letter LR-N07-0273
RELIEF REQUEST HC-RR-I2-W02
PROPOSED ALTERNATIVE REPAIR METHOD
Dated: October 19, 2007

In Reference 1, PSEG Nuclear LLC (PSEG) proposed an alternative to the requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI, Rules for Inservice Inspection of Nuclear Power Plant Components. This proposed alternative would permit the use of a full structural weld overlay repair for an indication identified in the N2A recirculation inlet nozzle safe-end to nozzle weld joint.

On October 26, 2007, the NRC provided PSEG a draft Request for Additional Information (RAI) on the Reference 1 submittal. PSEG and the NRC discussed the draft RAI in a conference call on October 29, 2007. The response to the RAI is provided in the attachment to this letter.

If you have any questions or require additional information, please contact Mr. Philip J. Duca at (856) 339-1640.

Sincerely,

George P. Barnes

George P. Barnes
Site Vice President – Hope Creek

Attachment

A047
NRR

95-2168 REV. 7/99

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LR-N07-0281

CC Mr. S. Collins, Administrator - Region I
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475 Allendale Road
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Mr. R. Ennis, Licensing Project Manager – Hope Creek
U. S. Nuclear Regulatory Commission
Mail Stop 08B1
Washington, DC 20555

Mr. P. Mulligan
Bureau of Nuclear Engineering
P. O. Box 415
Trenton, NJ 08625

USNRC Senior Resident Inspector – Hope Creek (X24)

Attachment
LR-N07-0281

RESPONSE TO RAI #2 FOR RELIEF REQUEST HC-RR-I2-W02

NRC RAI #2:

1. The relief request states that full ultrasonic examination of the final weld surface and band area (1.5T width) will not be performed. How much of the final weld surface and band area will be examined using the ultrasonic method?

   PSEG Response #1:
   Code case N-504-3 and Non-mandatory Appendix Q required weld volumes were met during the ultrasonic (UT) examination. The weld and heat affected zone (HAZ) beneath the weld overlay were post-weld overlay volumetrically examined. The ultrasonic examination did not extend up to the very edge of the overlay. Refer to Figures 1 and 2 for extent of coverage attained for scans in the circumferential and axial directions. Surface examinations of the entire weld overlay surface, at least 2inches-inch of the adjacent safe-end surface, and at least 2.5-inch of the adjacent ferritic steel nozzle surface were performed acceptably. These examinations ensure sound weld metal was deposited and that the process has not introduced flaws in the base material.

2. Since full ultrasonic examination of the final weld surface and band area (1.5T width) as required by Code Case N-638-1 will not be performed, a much more complete explanation of the examinations that will be performed and the basis for these alternative examinations is required.

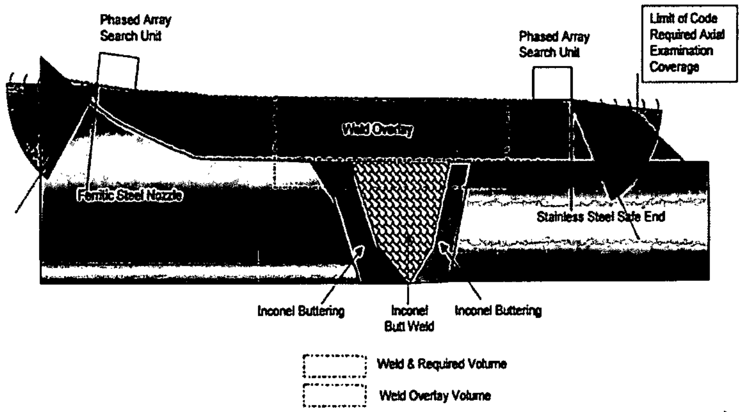
   PSEG Response #2:
   Full UT of the 1.5T band was not performed. Ultrasonic and surface examinations of the weld overlay (welded region) were performed as required by Code case N-504-3 and Non-mandatory Appendix Q. The examination volumes required by these documents were met during the examinations. The weld overlay extends onto the blend radius of the nozzle beyond the length required by Code Case N-504-3 for structural reinforcement. This extension onto the blend radius eliminates a stress riser on the nozzle and provides additional OD surface area for UT examination of the defect area in the original weld.

   Because this is a surface application of the temperbead welding process (specifically performed to minimize heat input to the ferritic steel nozzle), there is minimal impact to the volume of the ferritic steel nozzle material in the area surrounding the weld overlay. Also there is no additional useful information that can be gained by a volumetric examination of the area beyond the physical limits of the weld overlay. The weld and HAZ beneath the weld overlay were post-weld overlay volumetrically examined. The examinations performed have ensured sound weld metal was deposited and that the process did not introduce flaws in the base material. Surface examinations of the entire weld overlay surface, at least 2-inch of the adjacent safe-end surface, and at least 2.5-inch of the adjacent ferritic steel nozzle surface were performed acceptably. This is sufficient to verify that defects were not induced in either the ferritic steel nozzle material or stainless steel safe-end due to welding.

Later editions of Section XI as well as Code Case N-638-2 have deleted the requirement for the 1.5T examination band for both ultrasonic examination and surface examination. This is consistent with the less restrictive requirements for ultrasonic examination of the ferritic nozzle because hydrogen cracking away from the temper bead weld is not considered a concern. The NDE requirements in these documents apply to any type of welding where a temperbead technique is to be employed (which includes weld repairs of excavated flaws) and is not specifically written for weld overlay. For the weld overlay type of repair, any ferritic steel base material cracking would occur in the HAZ directly below or adjacent to the weld overlay and not in the 1.5T examination band of ferritic material beyond the edges of the weld overlay. If this type of cracking had occurred it would have been detected by the NDE of the weld overlay and adjacent ferritic steel surfaces as required by Code case N-504-3 and Non-mandatory Appendix Q.

Attachment
LR-N07-0281

FIGURE 1
PHASED ARRAY ULTRASONIC EXAMINATION AXIAL COVERAGE RECORD
HOPE CREEK RECIRCULATION INLET NOZZLE N2A



Axial Examination Coverage Summary

The Axial coverage of the Weld and Required Volume of the Base Material (WBM) was not limited.
The Axial coverage of the Weld Overlay material (WOL) was not limited, except the area of the taper outside the Code Required Volume

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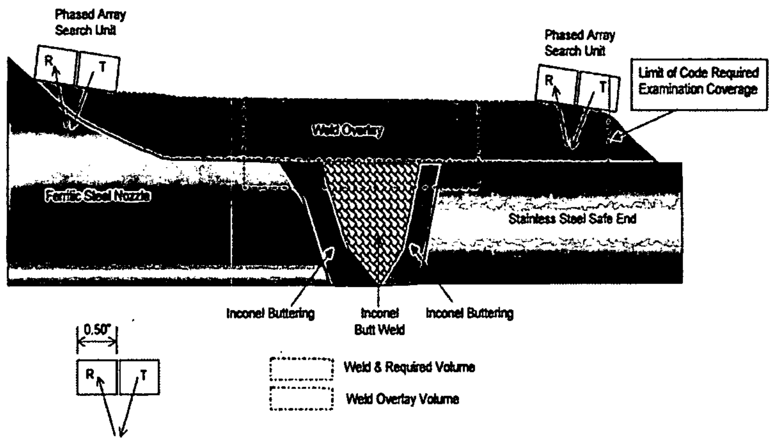
Attachment
LR-N07-0281

FIGURE 2
PHASED ARRAY ULTRASONIC EXAMINATION CIRCUMFERENTIAL COVERAGE RECORD
HOPE CREEK RECIRCULATION INLET NOZZLE N2A



Circumferential Examination Coverage Summary
The Circumferential coverage of the Weld Overlay material (WOL) was limited at each edge of the overlay by 0.50", which is the dimension of the transmit / receive search unit wedge element.
The circumferential coverage the Weld and Required Volume of the Base Material (WBM) was not limited.
All areas were scanned in the Clockwise and Counter-Clockwise directions, T/R positions in the illustration above would be reversed for opposite scans.

4 of 4

April 17, 2008

Mr. William Levis
President & Chief Nuclear Officer
PSEG Nuclear LLC - N09
Post Office Box 236
Hancocks Bridge, NJ 08038

SUBJECT: HOPE CREEK GENERATING STATION - EVALUATION OF RELIEF REQUEST HC-RR-I2-W02 (TAC NO. MD7028)

Dear Mr. Levis:

By letter dated October 19, 2007, as supplemented by letter dated October 29, 2007, and two letters dated October 30, 2007, PSEG Nuclear LLC (PSEG) submitted relief request HC-RR-I2-W02 which proposed an alternative to certain requirements of Section XI of the American Society of Mechanical Engineers (ASME) *Boiler and Pressure Vessel Code* (Code) for Hope Creek Generating Station (HCGS). The proposed alternative was requested to permit the use of a full structural weld overlay repair, during HCGS refueling outage (RFO) 14, for the reactor vessel N2A recirculation inlet nozzle-to-safe end dissimilar metal weld joint.

The Nuclear Regulatory Commission (NRC) staff completed its review of relief request HC-RR-I2-W02 and provided verbal authorization of the proposed alternative in a conference call with PSEG on November 1, 2007. The principal NRC Office of Nuclear Reactor Regulation staff members who participated in the conference call with Mr. Jeffrie Keenan and other members of the PSEG staff included:

Mr. Matthew A. Mitchell	Chief, Vessels & Internals Integrity Branch Division of Component Integrity
Mr. Harold K. Chernoff	Chief, Plant Licensing Branch I-2 Division of Operating Reactor Licensing
Mr. Richard B. Ennis	Senior Project Manager, Plant Licensing Branch I-2, Division of Operating Reactor Licensing

The enclosed Safety Evaluation (SE) documents the basis on which the NRC staff verbally authorized the proposed alternative. As discussed in the SE, the NRC staff concluded that the proposed alternative provides an acceptable level of quality and safety. Therefore, the proposed alternative was authorized pursuant to Section 50.55a(a)(3)(i) of Title 10 of the *Code of Federal Regulations* for the repair of the HCGS reactor vessel N2A recirculation inlet nozzle-to-safe end weld joint during RFO 14.

All other ASME Code, Section XI requirements for which relief was not specifically requested and approved in this relief request remains applicable, including third-party review by the authorized Nuclear Inservice Inspector.

W. Levis - 2 -

If you have any questions concerning this matter, please contact the HCGS Project Manager, Mr. Richard Ennis, at (301) 415-1420.

Sincerely,

/RA/

Harold K. Chernoff, Chief
Plant Licensing Branch I-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-354

Enclosure: As stated

cc w/encl: See next page

Hope Creek Generating Station

cc:

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO RELIEF REQUEST HC-RR-I2-W02

PSEG NUCLEAR LLC

HOPE CREEK GENERATING STATION

DOCKET NO. 50-354

1.0 INTRODUCTION

By letter dated October 19, 2007, as supplemented by a letter dated October 29, 2007, and two letters dated October 30, 2007 (Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML073030460, ML073100369, ML073100717, and ML073100791, respectively), PSEG Nuclear LLC (PSEG or the licensee), submitted relief request HC-RR-I2-W02 which proposed an alternative to certain requirements of Section XI of the American Society of Mechanical Engineers (ASME) *Boiler and Pressure Vessel Code* (Code) for Hope Creek Generating Station (HCGS). The proposed alternative was requested to permit the use of a full structural weld overlay repair, during HCGS refueling outage (RFO) 14, for the reactor vessel N2A recirculation inlet nozzle-to-safe end dissimilar metal weld joint. Specifically, the licensee proposed to implement a weld overlay repair in accordance with ASME Code Cases N-638-1, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW [gas tungsten arc weld] Temper Bead Technique, Section XI, Division 1," and N-504-3, "Alternative Rules for Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping, Section XI, Division 1," as modified by the licensee in its submittal letters. The subject welds were fabricated using Alloy 82, with Alloy 182 buttering.

2.0 REGULATORY EVALUATION

The inservice inspection (ISI) of ASME Code Class 1, 2, and 3 components is to be performed in accordance with Section XI of the ASME Code and applicable edition and addenda as required by Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.55a(g), except where specific relief has been granted by the Nuclear Regulatory Commission (NRC or Commission) pursuant to 10 CFR 50.55a(g)(6)(i). Pursuant to 10 CFR 50.55a(a)(3), alternatives to the requirements of paragraph (g) may be used, when authorized by the NRC, if the licensee demonstrates that: (i) the proposed alternatives would provide an acceptable level of quality and safety, or (ii) compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Pursuant to 10 CFR 50.55a(g)(4), ASME Code Class 1, 2, and 3 components (including supports) must meet the requirements, except the design and access provisions and the preservice examination requirements, set forth in the ASME Code, Section XI, "Rules for

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Inservice Inspection of Nuclear Power Plant Components," to the extent practical within the limitations of design, geometry, and materials of construction of the components. The regulation requires that inservice examination of components and system pressure tests conducted during the first 10-year interval, and subsequent intervals, comply with the requirements in the latest edition and addenda of Section XI of the ASME Code incorporated by reference in 10 CFR 50.55a(b) 12 months prior to the start of the 120-month interval, subject to the limitations and modifications listed therein. The HCGS second ten-year ISI interval began December 13, 1997, and ended on December 12, 2007. The ISI Code of record for HCGS for the second 10-year ISI interval was the ASME Code Section XI, 1998 Edition, including Addenda through 2000.

3.0 TECHNICAL EVALUATION

3.1 Code Requirements for which Relief is Requested

Under the rules of IWA-4220, repairs shall be performed in accordance with the licensee's design specification and the original Construction Code. Later editions and addenda of the Construction Code or of ASME Section III, either in their entirety or portions thereof, and Code Cases may be used.

The licensee requested to use Code Cases N-638-1 and N-504-3 with modifications, as discussed in Safety Evaluation (SE) Section 3.2. The basis for those modifications is discussed in SE Section 3.3.

At the time of the licensee's request, Code Cases N-638-1 and N-504-2 had been conditionally accepted by the NRC in Revision 14 of Regulatory Guide (RG) 1.147, and that revision of the RG was incorporated by reference in 10 CFR 50.55a(b)(5). Although Code Case N-504-3 had been conditionally accepted by the NRC prior to the licensee's request in Revision 15 of RG 1.147, that revision of the RG had not yet been incorporated by reference in 10 CFR 50.55a(b)(5). As such, the licensee also provided an evaluation of the changes between Code Case N-504-2 and Code Case N-504-3, and the basis for the use of the changes. Details of that evaluation are provided in SE Section 3.4.

3.2 Licensee's Modifications to Code Cases N-504-3 and N-638-1

The licensee proposed the following modifications to Code Case N-504-3:

- Code Case N-504-3 was prepared specifically for overlaying austenitic stainless steel piping material with an austenitic stainless steel weld filler metal. An alternate application for nickel-based austenitic materials is needed due to the specific materials and configuration of the existing nickel-based alloy weld and buttering.
- Code Case N-504-3, Requirement (b) requires that the weld overlay shall be low carbon (0.035% maximum) austenitic stainless steel. A nickel-based filler, Alloy 52M, was used.
- Code Case N-504-3, Requirement (e) requires the first two layers of the weld overlay to have a ferrite content of at least 7.5 Ferrite Number (FN). These measurements were not

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performed for this overlay since the nickel alloy filler is a fully austenitic material.

- Code Case N-504-3, Requirement (h) specifies that a system hydrostatic test shall be performed in accordance with IWA-5000 if the flaw penetrates the pressure boundary. In the event the flaw becomes through-wall, a system leakage test in accordance with ASME Section XI, IWA-5000, will be performed in lieu of the system hydrostatic test.

The licensee proposed the following modifications to Code Case N-638-1:

- Code Case N-638-1 paragraph 1.0(a) specifies that the maximum weld area on the finished low alloy steel surface shall be 100 square inches. Restoring the structural integrity of the safe end-to-nozzle weld required application of the weld overlay on more than 100 square inches of surface on the low alloy steel base material.

- Code Case N-638-1 paragraph 4.0(b) specifies that the final weld surface and band area (1.5T width) shall be examined using surface and ultrasonic methods when the completed weld has been at ambient temperature for at least 48 hours. The ultrasonic examination shall be in accordance with ASME Code Section XI, Appendix I. Full ultrasonic examination of the 1.5T band was not performed and the examination was performed no sooner than 48 hours after completion of the third temper bead layer over the ferritic base material. Ultrasonic testing (UT) examinations were performed in accordance with ASME Code, Section XI, Appendix VIII, Supplement 11.

- Code Case N-638-1 paragraph 4.0(c) specifies that the area from which weld-attached thermocouples have been removed shall be ground and examined using a surface examination method. Thermocouples were not used. Calibrated pyrometers were utilized to monitor preheat and interpass temperatures.

3.3 Licensee's Basis for Modifications to Code Cases N-504-3 and N-638-1

The licensee's basis for the proposed modifications to the Code Case requirements was as follows:

Modification to Code Case N-504-3, Requirement (b)

A consumable welding wire highly resistant to stress corrosion cracking (SCC) was selected for the overlay material. This material, designated as UNS N06054, F-No. 43, is a nickel-based alloy weld filler material, commonly referred to as Alloy 52M and was deposited using the machine GTAW process with cold wire feed. Alloy 52M contains nominally 30% by weight (wt%) chromium, which imparts excellent corrosion resistance to the material. By comparison, Alloy 82 is identified as an SCC resistant material in NUREG-0313, Revision 2 and contains nominally 20 wt% chromium, while Alloy 182 has a nominal chromium content of 15 wt%. With its higher chromium content than Alloy 82/182, Alloy 52M provides an even higher level of resistance to SCC consistent with the requirements of the Code Case. Therefore, this alternative provides an acceptable level of quality and safety.

Modification to Code Case N-504-3, Requirement (e)

The composition of nickel-based Alloy 52M is such that delta ferrite does not form during welding. Delta ferrite measurements were not performed for this overlay because Alloy 52M welds contain no delta ferrite due to the high nickel composition (nominally 60 wt% nickel).

The weld overlay was deposited using Alloy 52M filler metal instead of austenitic stainless steel filler metals. The basis for crediting the first layer towards the required design thickness will be based on the chromium content of the nickel alloy filler metal. For boiling water reactor (BWR) applications, a diluted layer may be credited toward the required thickness provided the portion of the layer over the austenitic base material, austenitic filler material weld, and the associated dilution zone from an adjacent ferritic base material contains at least 20% chromium, and the chromium content of the deposited weld metal is determined by chemical analysis of the production weld or of a representative coupon taken from a mockup prepared in accordance with the welding procedure specification (WPS) for the production weld.

Structural Integrity Associates report SI-05-030, Revision 0, "Effect Of Chromium Content On Nickel-Base Alloy SCC Resistance," is available on the ASME website in support of crediting the first overlay layer towards the design thickness for both BWR and pressurized water reactor applications. The report concludes that a minimum of 20% chromium must be present in the first overlay layer to be considered resistant to intergranular stress-corrosion cracking in the BWR environment.

Therefore, this alternative provides an acceptable level of quality and safety.

Modification to Code Case N-504-3, Requirement (h)

Code Case N-504-3 requirement (h) specifies that a system hydrostatic test shall be performed in accordance with IWA-5000 if the flaw penetrates the pressure boundary. System leakage testing in accordance with ASME Section XI, IWA-5000 will be performed. Therefore, this alternative provides an acceptable level of quality and safety.

Modification to Code Case N-638-1 Paragraph 1.0(a)

Code Case N-638-1 paragraph 1.0(a) specifies that the maximum weld area on the finished surface shall be 100 square inches. Restoring the structural integrity with the weld overlay of the safe end-to-nozzle weld required welding on more than 100 square inches of surface on the low alloy steel base material.

Electric Power Research Institute (EPRI) Technical Report 1003616 provides technical justification for extending the size of the temper bead repairs up to a finished area of 500 square inches over the ferritic material. The area of the finished overlay over the ferritic material was substantially less than this. The total area of coverage over the P3 (ferritic) material was approximately 160 square inches of overlay surface area. The weld overlay was extended over the ferritic material so that qualified UT of the required volume can be performed. There have been a number of temper bead weld overlay repairs applied to safe end-to-nozzle welds in the nuclear industry, and weld overlay repairs having 300 square inches surface area were recently approved for Susquehanna Steam Electric Station Unit 1 and D.C. Cook Unit 1.

Results of industry analyses and testing performed to date have indicated that there is no direct correlation of amount of surface area repaired when comparing residual stresses using temper bead welding. Residual stresses associated with larger area repairs (>100 square inches) remain compressive at an acceptable level. Therefore, this alternative provides an acceptable level of quality and safety.

Modification to Code Case N-638-1 Paragraph 4.0(b)

Code Case N-638-1 Paragraph 4.0(b) specifies that the final weld surface and band area (1.5T width) shall be examined using surface and ultrasonic methods when the completed weld has been at ambient temperature for at least 48 hours. The required liquid penetrant examination of 4.0 (b) was performed. In lieu of the ultrasonic examination in accordance with Appendix I, the ultrasonic examination was performed in accordance with Code Case N-504-3 and Non-mandatory Appendix Q which states to perform UT examinations in accordance with ASME Code, Section XI, Appendix VIII.

The weld and heat affected zone (HAZ) beneath the weld overlay were post-weld overlay volumetrically examined. The ultrasonic examination did not extend up to the very edge of the overlay. The weld overlay extends onto the blend radius of the nozzle beyond the length required by Code Case N-504-3 for structural reinforcement. This extension onto the blend radius eliminates a stress riser on the nozzle and provides additional outside diameter surface area for UT examination of the defect area in the original weld. Because this is a surface application of the temper bead welding process (specifically performed to minimize heat input to the ferritic steel nozzle), there was minimal impact on the volume of the ferritic steel nozzle material in the area surrounding the weld overlay. Also there is no additional useful information that can be gained by a volumetric examination of the area beyond the physical limits of the weld overlay. The weld and HAZ beneath the weld overlay were post-weld overlay volumetrically examined. The examinations performed have ensured that sound weld metal was deposited and that the process did not introduce flaws in the base material. Surface examinations of the entire weld overlay surface, at least 2 inches of the adjacent safe-end surface, and at least 2.5 inches of the adjacent ferritic steel nozzle surface, were performed acceptably. This was sufficient to verify that defects were not induced in either the ferritic steel nozzle material or stainless steel safe-end due to welding.

Later editions of ASME Code, Section XI, as well as Code Case N-638-2, have deleted the requirement for the 1.5T examination band for both ultrasonic examination and surface examination. This is consistent with the less restrictive requirements for ultrasonic examination of the ferritic nozzle because hydrogen cracking away from the temper bead weld is not considered a concern. The non-destructive examination (NDE) requirements in these documents apply to any type of welding where a temper bead technique is to be employed (which includes weld repairs of excavated flaws) and is not specifically written for weld overlay repairs. For the weld overlay type of repair, any ferritic steel base material cracking would occur in the HAZ directly below or adjacent to the weld overlay and not in the 1.5T examination band of ferritic material beyond the edges of the weld overlay. If this type of cracking had occurred, it would have been detected by the NDE of the weld overlay and adjacent ferritic steel surfaces as required by Code Case N-504-3 and Non-mandatory Appendix Q.

Examination of the weld overlay covering the ferritic base material was performed no sooner than 48 hours after completion of the third temper bead layer over the ferritic base material. For the application of the weld overlay repair addressed in this request, the appropriate examination methodologies and volumes are provided in Code Case N-504-3 and Non-mandatory Appendix Q. Code Case N-638-1 applies to any type of welding where a technique is to be employed and is not specifically written for a weld overlay repair. EPRI research (Technical Report 1013558, "Temperbead Welding Applications - 48 Hour Hold Requirement for Ambient Temperature Temperbead Welding") has shown that it is not necessary to wait until ambient temperature is reached before initiating the 48-hour hold in order to assure adequate hydrogen removal. No further tempering or potential hydrogen absorption effects will occur after deposition of the third overlay layer. The described approach has previously been reviewed and approved by the NRC (Safety Evaluation for Callaway Plant dated July 10, 2007). Therefore, this alternative provides an acceptable level of quality and safety.

Modification to Code Case N-638-1 Paragraph 4.0(c)

Code Case N-638-1 paragraph 4.0(c) specifies that the area from which weld-attached thermocouples have been removed shall be ground and examined using a surface examination method. Due to the personnel radiological exposure associated with the installation and removal of the thermocouples, the nozzle configuration, and since the nozzle will be full of water, thermocouples were not used to verify that preheat and interpass temperature limits were met. In lieu of thermocouples, a calibrated contact pyrometer was used to verify preheat temperature and interpass temperature compliance with the WPS requirements. Therefore, this alternative provides an acceptable level of quality and safety.

3.4 Licensee's Evaluation of Changes between Code Cases N-504-3 and N-504-2

As discussed in SE Section 3.1, although Code Case N-504-3 had been conditionally accepted in Revision 15 of RG 1.147 (which was issued prior to the licensee's request), that revision of the RG had not yet been incorporated by reference in 10 CFR 50.55a(b)(5). As such, the licensee, in one of the letters dated October 30, 2007 (ADAMS Accession No. ML073100791), provided an evaluation of the changes between Code Case N-504-2 and Code Case N-504-3, and the basis for the use of the changes. A summary of the licensee's evaluation is discussed below.

- Changes were made to the Reply section of Code Case N-504-3. Changes were made to the edition and addenda of ASME Code, Section XI that the Code Case is applicable to. These changes were intended to make the case usable to all versions of Section XI from Summer 1978 Addenda through the 2004 Edition. This updated Code Case now refers to applicable paragraphs of ASME Code, Section XI, 1998 Edition including Addenda through 2000 applicable to the Nozzle N2A weld overlay activities.

- Changes were made to section (b) of Code Case N-504-3. The statement, "The submerged arc method shall not be used for weld overlay," was added to this section. The

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machine GTAW process was used for the weld overlay, so this change is not pertinent to the Nozzle N2A overlay activities.

- Paragraph (f)(1) of Code Case N-504-2 previously stated, "For circumferentially oriented flaws greater than 10% of the pipe circumference, axial flaws greater than 1.5 in., in length, or more than 5 axial flaws of any length, the weld reinforcement shall provide the necessary wall thickness..." Paragraph (f)(1) of Code Case N-504-3 states, "For circumferentially oriented flaws greater than 10% of the pipe circumference, axial flaws equal to or greater than 1.5 in., in length, or 5 or more axial flaws of any length, the weld reinforcement shall provide the necessary wall thickness..." This revision was made to eliminate the oversight of the case of an axial flaw exactly 1.5 in. long, and exactly five axial flaws of any length.

- The last sentence of paragraph (g)(2) of Code Case N-504-2 previously stated, "When structural credit is taken for SAW [submerged arc welding] or SMAW [shielded metal arc welding] weld metal in the original pipe weldment or the weld overlay, the evaluation requirements of Tables IWB-3641-5 and IWB-3641-6 shall be applied." Code Cases N-504-3 states, "When structural credit is taken for SAW or SMAW weld metal in the original pipe weldment or SMAW weld metal in the weld overlay, the evaluation requirements of IWB-3640 for SAW or SMAW welds, as applicable, shall be applied." This revision was made so that the applicable requirements in N-504-3 now refer to IWB-3640 rather than referring to each applicable table therein as previously done prior to the 1996 Addenda.

- Paragraph (i) of Code Case N-504-2 previously stated, "Preservice examination of the completed repair shall be performed in accordance with IWB-2200. For all classes of components, liquid penetrant and ultrasonic examination of the completed weld repair shall be performed. Examination procedures shall be specified in the Repair Program. The acceptance standards of Table IWB-3514-2 shall apply. Ultrasonic examinations shall verify the integrity of the newly applied weld reinforcement. Examinations shall also be performed to identify the original flaws in the outer 25% of the underlying pipe wall as a benchmark for subsequent examinations of the overlay. Grinding and machining of the as-welded overlay surface may be used to improve the surface finish for such examinations, when the overlay thickness is not reduced below design requirements." Paragraph (i) of Code Case N-504-3 states, "Preservice examination of the completed repair shall be performed in accordance with IWB-2200. For all classes of components, liquid penetrant and ultrasonic examination of the completed weld repair shall be performed. Examination procedures shall be specified in the Repair Program. The acceptance standards of Table IWB-3514-2 shall apply for planar flaws. The acceptance standards of Table IWB-3514-3 shall apply for laminar flaws provided the reduction in coverage of the examination volume is less than 10%. The dimensions of the uninspectable volume are dependent on the coverage achieved with the angle beam examination. Additionally, any uninspectable volume in the weld overlay shall be assumed to contain the largest radial planar flaw that could exist within that volume. The assumed planar flaw shall meet the inservice examination acceptance standards of Table IWB-3514-2. Both axial and circumferential flaws shall be assumed. As an alternative to the assumed planar flaw, radiography in accordance with the Construction Code shall be used to examine the uninspectable volume in the weld overlay. The radiographic acceptance criteria of the

Construction Code shall apply. Ultrasonic examinations shall verify the integrity of the newly applied weld reinforcement. Examinations shall also be performed to identify the original flaws in the outer 25% of the underlying pipe wall as a benchmark for subsequent examinations of the overlay. Grinding and machining of the as-welded overlay surface may be used to improve the surface finish for such examinations, when the overlay thickness is not reduced below design requirements." This revision clarifies which acceptance criteria applies to the different types of flaws and should have been included in the previous revision of the Code Case.

- Two other minor editorial changes were made to Code Case N-504-2 which corrected typographical errors or updates in terminology. These changes do affect the technical content of the Code Case.

3.4 Limitations for Use of Code Cases N-504-2, N-504-3, and N-638-1

As discussed in Table 2 of RG 1.147 (Revisions 14 and 15), Code Cases N-504-2, N-504-3 and N-638-1 are acceptable for use by licensees subject to certain limitations as discussed below.

Code Case N-504-2 and N-504-3 Limitation

The provisions of ASME Code, Section XI, Non-Mandatory Appendix Q, "Weld Overlay Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping Weldments," must also be met.

HCGS met the associated requirements contained in this non-mandatory Appendix Q.

Code Case N-638-1 Limitation

UT examinations shall be demonstrated for the repaired volume using representative samples which contain construction type flaws. The acceptance criteria of NB-5330 of the Section III edition and addenda approved in 10 CFR 50.55a apply to all flaws identified within the repaired volume.

For HCGS, the acceptance criteria that was used for the UT was ASME Code, Section XI Non-mandatory Appendix Q, as clarified under the modifications to Code Case N-638-1 Paragraph 4.0(b).

3.5 NRC Staff Evaluation of Modifications to Code Case N-504-3

Under the rules of ASME Code, Section XI, IWA-4220, repairs shall be performed in accordance with the licensee's design specification and the original Construction Code. Later editions and addenda of the Construction Code or of ASME Code, Section III, either in their entirety or portions thereof, and Code Cases may be used. In addition to the above, defects shall be removed or reduced in size in accordance with ASME Code, Section XI, IWA-4400. Code Case N-504-3 is being used by the licensee to perform a full structural weld overlay on the reactor vessel N2A recirculation inlet nozzle-to-safe end dissimilar metal weld joint. Code Case N-504-3 was conditionally approved by the NRC staff for use under RG 1.147, Revision 15. Therefore, the use of Code Case N-504-3 as an alternative to the mandatory ASME Code repair provisions is acceptable to the NRC staff, provided that all conditions and provisions specified in RG 1.147, Revision 15 are complied with, or modifications to those conditions and provisions are otherwise found to be acceptable by the staff.

The first proposed modification to the Code Case N-504-3 provisions involved the use of a nickel-based alloy weld material rather than the low carbon austenitic stainless steel. Paragraph (b) of Code Case N-504-3 requires that the reinforcement weld material shall be low carbon (0.035% maximum) austenitic stainless steel. In lieu of the stainless steel weld material, Alloy 52M, a consumable welding wire highly resistant to SCC, was proposed for the overlay weld material. The NRC staff notes that the use of 52M material is consistent with weld filler material used to perform similar weld overlays at other operating BWR facilities. The NRC staff also notes that the licensee performed a full structural weld overlay on a dissimilar metal weld made of Alloy 182 material. For material compatibility in welding, the NRC staff considers that Alloy 52M is a better choice of filler material than austenitic stainless steel material for a weld overlay. Alloy 52M contains about 30% chromium which provides excellent resistance to SCC if exposed to the reactor coolant environment. This material is identified as F-No. 43 Grouping for Ni-Cr-Fe, classification UNS N06052 Filler Metal and has been previously approved by the NRC staff for similar applications. Therefore, the licensee's proposed use of Alloy 52M for the weld overlays as a modification to the requirements of Code Case N-504-3, paragraph (b) is acceptable as it will provide an acceptable level of quality and safety.

The next proposed modification to the Code Case N-504-3 provisions involves Paragraph (e) of Code Case N-504-3 which requires as-deposited delta ferrite measurements of at least 7.5 FN for the weld reinforcement. The licensee proposed that delta ferrite measurements would not be performed for this overlay because the deposited Alloy 52M material is 100% austenitic and contains no delta ferrite due to the high nickel composition (approximately 60% nickel). Code Case N-504-3 allows the use of weld overlay repair by deposition of weld reinforcement on the outside surface of the pipe in lieu of mechanically reducing the defect to an acceptable flaw size. However, Code Case N-504-3 is designed for weld overlay repair of austenitic stainless steel piping. Therefore, the material requirements regarding the delta ferrite content of at least 7.5 FN, as delineated in Code Case N-504-3, paragraph (e), apply only to austenitic stainless steel weld overlay materials to ensure its resistance to SCC. These requirements are not applicable to Alloy 52M, a nickel-based material which the licensee used for the weld overlay.

The licensee's proposed modification to Paragraph (h) of Code Case N-504-3 is to perform leak testing in accordance with ASME Code, Section XI, IWA-5000. Precedence for use of a leak test at normal operating temperature and pressure in lieu of a hydrostatic test has been set with Code Case N-416-1, "Alternative Pressure Test Requirements for Welded Repairs or Installation of Replacement Items by Welding, Class 1, 2, and 3, Section XI, Division 1," that has been incorporated in ASME Code, Section XI beginning in the 1998 Edition with the 1999 Addenda. The HCGS second ten-year ISI interval began December 13, 1997, and ended on December 12, 2007. The ISI Code of record for HCGS for the second 10-year ISI interval is the ASME Code, Section XI, 1998 Edition, including Addenda through 2000. Therefore, this alternative provides an acceptable level of quality and safety.

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3.6 NRC Staff Evaluation of Modifications to Code N-638-1

The licensee is applying a 360-degree, full structural weld overlay to maintain weld integrity. The full structural weld overlay will fulfill all structural requirements, independent of the existing weld. Operational experience has also shown that SCC in Alloy 82/182 will blunt at the interface with stainless steel base metal, carbon steel base metal, or Alloy 52/152 weld metal.

To eliminate the need for preheat and post-weld heat treatment under the Construction Code, the industry developed requirements for implementation of a temper bead welding technique which were published in Code Case N-638-1. The NRC endorsed Code Case N-638-1 in RG 1.147, Revision 14. The temper Code Case bead technique carefully controls heat input and bead placement which allows subsequent welding passes to stress relieve and temper the HAZ of the base material and preceding weld passes. The welding is performed with low hydrogen electrodes under a blanket of inert gas. The inert gas shields the molten metal from moisture and hydrogen. Therefore, the need for the preheat and post-weld heat treatment specified by the ASME Construction Code is not necessary to produce a sound weld using a temper bead welding process which meets the requirements of Code Case N-638-1.

The licensee met the requirements of Code Case N-638-1, except paragraph 1.0(a), which requires the maximum area of an individual weld, based on the finished surface, be limited to 100 square inches and the depth of the weld to exceed one-half of the ferritic base metal thickness. This condition was not met because the design for the weld overlay covered an area up to approximately 160 square inches which exceeds the limitations of Code Case N-638-1. The licensee performed an evaluation to determine the effect of exceeding the 100 square inch area limitation for temper bead welding onto a low alloy steel nozzle. This evaluation was conducted under the guidance of Code Case N-504-3. Paragraphs (g)(2) and (g)(3) of Code Case N-504-3 require consideration of the effects of residual stresses produced by the weld overlay, when coupled with other applied loads on other welds and components throughout the system. The evaluation of other welds and components in the system considers potential increases in loading, including shrinkage effects, due to all weld overlays in the reactor coolant system. These welds and components are to meet the applicable stress limits of the Construction Code. The NRC staff considers this evaluation important in assuring that the reactor coolant system will not be adversely affected after the weld overlay is deposited. EPRI Technical Report 1003616 provides technical justification for exceeding the size of the temper bead repairs up to a finished area of 500 square inches over the ferritic material. The total area of coverage over the P3 (ferritic) material was approximately 160 square inches of overlay surface area. There have been a number of temper bead weld overlay repairs applied to safe end-to-nozzle welds in the nuclear industry, and weld overlay repairs having 300 square inch surface areas were approved for Susquehanna Unit No. 1 and D.C. Cook Unit No. 1. Results of industry analyses and testing performed to date have indicated that there is no direct correlation of amount of surface area repaired when comparing residual stresses using temper bead welding. Residual stresses associated with larger area repairs (>100 square inches) remain compressive at an acceptable level. Based on the preceding discussions, the NRC staff concludes that the modification to increase the weld overlay to approximately 160 square inches provided an acceptable level of quality and safety and is, therefore, acceptable.

The second modification requested by the licensee was that full UT of the 1.5T band would not be performed as required under Paragraph 4.0(b). Using Code Case N-638-1, the temper bead weld is for filling a cavity in the base metal. The licensee's application, however, is for a structural weld overlay above the base metal, which resulted in a contour that was UT inspectable except for the edge taper where the overlay transitions to the nozzle surface and on the curvature of the nozzle. The proposed weld edge configuration has the same UT examination difficulties as are considered under ASME Section XI, Appendix Q. Appendix Q only requires a surface examination of the tapered area of the weld overlay. In addition to verifying the soundness of the weld, a purpose of the UT is to assure that delayed cracking due to hydrogen introduced during the temper bead welding process or cracking in unannealed ferritic material does not occur. In the unlikely event cracking does occur, it would initiate on the surface on which the welding is actually performed or in the HAZ immediately adjacent to the weld. The most appropriate technique to detect surface cracking is a surface examination technique. Therefore, use of a surface examination in the area of the weld overlay taper and band beyond the toe of the overlay on the ferritic material was acceptable in that it provided an acceptable level of safety and quality.

Code Case N-638-1 paragraph 4.0(c) specifies that the area from which weld-attached thermocouples have been removed shall be ground and examined using a surface examination method. The licensee has stated that, due to the personnel exposure associated with the installation and removal of the thermocouples, the nozzle configuration, and because the nozzle will be full of water, thermocouples were not used to verify that the preheat and interpass temperature limits were met. In lieu of thermocouples, a contact pyrometer was used to verify preheat temperature and interpass temperature compliance with the WPS requirements.

The preheat temperature required for this welding was 50 °F. The maximum interpass temperatures required for this welding were 150 °F for the first three layers, and 350 °F for the balance of welding. A contact pyrometer was used to adequately monitor these preheat and interpass temperatures. Also, the large mass of the nozzle coupled with the low heat input GTAW process helped ensure that the maximum interpass temperature was not exceeded. The alternate temperature measurement method ensured that a close control was maintained on these temperatures. Therefore, this type of temperature measurement provided an acceptable level of quality and safety.

4.0 CONCLUSION

Based on the discussion in SE Sections 3.5 and 3.6, the NRC staff concludes that the proposed alternative provides an acceptable level of quality and safety. Therefore, the proposed alternative is authorized pursuant to 10 CFR 50.55a(a)(3)(i) for the repair of the HCGS reactor vessel N2A recirculation inlet nozzle-to-safe end weld joint during RFO 14.

All other ASME Code, Section XI requirements for which relief was not specifically requested and approved in this relief request remain applicable, including third-party review by the Authorized Nuclear Inservice Inspector.

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Date: April 17, 2008

A.9 Duane Arnold Nozzles N2C and N2F (RR, RAI, and SER)

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February 24, 2007

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10 CFR 50.55a(a)(3)(i)

U.S. Nuclear Regulatory Commission
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Duane Arnold Energy Center
Docket No: 50-331
Op. License No: DPR-49

Alternative to ASME Section XI Requirements to use Code Cases N-504-2 and N-638-1 for Weld Overlay Repairs at the Duane Arnold Energy Center

References:
1) Letter, C. Craig (USNRC) to E. Protsch (IES Utilities), "Alternative to the American Society Of Mechanical Engineers Boiler and Pressure Vessel Code Repair Requirements for the Recirculation Line for Duane Arnold Energy Center (TAC NO. MA7125)," dated November 19, 1999 (ML9933004430) and supporting Safety Evaluation (ML9933004460)

2) Letter, D. Roberts (USNRC) to W. Levis (PSEG Nuclear, LLC), "Hope Creek Generating Station - Evaluation of Relief Request HC-RR-I2-W01 (TAC NO. MC5173)," dated August 29, 2005 (ML051520177)

Pursuant to 10 CFR 50.55a(a)(3)(i), FPL Energy Duane Arnold requests NRC authorization of an alternative to the requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI, Rules for Inservice Inspection of Nuclear Power Plant Components. The Duane Arnold Energy Center (DAEC) Inservice Inspection (ISI) Program complies with the requirements of the ASME Code Section XI, 2001 Edition with Addenda through 2003. This proposed alternative would permit the use of a full structural weld overlay repair for an indication identified in the N2C and N2F recirculation inlet nozzle, safe-end-to-nozzle weld joint (RRC-F002 and RRF-F002). The DAEC is currently in its fourth ten-year ISI interval, which began November 1, 2006 and will end concurrent with the DAEC Operating License on February 21, 2014. Consequently, the requested relief is for the remainder of the current Operating License. Enclosure 1 to this letter contains that request for relief.

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During the current DAEC refueling outage (RFO20), augmented weld inspections were being performed in accordance with the DAEC fourth ten-year interval ISI program. The original scope of examinations included four recirculation riser safe-end-to-nozzle welds and one Core Spray (CS) safe-end-to-nozzle weld. These inspections identified a new indication in the safe-end-to-nozzle weld in the N2F recirculation riser (weld RRF-F002). The N2F nozzle had a previously-identified indication (sub-surface flaw) in the RRF-F002 weld, in a different location, that was found during the inspections conducted during RFO16 (1999). Consequently, the N2F nozzle was being re-inspected this RFO as an ASME Code required successive examination. A more-detailed history of the examinations of this nozzle weld is included in the Enclosure 2 to this letter.

Due to the identification of the new indication in RRF-F002, the RFO20 inspection scope has been expanded to include two additional F002 recirculation riser safe-end-to-nozzle welds, as well as the other CS safe-end-to-nozzle weld. The remaining two F002 welds had structural overlays applied in 1999 and are not considered susceptible to further cracking and thus, were not inspected. During the expanded scope of inspections, a new indication on the N2C safe-end-to-nozzle weld (RRC-F002) was found. This indication will also require repair prior to resuming power operations. The other F002 weld and CS nozzle weld have had their inspections completed, with no new indications found.

While the determination of the formal root cause is being tracked in the Corrective Action Program (RCE01062), the preliminary assessment is that the indication is due to Stress Corrosion Cracking (SCC).

10CFR50.55a(a)(3)(i) states that proposed alternatives may be used when authorized by the Director of the Office of Nuclear Reactor Regulation provided that the proposed alternatives provide an acceptable level of quality and safety. FPL Energy Duane Arnold hereby requests NRC authorization to use Code Cases N-504-2 and N-638-1, with the exceptions and clarifications noted in Enclosure 1, to perform repair activities on safe-end-to-nozzle welds RRF-F002 and RRC-F002.

The requested relief is similar to that previously granted for the DAEC in 1999 (Reference 1) and to one more recently approved for the Hope Creek Generating Station in 2005 (Reference 2).

FPL Energy Duane Arnold requests approval of this request prior to beginning the weld overlay repair of safe-end-to-nozzle welds RRC-F002 and RRF-F002, currently scheduled for February 26, 2007.

This letter contains no new commitments and no revisions to existing commitments.

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Questions regarding this matter should be directed to Steve Catron, Licensing Manager, at (319) 851-7234.

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Enclosures (2)

cc: Administrator, Region III, USNRC
Project Manager, DAEC, USNRC
Resident Inspector, DAEC, USNRC

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Alternative to ASME Section XI Repair Requirements to use Code Cases N-504-2 and N-638-1 for Weld Overlay Repairs at the Duane Arnold Energy Center

1.0 ASME Code Component(s) Affected

Code Class:	1
References:	ASME Section XI, 2001 Edition, including and through the 2003 Addenda ASME Section XI, Case N-504-2 ASME Section XI, Case N-638-1 NUREG-0313 Rev 2 Generic Letter 88-01 BWRVIP-75 DAEC Fourth Ten Year ISI Plan – NRC Approved Relief Request NDE-R002, "Relief to use the PDI Program for Implementation of Appendix VIII, Supplement 11 requirements," and Relief Request NDE-R005 "Risked Informed ISI for Class 1 B-F & B-J Welds and Class 2 C-F-2 Welds (ML070090357)
Examination Categories:	R-A (B-F)
Item Number:	R1.16 (B5.10)
Description:	Alternative Repair for the RRC-F002 and RRF-F002 Recirculation Inlet Nozzle, Safe-end-to-Nozzle Welds
Component Numbers:	RRC-F002 Recirculation Inlet Nozzle Safe-end Weld RRF-F002 Recirculation Inlet Nozzle Safe-end Weld

2.0 Applicable Code Edition and Addenda

ASME Code Section XI, 2001 Edition, including Addenda through 2003.

3.0 Applicable Code Requirement

IWA-4421(a) and IWA-4611.1(a) require removal of the detected flaw.

IWA-4610(a) requires that the area to be welded shall be pre-heated to 300°F minimum for gas tungsten arc welding (GTAW).

IWA-4610(a) requires that thermocouples shall be used to monitor process temperatures.

IWA-4631(b) specifies that the surface of the completed weld on the ferritic steel shall not exceed 100 square inches.

IWA-4633.2(c) specifies that the first three layers of the weld shall be deposited with heat inputs within ±10% of that used in the procedure qualification test. Subsequent layers shall be deposited using heat input equal to or less than that used for layers beyond the third in the procedure qualification.

IWA-4633.2(c) also specifies that at least one layer of weld reinforcement shall be deposited and then this reinforcement shall be removed substantially flush with the surface surrounding the weld.

4.0 Reason for Request

The request is based on restoring the structural integrity of the RRC-F002 and RRF-F002 recirculation inlet nozzle safe-end-to-nozzle weld joints using technically sound welding practices and non-destructive examination (NDE), while limiting repair personnel exposure to the maximum extent practical. The following cited Code articles identify the actions that would be required if the repair were conducted in accordance with the Code without exception.

IWA-4421(a) and IWA-4611.1(a) require defect removal in this case. The repair cavity would extend through wall since outer diameter (OD) removal would be required. Internal diameter (ID) removal of the indication would be impractical since it would require the removal of the thermal sleeve and jet pump riser from the reactor interior.

IWA-4610(a) requires the area to be welded shall be pre-heated to 300°F minimum for GTAW. Since the nozzle will remain full of water, establishing the 300°F minimum pre-heat temperature cannot be achieved.

IWA-4610(a) also requires the use of thermocouples to monitor process temperatures. Due to the personnel exposure associated with the installation and removal of the thermocouples, the nozzle configuration, and because the nozzle will be full of water, a contact pyrometer will be used, in lieu of thermocouples, to verify pre-heat and interpass temperature limits are met.

IWA-4631(b) specifies the surface of the completed weld on the ferritic steel shall not exceed 100 square inches. Restoring the structural integrity of the safe-end-to-nozzle weld with the weld overlay will require welding on more than 100 square inches of surface on the low alloy steel base material.

IWA-4633.2(c) specifies the first three layers of the weld shall be deposited with heat inputs within ±10% of that used in the procedure qualification test. Subsequent layers shall be deposited using heat input equal to or less than that used for layers beyond the third in the procedure qualification. Code Case N-638-1 allows for layers beyond the third to exceed the heat input, provided it is in accordance with the procedure qualification records (PQRs).

IWA-4633.2(c) also specifies that at least one layer of weld reinforcement shall be deposited and then this reinforcement shall be removed substantially flush with the surface surrounding the weld. The weld reinforcement will not be removed flush to the surface.

5.0 Proposed Alternative and Basis for Use

A full structural weld overlay repair is proposed for the safe-end-to-nozzle weldments. The nozzle material is SA-508 Class 2 low alloy steel. The safe-end is Alloy 600 SB-166. The existing weld material is Alloy 82, with Alloy 182 buttering.

The weld overlay will be designed consistent with the requirements of NUREG-0313, Revision 2 (which was implemented by Generic Letter (GL) 88-01), Code Case N-504-2, "Alternative Rules for Repair of Classes 1, 2, and 3 Austenitic Stainless Steel Piping," Code Case N-638-1, "Similar and Dissimilar Metal Welding Using Ambient Temperature GTAW Temper Bead Technique," and IWB-3640, ASME Section XI 2001 Edition, including Addenda through 2003 with Appendix C.

Welder Qualification And Welding Procedures

All welders and welding operators will be qualified in accordance with ASME Section IX and any special requirements of ASME XI or applicable code cases. Qualified personnel under the vendor's (Welding Services Inc. (WSI)) welding program will perform the weld overlay repair.

Welding Procedure Specification (WPS) WPS 03-43-T-804-102967 (machine GTAW with cold wire feed) for welding SFA-5.14, ERNiCrFe-7A, UNS N06054, F-No. 43 (commercially known as Alloy 52M) will be used.

If repairs to the overlay are required, manual GTAW for welding SFA-5.14, ERNiCrFe-7A, UNS N06054, F-No. 43 (commercially known as Alloy 52M) will be used. In the unlikely event of a through-wall defect, UNS W86152, F No. 43 (commercially known as Alloy 152) will be used to seal any defect if it is greater than 0.125 inch from the P-3 nozzle material before beginning the structural weld overlay using GTAW.

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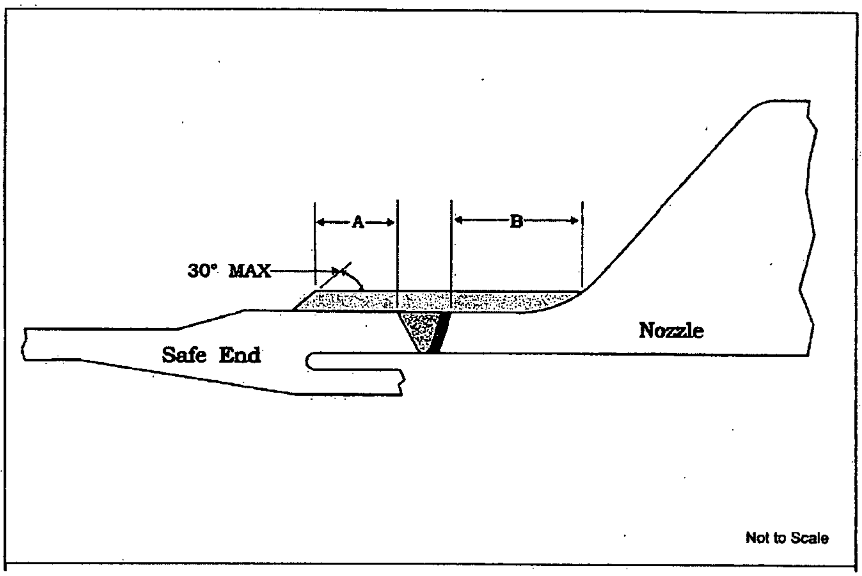
Welding Wire and Electrodes

A consumable welding wire, highly resistant to stress corrosion cracking (SCC), was selected for the overlay material. Alloy 52M contains a nominal 30 wt% Cr that imparts excellent resistance to SCC. Where localized repairs are required, Alloy 52M will be used.

Weld Overlay Design

The weld overlay will extend around the full circumference of the safe-end-to-nozzle weldment location in accordance with NUREG-0313, Rev. 2, Code Case N-504-2, and GL 88-01. The overlay length will extend across the projected flaw intersection with the outer surface beyond the extreme axial boundaries of the flaw. The design thickness and length has been computed in accordance with the guidance provided in Code Case N-504-2 and ASME Section XI, IWB-3640, 2001 Edition including Addenda through 2003 and Appendix C. The overlay will completely cover the area of the flaw and other Alloy 182 susceptible material with the highly resistant Alloy 52M weld filler material.



Design Dimensions		
A	B	Thickness
2.0 inch	Overlay to be gently blended into nozzle to minimize stress concentration and to accommodate temper bead weld passes	0.500 inch

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To provide the necessary weld overlay geometry, it will be necessary to weld on the low alloy steel nozzle base material. A temper bead welding approach will be used for this purpose following the guidance of ASME Section XI Code Case N-638-1, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique." This Code Case provides for machine GTAW temper bead weld repairs to P-No. 3, Group No. 3, nozzle base material at ambient temperature. The temper bead approach was selected because temper bead welding supplants the requirement for post-weld heat treatment (PWHT) of the heat-affected zone (HAZ) in welds on low alloy steel material. Also, the temper bead welding technique produces excellent toughness and ductility as demonstrated by welding procedure qualification in the HAZ of welds on low alloy steel materials, and, in this case, results in compressive residual stresses on the inside surface, which assists in inhibiting SCC. This approach provides a comprehensive weld overlay repair and increases the volume under the overlay that can be examined.

The overlay length conforms to the guidance of Code Case N-504-2, which satisfies the stress requirements.

Examination Requirements

NUREG-0313, Rev. 2, and Code Case N-504-2, specify ultrasonic test (UT) using methods and personnel qualified in accordance with ASME Section XI, Appendix I. The UT techniques to be used for the final post-weld examination have been qualified through the Electric Power Research Institute (EPRI) NDE Center, which satisfies the requirements of ASME Section XI, Appendix I. Furthermore, NUREG-0313 states that the UT to be performed in accordance with the requirements of the applicable Edition and Addenda of ASME Section XI. ASME Section XI, 2001 Edition including Addenda through 2003 is the Code of record for the DAEC fourth 10-year Inservice Inspection Interval. Therefore, the acceptance criteria that will be used for the UT will be IWB-3130, "Inservice Volumetric and Surface Examinations," and ASME Section XI Non-mandatory Appendix Q, "Weld Overlay Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping Weldments," as clarified under Exceptions to Code Case N-638-1 Paragraph 4.0(b). In addition, an NRC-approved relief request (NDE-R002) for the DAEC (ML070090357) allows the use of the Performance Demonstration Initiative (PDI) Program for implementation of Appendix VIII, Supplement 11 requirements for the examination of piping welds with overlays.

The examination requirements for the weld overlay repair are summarized in Table 1. No final post-weld examinations will be performed until 48 hours has elapsed after completion of welding. This is required to detect any possible hydrogen-induced cracking that may occur in the low alloy steel nozzle HAZ.

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TABLE 1
Examination Requirements

Exam Description	Method	Technique	Reference
As Found Flaw Detection	Auto UT	PDI Qualified Implementing ASME Section XI Appendix VIII	IWB-3514.4
Pre-weld UT Thickness	Manual UT	0°	N-504-2
Surface Prior to Welding	PT	Color Contrast (Visible) Penetrant	IWA-4611.1(a) N-504-2(c) N-638-1,4.0(a)
Final Weld Overlay Surface	PT	Color Contrast (Visible) Penetrant	IWA-4634 N-504-2(j) N-638-1,4.0(b)
Final Weld Overlay for Thickness	UT	0°	IWA-4634 N-504-2(j) N-638-1,4.0(b)
Final Weld Overlay and Outer 25% of the Underlying Wall Thickness Volumetric Pre-service	UT	PDI Qualified Implementing ASME Section XI Appendix VIII RR-NDE-002	IWA-4634 IWB-3514.4 N-504-2(j) N-638-1,4.0(b) Appendix Q

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Pressure Testing

The completed repair shall be given a system leakage test in accordance with ASME Section XI, IWA-5000, since the pressure boundary has not been penetrated (no leakage has occurred). In the event an unexpected through wall defect is identified, either before or during the repair, an additional exception from the hydrostatic pressure test requirements defined in Code Case N-504-2 will be needed. A system leakage test will be performed in accordance with ASME Section XI, IWA-5000 of the 2001 Edition with the 2003 Addenda. Precedence for use of a leak test at normal operating temperature and pressure, in lieu of a hydrostatic test, has been set with Code Case N-416-1, which has been incorporated in ASME Section XI starting with the 1998 Edition, 1999 Addenda.

Pre-heat and PWHT Requirements

Pre-heat and PWHT are typically required for welding on low alloy steel material. ASME Section III specifies PWHT on P-No. 3, Group No. 3, base materials unless temper bead welding is performed under limited restrictions (area and depth limits). ASME Section XI, 2001 Edition including Addenda through 2003, specifies 300°F minimum pre-heat be used for temper bead welding. PWHT cannot be performed and the pre-heat requirements would necessitate draining the reactor pressure vessel (RPV) and a portion of the recirculation system piping. This would result in unacceptable radiation dose rates. Therefore, consistent with ALARA practices and prudent utilization of outage personnel, the RPV will not be drained for this activity. The nozzle and connected piping will be full of water.

Alternatives to Code Case N-504-2

Code Case N-504-2 Applicability to Nickel Based Austenitic Steel

Code Case N-504-2 was prepared specifically for austenitic stainless steel material. An alternate application for nickel based austenitic materials (Alloy 52M) is needed due to the specific materials and configuration of the existing nickel based alloy weld and buttering (Alloy 82 and Alloy 182).

Exception to Code Case N-504-2, Requirement (b)

Code Case N-504-2, Requirement (b) requires the weld overlay shall be low carbon (0.035% maximum) austenitic stainless steel. A nickel-based filler is required and Alloy 52M has been selected to be used.

Exception to Code Case N-504-2, Requirement (e)

Code Case N-504-2, Requirement (e) requires the first two layers of the weld overlay to have a ferrite content of at least 7.5 FN (Ferrite Number). These measurements will not be performed for this overlay since the nickel alloy filler is a fully austenitic material.

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Exception to Code Case N-504-2, Requirement (h)

Code Case N-504-2, Requirement (h) specifies that a system hydrostatic test shall be performed in accordance with IWA-5000 if the flaw penetrates the pressure boundary. In the event the flaw becomes through wall, leak testing only, in accordance with ASME Section XI, IWA-5000, will be performed.

Alternatives to Code Case N-638-1

Exception to Code Case N-638-1 Paragraph 1.0(a)

Code Case N-638-1 paragraph 1.0(a) specifies that the maximum weld area on the finished surface shall be 100 square inches. Restoring the structural integrity of the safe-end-to-nozzle weld with the weld overlay will require welding on more than 100 square inches of surface on the low alloy steel base material.

Exception to Code Case N-638-1 Paragraph 4.0(b)

Code Case N-638-1 paragraph 4.0(b) specifies that the final weld surface and the band around the area (1.5T width or 5 inches, whichever is less) shall be examined using surface and ultrasonic methods when the completed weld has been at ambient temperature for at least 48 hours. The UT shall be in accordance with ASME Section XI Appendix I. Full UT of the 1.5T band will not be performed.

Exception to Code Case N-638-1 Paragraph 4.0(c)

Code Case N-638-1 paragraph 4.0(c) specifies that the area from which weld-attached thermocouples have been removed shall be ground and examined using a surface examination method. Thermocouples will not be used. Calibrated pyrometers will be utilized to monitor pre-heat & interpass temperatures.

Basis For The Alternatives

IWA-4421(a) and IWA-4611.1(a) require defect removal in this case. The repair cavity would extend through wall since OD removal would be required. The ID is inaccessible due to the thermal sleeve. Therefore, the flaw will not be removed. Structural weld overlays covering flaws are permitted by Code Case N-504-2, provided the necessary weld overlay geometry is used. Therefore, this alternative provides an acceptable level of quality and safety.

IWA-4610(a) requires the area to be welded shall be pre-heated to 300°F minimum for GTAW. Since the nozzle will remain full of water, establishing the 300°F minimum pre-heat temperature cannot be achieved. Code Case N-638-1, paragraph 1.0(b) provides for machine GTAW temper bead weld repairs to P-No. 3, Group No. 3, nozzle base material at ambient temperature. The ambient temperature temper bead approach was selected because temper bead welding supplants the requirement for PWHT of the HAZ in welds on low alloy steel material. Also, the temper bead welding technique produces excellent toughness and ductility, as demonstrated by welding procedure qualification, in HAZ of welds on low alloy steel materials. Welding procedure qualifications have been successfully performed using Alloy 52M welds on P-No. 3, Group No. 3, base material using the ambient temperature temper bead technique. Therefore, this alternative provides an acceptable level of quality and safety.

IWA-4610(a) also requires the use of thermocouples to monitor process temperatures. Due to the personnel exposure associated with the installation and removal of the thermocouples, the nozzle configuration, and because the water in the line containing the nozzle will not be drained, thermocouples will not be used to verify that pre-heat and interpass temperature limits are met. In lieu of thermocouples, a contact pyrometer will be used to verify pre-heat temperature and interpass temperature compliance with the WPS requirements. The use of a contact pyrometer provides equivalent temperature monitoring capabilities and is recognized as acceptable calibrated measuring and test equipment (M&TE). Therefore, this alternative provides an acceptable level of quality and safety.

IWA-4631(b) specifies the surface of the completed weld on the ferritic steel shall not exceed 100 square inches. Restoring the structural integrity with the weld overlay of the safe-end-to-nozzle weld will require welding on more than 100 square inches of surface on the low alloy steel base material. If this limit were maintained, the length of weld overlay extension on the nozzle base material would be limited to approximately 2.25 inches, including the taper. This distance could be justified as sufficient to provide load redistribution from the weld overlay back into the nozzle without violating ASME III stress limits for primary local and bending stresses, and secondary and peak stresses. However, this length would not permit a complete UT of the outer 25% of the nozzle and safe-end thickness as specified by Code Case N-504-2. The overlay will extend to the transition taper of the low alloy steel nozzle so that qualified UT of the required volume can be performed. Therefore, this alternative provides an acceptable level of quality and safety.

Code Case N-432 has always allowed temper bead welding on low alloy steel nozzles without limiting the temper bead weld surface area. The two additional conditions required by N-432, that are not required by Code Case N-638, are that temper bead welds have pre-heat applied and that the procedure qualification be performed on the same specification, type, grade, and class of material. As previously discussed, elevated pre-heat necessitates draining of the RPV and a portion of the recirculation system piping. This would result in unacceptable radiation dose rates.

The ASME Code committees have recognized that the 100 square inches restriction on the surface area is unnecessarily limiting and Code Case N-638-3 has been issued to increase the surface area limit to 500 square inches. The code case attempts to combine the features of Code Case N-432 and N-638 into a single code case. The supporting analysis for the code case (EPRI Technical Report 1008454, "Proposed

Code Case, Expansion of Temper Bead Repair") concluded that the residual stresses are not detrimentally changed by increasing the surface area of the repair and increasing the HAZ tempering is unaffected by the weld overlay application. Therefore, this alternative provides an acceptable level of quality and safety.

IWA-4633.2(c) specifies the first three layers of the weld shall be deposited with heat inputs within ±10% of that used in the procedure qualification test. Subsequent layers shall be deposited using heat input equal to or less than that used for layers beyond the third in the procedure qualification. Code Case N-638-1 allows for layers beyond the third to exceed the heat input provided it is in accordance with the PQRs. Therefore, this alternative provides an acceptable level of quality and safety.

IWA-4633.2(c) also specifies that at least one layer of weld reinforcement shall be deposited and then this reinforcement shall be removed, to be substantially flush with the surface surrounding the weld. The weld overlay is austenitic and thus, there is no need to remove the final layer. Also, overlays, by definition, cannot be substantially flush with the surrounding surface. Overlays are permitted per Code Case N-504-2. The toe of the weld on the low alloy steel nozzle shoulder will be indexed between layers such that proper HAZ tempering will result. Therefore, this alternative provides an acceptable level of quality and safety.

Code Case N-638-1 is approved (with one limitation) for generic use in Regulatory Guide (RG) 1.147, Revision 14, and was developed for both similar and dissimilar metal welding using ambient temperature machine GTAW temper bead technique. The welding methodology of Code Case N-638-1 will be followed for the overlay, whenever welding within the 0.125-inch minimum distance from the low alloy steel nozzle base material.

Code Case N-504-2 is approved (with one limitation) for generic use in RG 1.147, Revision 14, and was developed for welding on and using austenitic stainless steel material. An alternate application for nickel-based and low alloy steel materials is proposed due to the specific configuration of this weldment. The weld overlay proposed is austenitic material having a mechanical behavior similar to austenitic stainless steel. It is also compatible with the existing weld and base materials.

The methodology of Code Case N-504-2 is to be followed, except for the following:

<u>Exception to Code Case N-504-2, Requirement (b)</u>

Code Case N-504-2, Requirement (b) requires the weld overlay shall be low carbon (0.035% maximum) austenitic stainless steel.

A consumable welding wire highly resistant to SCC was selected for the overlay material. This material, designated as UNS N06054, F-No. 43, is a nickel based alloy weld filler material, commonly referred to as Alloy 52M and will be deposited using the machine GTAW process with cold wire feed. Alloy 52M contains about 30 wt%

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chromium, which imparts excellent corrosion resistance to the material. By comparison, Alloy 82 is identified as a SCC-resistant material in NUREG-0313 Revision 2 and contains nominally 20 wt% chromium, while Alloy 182 has a nominal chromium content of 15 wt%. With its higher chromium content than Alloy 82, Alloy 52M provides an even higher level of resistance to SCC consistent with the requirements of the Code Case. Therefore, this alternative provides an acceptable level of quality and safety.

Exception to Code Case N-504-2, Requirement (e)

Code Case N-504-2, Requirement (e) requires the first two layers of the weld overlay to have a ferrite content of at least 7.5 FN (Ferrite Number).

The composition of nickel-based Alloy 52M is such that delta ferrite does not form during welding, because Alloy 52M welds are 100% austenitic and contain no delta ferrite due to the high nickel composition (approximately 60 wt% nickel). Consequently, delta ferrite measurements will not be performed for this overlay. Therefore, this alternative provides an acceptable level of quality and safety.

Exception to Code Case N-504-2, Requirement (h)

Code Case N-504-2, Requirement (h) specifies that a system hydrostatic test shall be performed in accordance with IWA-5000 if the flaw penetrates the pressure boundary.

Leak testing in accordance with ASME Section XI (2001 Edition with the 2003 Addenda), IWA-5000, will be performed. Precedence for use of a leak test at normal operating temperature and pressure in lieu of a hydrostatic test has been set with Code Case N416-1 that has been incorporated in ASME Section XI beginning in the 1998 Edition with the 1999 Addenda. Therefore, this alternative provides an acceptable level of quality and safety.

Exception to Code Case N-638-1 Paragraph 1.0(a)

Code Case N-638-1 paragraph 1.0(a) specifies that the maximum weld area on the finished surface shall be 100 square inches. Restoring the structural integrity with the weld overlay of the safe-end-to-nozzle weld will require welding on more than 100 square inches of surface on the low alloy steel base material. The weld overlay will cover approximately 180 square inches of the low alloy steel nozzle.

Code Case N-432 allows temper bead welding on low alloy steel nozzles without limiting the temper bead weld surface area. The two additional conditions required by N-432, that are not required by Code Case N-638-1, are that temper bead welds have pre-heat applied and that the procedure qualification be performed on the same specification, type, grade and class of material. As previously discussed, elevated pre-heat necessitates draining of the RPV and a portion of the recirculation system piping. By removing the water in the pipe, nozzle area, and (in vessel) inlet riser a large amount of shielding is removed. The radiation dose rates at the weld overlay location would increase, thereby significantly increasing personnel dose.

The ASME Code committees have recognized that the 100 square inches restriction on the surface area is unnecessarily limiting and Code Case N-638-3 has been issued to increase the surface area limit to 500 square inches. The code case attempts to combine the features of Code Case N-432 and N-638 into a single code case. The supporting analysis for the code case is found in EPRI Technical Report 1008454, "Expansion of Temperbead Repair: Proposed Code Case," which concluded that the residual stresses are not detrimentally changed by increasing the surface area of the repair and increasing the HAZ tempering is unaffected by the weld overlay application. The technical basis that justifies exceeding 100 square inches of surface area for repair welds is found in EPRI Technical Report 1003616, "Additional Evaluations to Expand Repair Limits for Pressure Vessels and Nozzles." This technical report describes an ANSYS Finite Element Analysis (FEA) conducted on the Nine Mile Point - Unit 2 feedwater nozzle weld overlay repair. The analysis consisted of modeling the welding processes for both thermal and mechanical respects. The two overlays were modeled; one was 100 square inches, the other was extended to blend into the nozzle radius to achieve greater than 100 square inches surface area repair currently permitted by the ASME Code requirements. Comparison of the residual stresses of the two overlays showed that the effect of extending the overlay to the nozzle radius minimally impacted the residual stress profile and, in some cases, slightly increased the beneficial compressive stresses on the nozzle inner diameter. Therefore, this alternative provides an acceptable level of quality and safety.

Exception to Code Case N-638-1 Paragraph. 4.0(b)

Code Case N-638-1 Paragraph 4.0(b) specifies that the final weld surface and band area (1.5T width or 5 inches, whichever is less) shall be examined using surface and ultrasonic methods when the completed weld has been at ambient temperature for at least 48 hours. The UT shall be in accordance with ASME Section XI, Appendix I. Surface exams will be performed. IWA-4634 requires UT of the weld only. Any laminar flaws in the weld overlay will be evaluated in accordance with ASME Section XI Non-mandatory Appendix Q, Paragraph Q-4100, except, as allowed by IWB-3132.3, any flaws that exceed the acceptance standards of Table IWB-3410-1 are acceptable for continued service, without repair, if an analytical evaluation, performed in accordance with IWB-3600, meets the acceptance criteria of IWB-3600. Full UT of the 1.5T band will not be performed. The weld overlay will extend into the blend radius of the nozzle beyond the length required by Code case N-504-2 for structural reinforcement. This extension onto the blend radius eliminates a stress riser on the nozzle and provides additional OD surface area for UT examination of the defect area. UT examination on the nozzle beyond the overlay will not provide any information regarding the area of the defect that required repair. Additionally, such UT would likely be unsatisfactory when applied to the nozzle blend radius, where the toe of the weld overlay resides. The UT return signal would be difficult to obtain and to interpret. Alternatively, surface examination will assure that no defects have been created at the toe of the weld overlay. Therefore, this alternative provides an acceptable level of quality and safety.

Enclosure 1 to
NG-07-0176

Exception to Code Case N-638 Paragraph 4.0(c)

Code Case N-638-1 paragraph 4.0(c) specifies that the area from which weld-attached thermocouples have been removed, shall be ground and examined using a surface examination method. Due to the personnel exposure associated with the installation and removal of the thermocouples, the nozzle configuration, and because the nozzle will be full of water, thermocouples will not be used to verify that the pre-heat and interpass temperature limits are met. In lieu of thermocouples, a contact pyrometer will be used to verify pre-heat temperature and interpass temperature compliance with the WPS requirements. Therefore, this alternative provides an acceptable level of quality and safety.

The use of overlay filler material that provides excellent resistance to SCC develops an effective barrier to flaw extension. Also, temper bead welding techniques produce excellent toughness and ductility in the weld HAZ low alloy steel materials, and in this case, results in compressive residual stresses on the inside surface that help to inhibit further SCC. The design of the overlay for the safe-end-to-nozzle weldment uses methods that are standard in the industry. There are no new or different approaches in this overlay design which would be considered either first-of-a-kind or inconsistent with previous approaches. The overlay will be designed as a full structural overlay in accordance with Code Case N-504-2. The temper bead welding technique that will be implemented in accordance with Code Case N-638-1 will produce a tough, ductile, corrosion-resistant overlay.

Use of Code Cases N-504-2 and N-638-1 has been accepted in RG 1.147, Revision 14, with the following limitations as providing an acceptable level of quality and safety.

Code Case N-504-2 Limitation

The provisions of Section XI, Non-mandatory Appendix Q, "Weld Overlay Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping Weldments," must also be met, as noted in RG 1.147.

The DAEC will meet the associated requirements contained in this non-mandatory Appendix Q.

Code Case N-638-1 Limitation

UT examinations shall be demonstrated for the repaired volume using representative samples which contain construction type flaws. The acceptance criteria of NB-5330 of Section III edition and addenda approved in 10CFR50.55a apply to all flaws identified in the repair volume

The DAEC will implement this limitation.

Enclosure 1 to
NG-07-0176

FPL Energy Duane Arnold concludes that the alternative repair approach described above presents an acceptable level of quality and safety to satisfy the requirements of 10CFR50.55a(a)(3)(i).

6.0 Duration of Proposed Alternative

The DAEC is currently in its fourth ten-year ISI interval, which began November 1, 2006 and will end concurrent with the DAEC Operating License on February 21, 2014. Consequently, the requested relief is for the remainder of the current Operating License.

7.0 Precedents

The observed flaws at DAEC are consistent with the documented SCC observed at DAEC in 1999 on the safe-end-to-nozzle welds N2B and N2D. Similar flaws have been observed at other BWRs, including Perry, Nine Mile Point – Unit 2, Susquehanna – Unit 1, and more recently at Hope Creek Generating Station.

Enclosure 2 to
NG-07-0176

Supplemental Information on Duane Arnold Energy Center Recirculation Nozzle to Safe End Welds RRC-F002 and RRF-F002

Recirculation Piping Safe End Design

The function of the N2 nozzles is to connect the recirculation system inlet piping to the RPV. The design includes a safe-end and thermal sleeve connecting the external recirculation piping to the internal jet pump riser (see Figures 1 and 2).

The existing safe-end-to-nozzle weld is Alloy 82 and connects the Alloy 600 SB-166 safe-end to the SA-508 Class 2 low alloy steel nozzle, buttered with Alloy 182. A portion of the original Alloy 82/182 safe-end-to-nozzle weld remains on the nozzle side as a result of installing a modified safe-end with an integrally-attached thermal sleeve in 1978.

This is an ASME Section II, Part C, SFA-5.14 ERNiCr-3 UNS N06082 (commercially known as Alloy 82) weld, that connects an approximately 13.12 inch OD by 11.00 inch ID Alloy 600 SB-166 safe-end to the SA-508 Class 2 low alloy steel nozzle, buttered with ASME Section II, Part C, SFA-5.11 ENiCrFe-3, UNS W86182 (commercially known as Alloy 182).

DAEC ISI Program

The DAEC has implemented the Risked-Informed ISI Program using the methodology in EPRI TR—112657 Rev B-A, in accordance with RG 1.178. The Risked-Informed implementation started in the third 10-year interval in the second period. A Relief Request (NDE-R005) was approved granting continuation of the Risk-Informed program for the current fourth 10-year interval (ML070090357).

The RRC-F002 and RRF-F002 safe-end-to-nozzle welds were classified as Category R-A (B-F), Item No. R1.16 (B5.10) welds.

Failure Mechanism	Risk Ranking	Failure Potential	Consequence	Risk Category
TT (IGSCC)	High (High)	Medium	High	2(2)

RRF-F002 was ranked as a Category 2 with a consequence ranking of High and degradation mechanisms of thermal fatigue and IGSCC. This means that RRC-F002 and RRF-F002 are in the sample where 25% of the welds are required to be examined once every 10 years. RRF-F002 was part of the 25% population. RRC-F002 was not chosen as part of the 25% population.

Current Inspection Results

During RFO20, ISI UT examinations of the dissimilar weld metal joint at the N2F recirculation inlet nozzle, safe-end-to-nozzle weld (RRF-F002) was examined, as an

Enclosure 2 to
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ASME Code required successive examination. The RRF-F002 weld has a sub-surface indication identified during a previous inspection (RFO16). This was the third, and last, successive examination. This indication has not changed.

The welds were examined with an ASME Section XI, Appendix VIII qualified, Electric Power Research Institute (EPRI) - Performance Demonstration Initiative (PDI) procedure. The inspection was performed using encoded, manual, phased-array UT. As a result of this examination, a circumferentially-oriented indication was identified in RRF-F002. The indication appears to be planar with a length of approximately 7 inches and a depth of 56% through-wall.

Due to finding the above indication, the original examination scope was expanded to include the other susceptible safe-end-to-nozzle welds in the recirculation and Core Spray nozzles. Because the N2B and N2D nozzles had previously been repaired with full structural overlays in 1999 (ML9933004460), those nozzles are no longer considered to be susceptible and were excluded from the expanded scope. Those examinations found a new indication in the F002 weld in the N2C nozzle. This indication is circumferentially-oriented and appears to be planar with a length of approximately 6 inches and a depth of 74% through wall.

The above flaw in each weld is not believed to extend through wall as verified by no observed leakage of the entire OD weld surface and adjacent areas. Estimates on indication depth provided from information available from the detection and length sizing examination data indicates that the flaw size estimates would exceed the acceptance criteria stated in IWB-3514-2.

Suspected Degradation Mechanism

Even though the root cause evaluation has not been completed, experience at the same weld joint on the N2B & D Nozzles (RRB-F002 and RRD-F002) at DAEC in 1999 and at other Boiling Water Reactors (BWRs), it appears that the cause of the flaw is most likely due to stress corrosion cracking (SCC).

Hydrogen Water Chemistry (HWC) was implemented in 1987. The injection rate for HWC is at 2.6 standard cubic feet per minute (scfm) that results in an Electro-Chemical Potential (ECP) of below -230 μMho/cm. NobleChem™ was initially implemented in 1996, with follow-up injections in 1999 and 2005.

In addition, no stress improvement (either mechanical or inductive heat) has been used on these welds.

Inspection History

Below is the history of examinations for the safe-end-to-nozzle weld RRF-F002 during the second and third inspection intervals. It is important to note that the examination history includes examinations from both the Augmented Inspection Program (Generic Letter 88-01) and the ASME Code Program.

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NG-07-0176

Examination History of Safe-end to Nozzle Weld RRF-F002

Examination Date	Type of Examination (Automated/Manual)	Results
1987	Manual	ID Geometry (counterbore)
1988	Manual	Dissimilar Material Interface ID Geometry
1990	Automated GE Smart UT System	60° L-wave recorded root and inside surface geometry from both sides of weld 45° L-wave recorded root geometry on upstream side also acoustic interface from downstream side 45° shear recorded root geometry on upstream side
1996	Automated GE Smart 2000 System	45° Shear Wave recorded weld root geometry from the upstream side. 45° L-wave recorded weld root geometry from upstream side. 60° L-wave recorded weld root geometry from both sides.
1999	Automated GE Smart 2000 System	45° RL recorded ID surface geometry 60° RL recorded root and ID surface geometry 70° RL recorded acoustic interface, clad interface
*1999 Supplement After portion of crown removal 4" to 15" clockwise from Top-Dead Center	Automated GE Smart 2000 System	45° RL recorded root geometry 60° RL recorded root geometry and lack of fusion 70° RL recorded lack of fusion
2001	Manual	No Change in previously recorded indication

Enclosure 2 to
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Examination Date	Type of Examination (Automated/Manual)	Results
2005	Automated	45° RL recorded root geometry 45° Shear recorded root geometry 60° RL recorded weld repair area, ID geometry and Interface
2007	Encoded Manual Phased Array	1 - Linear Ind. 7" long TRL 90 & TRL 270 - ID Geometry (Root) 1 - Weld Defect 15mm long (same as 2005 data)

*This examination put the weld in a Successive Examination Schedule

<u>Examination History of Safe-end to Nozzle Weld RRC-F002</u>

Examination Date	Type of Examination (Automated/Manual)	Results
1983	Manual	360° impedance mismatch
1985	Manual	ID & OD Geometry ID Counter-bore
1987	Manual	ID Geometry
1988	Manual	Dissimilar. Material. Interface, ID Geometry
1992	Manual	45° RL recorded non-relevant indications, ID surface geometry 60° RL recorded non-relevant indications and acoustic interface.
1995	Automated GE Smart 2000 System	45° RL recorded ID surface geometry 60° RL recorded root and ID surface geometry
1999	Automated GE Smart 2000 System	45° RL recorded ID surface geometry 60° RL recorded root and ID surface geometry 70° RL recorded acoustic interface
2007	Encoded Manual Phased Array	1 - Linear Ind. 6" long TRL 90 & TRL 270 - ID Geometry (Root)

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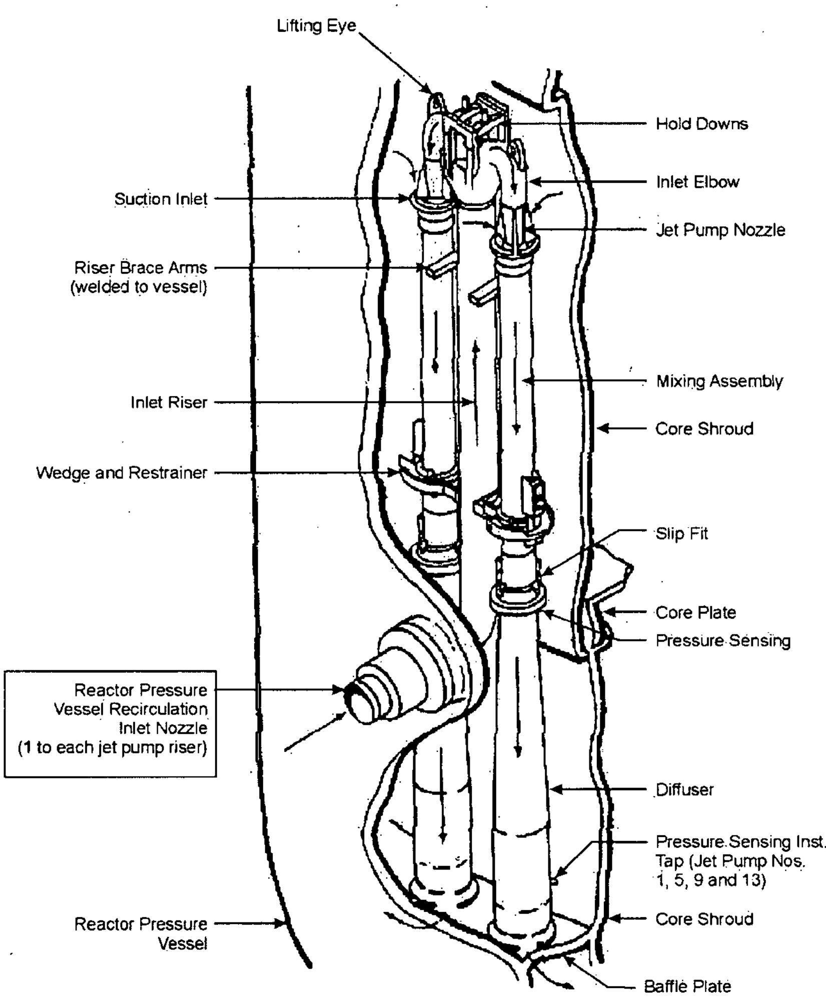
NG-07-0176

Similar BWR Experience

The observed flaw at DAEC is consistent with the documented SCC observed at DAEC in 1999 on safe-end-to-nozzle welds. Similar flaws have been observed at other BWRs, including Perry, Nine Mile Point - Unit 2, Susquehanna - Unit 1, and more-recently Hope Creek Generating Station.

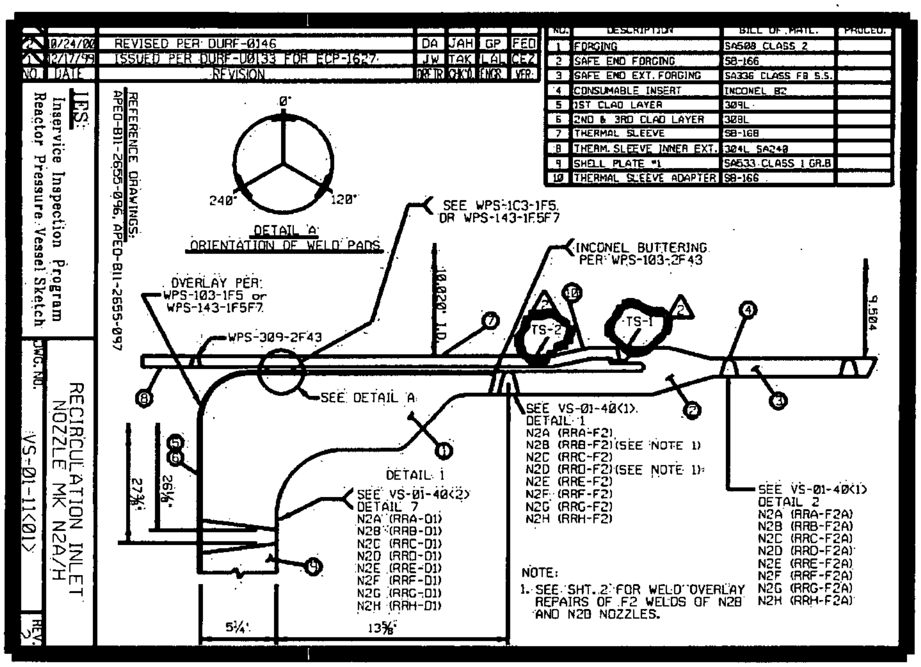
Enclosure 2 to
NG-07-0176

FIGURE 1



Enclosure 2 to
NG-07-0176

FIGURE 2



FPLEnergy.
Duane Arnold Energy Center

FPL Energy Duane Arnold, LLC
3277 DAEC Road
Palo, Iowa 52324

February 28, 2007

NG-07-0191
10 CFR 50.55a(a)(3)(i)

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

Duane Arnold Energy Center
Docket No: 50-331
Op. License No: DPR-49

Response to Request for Additional Information on Alternative to ASME Section XI Requirements to use Code Cases N-504-2 and N-638-1 for Weld Overlay Repairs at the Duane Arnold Energy Center

Reference: Letter, Gary Van Middlesworth (FPL Energy Duane Arnold) to Document Control Desk (USNRC) - Alternative to ASME Section XI Requirements to use Code Cases N-504-2 and N-638-1 for Weld Overlay Repairs at the Duane Arnold Energy Center, dated February 24, 2006

The referenced letter forwarded the FPL Energy Duane Arnold request for relief to allow use of an alternative to ASME Section XI Requirements to use Code Cases N-504-2 and N-638-1 for weld overlay repairs at the Duane Arnold Energy Center (DAEC). In a conference call with the Staff on February 27, 2007, the NRC requested additional clarifying information concerning the referenced relief request. The Enclosure to this letter contains the requested information.

This letter contains no new commitments and no revisions to existing commitments.

Questions regarding this matter should be directed to Steve Catron, Licensing Manager, at (319) 851-7234.

Sincerely yours,

Gary Van Middlesworth
Site Vice President, Duane Arnold Energy Center
FPL Energy Duane Arnold

A047

NG-07-0191
February 28, 2007
Page 2 of 2

Enclosure

cc: Administrator, Region III, USNRC
Project Manager, DAEC, USNRC
Resident Inspector, DAEC, USNRC

Enclosure to
NG-07-0191

Response to Request for Additional Information on Alternative to ASME Section XI Requirements to use Code Cases N-504-2 and N-638-1 for Weld Overlay Repairs at the Duane Arnold Energy Center

Request #1

FPL Energy Duane Arnold credits a PQR for the qualification of the WSI weld overlay procedure. What material was used for that test?

FPL Energy Duane Arnold Response:

There are a total of three PQRs that support the weld procedure:

1) PQR-03-03-T-803 used a base material of SA-533, Grade B Class1;
2) PQR-43-43-T-001 used SB-168 to SB-168; and,
3) PQR-03-43-T-001 used SA-533, Type A Class 2 to SB-168.

Request #2

FPL Energy Duane Arnold requested up to 500 square inches (per Code Case), but NRC has not approved any request over 300 square inches. The referenced relief request anticipated approximately 180 square inches of coverage. What is the maximum expected weld overlay coverage?

FPL Energy Duane Arnold Response:

The weld overlay will not exceed 260 square inches on the low alloy nozzle (Area under the segment labeled "B" in the Figure on page 4 of 14 of the relief request (Reference 1)).

Request #3

What is the expected distance of the pre-service UT inspection on the nozzle side from the edge of the new weld? FPL Energy Duane Arnold provided verbal discussion during the conference call to indicate that it will depend on the transducer size and how far it will give data before it loses contact. NRC would like FPL Energy Duane Arnold to provide an estimate.

Enclosure to
NG-07-0191

FPL Energy Duane Arnold Response:

Based upon an in-the-field measurement of the actual transducer, FPL Energy Duane Arnold has estimated the limitation of the UT exams on the nozzle side in the four orthogonal directions: in the circumferential direction, for scanning clockwise and counterclockwise, the limitation distance is 0.4 inch; in the direction scanning toward the nozzle the limitation distance is 0.4 inch; and when scanning away from the nozzle taper, the limitation distance is 0.6 inch.

Reference:

Letter, Gary Van Middlesworth (FPL Energy Duane Arnold) to Document Control Desk (USNRC) - Alternative to ASME Section XI Requirements to use Code Cases N-504-2 and N-638-1 for Weld Overlay Repairs at the Duane Arnold Energy Center, dated February 24, 2004.

FPL Energy.

Duane Arnold Energy Center

FPL Energy Duane Arnold, LLC
3277 DAEC Road
Palo, Iowa 52324

February 26, 2007

NG-07-0188
10 CFR 50.55a(a)(3)(i)

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

Duane Arnold Energy Center
Docket No: 50-331
Op. License No: DPR-49

Response to Requests for Additional Information on Alternative to ASME Section XI Requirements to use Code Cases N-504-2 and N-638-1 for Weld Overlay Repairs at the Duane Arnold Energy Center

Reference: 1) Letter, Gary Van Middlesworth (FPL Energy Duane Arnold) to Document Control Desk (USNRC) - Alternative to ASME Section XI Requirements to use Code Cases N-504-2 and N-638-1 for Weld Overlay Repairs at the Duane Arnold Energy Center, dated February 24, 2006

Reference 1 forwarded the FPL Energy Duane Arnold request for relief to allow use of an alternative to ASME Section XI Requirements to use Code Cases N-504-2 and N-638-1 for weld overlay repairs at the Duane Arnold Energy Center (DAEC). In an email dated February 26, 2007, the NRC provided a request for additional information concerning Reference 1. This submittal provides the responses to the requests.

FPL Energy Duane Arnold requests approval of Reference 1 prior to beginning the weld overlay repair of safe-end-to-nozzle welds RRC-F002 and RRF-F002, currently scheduled for February 27, 2007.

This letter contains no new commitments and no revisions to existing commitments.

A047

NG-07-0188
February 26, 2007
Page 2 of 2

Questions regarding this matter should be directed to Steve Catron, Licensing Manager, at (319) 851-7234.

2/26/07

Gary Van Middlesworth
Site Vice President, Duane Arnold Energy Center
FPL Energy Duane Arnold

Enclosure

cc: Administrator, Region III, USNRC
Project Manager, DAEC, USNRC
Resident Inspector, DAEC, USNRC

Enclosure to
NG-07-0188

Response to Requests for Additional Information on Alternative to ASME Section XI Requirements to use Code Cases N-504-2 and N-638-1 for Weld Overlay Repairs at the Duane Arnold Energy Center

Request #1

How has the licensee addressed the rapid cooling rates which are possible from water-backed welding on the SA-508 Class 2 base metal? Has a mockup or procedure qualification record (PQR) of a water-backed weld overlay been performed? What overlay thickness was used on the mockup or PQR? What is the thickness of the nozzle under the weld overlay? Has any testing (metallurgical, destructive, non-destructive, etc.) been performed on any weld overlays fabricated on water-backed SA-508 Class 2 base metal?

FPL Energy Duane Arnold Response:

The welding procedure was qualified for water-backed welding. The procedure was qualified using PQR 0303T803 Rev. 0 which is a water-backed PQR. The overlay thickness used for the PQR was 1.5 inch deep cavity on a 3 inch coupon. The nozzle thickness in the area of the overlay is 1.06 inch. FPL Energy Duane Arnold has performed pre-service and inservice examinations of the two overlays that were completed using Code Cases N-504-1 and N-606 in 1999.

Request #2

What is the maximum area of the P-3 material that will be welded on? This should be stated in the relief request. The relief request mentions 500 sq. in., but not as the maximum area that is to be welded on during this specific repair.

FPL Energy Duane Arnold Response:

The weld overlay will cover approximately 180 square inches of the low alloy nozzle (ref. page 11 of 14 of the relief request (Reference 1)).

Request #3

How often will contact pyrometers be used to measure weld preheat and interpass temperatures? Every pass? Every layer? Once during welding?

FPL Energy Duane Arnold Response:

The contact pyrometers will be used to verify pre-heat prior to welding and every three to five beads on the first three layers.

Enclosure to
NG-07-0188

Request #4

On page 12 of 14 [of Reference 1], under "Exception to Code Case N-638-1, Paragraph 4.0(b)," how far will the surface examination be continued past the toe of the weld overlay on the SA-508 Class 2 base metal?

FPL Energy Duane Arnold Response:

The surface examination will extend to 1.5" up on the nozzle.

Request #5

On page 12 of 14 [of Reference 1], under "Exception to Code Case N-638-1, Paragraph 4.0(b)," will the ultrasonic examination extend up to the very edge of the overlay?

FPL Energy Duane Arnold Response:

The ultrasonic examination will be performed in accordance with PDI-UT-8 Revision F which states: "Pre-service examinations shall be performed across the entire overlay surface. Inservice examinations shall be performed to the extent necessary to cover the required examination volume." The examination volume is depicted in Figure 4300-1 of Appendix Q.

Request #6

On Page 12 of 14 [of Reference 1], under "Exception to Code Case N-638-1 Paragraph 4.0(b), the licensee states that "...Any laminar flaws in the weld overlay will be evaluated in accordance with ASME Section XI Non-mandatory Appendix Q, Paragraph Q-4100, except, as allowed by IWB-3132.2, any flaws that exceed the acceptance standards of Table IWB-3410-1 are acceptable for continued service, without repair, if an analytical evaluation, performed in accordance with IWB-3600, meets the acceptance criteria of IWB-3600."

The staff does not agree with the licensee's exception to Appendix Q, Paragraph Q-4100. Paragraph Q-4100(1) does not allow laminar flaws to be accepted by IWB-3600. In addition, Code Case N-504-2, Paragraph (i) does not allow flaw acceptance by IWB- 3600 for the preservice examination. The NRC staff's position is that any flaw detected in the weld overlay during the preservice examination that does not satisfy the acceptance standards of Table IWB-3514-2 must to be removed or repaired. Therefore, the licensee should modify its relief request to be consistent with the NRC staff's position or provide a detailed, technical basis to support its exception to paragraph Q-4100 of Appendix Q of the ASME Code, Section XI.

Enclosure to
NG-07-0188

FPL Energy Duane Arnold Response:

The exception as noted in the original relief request will be removed. The DAEC will comply with the requirements contained in Non-mandatory Appendix Q Paragraph Q-4100(1). The exception on page 12 of 14 from Reference 1 is hereby revised as follows:

"Code Case N-638-1 Paragraph 4.0(b) specifies that the final weld surface and band area (1.5T width or 5 inches, whichever is less) shall be examined using surface and ultrasonic methods when the completed weld has been at ambient temperature for at least 48 hours. The UT shall be in accordance with ASME Section XI, Appendix I. Surface exams will be performed. IWA-4634 requires UT of the weld only. ~~Any laminar flaws in the weld overlay will be evaluated in accordance with ASME Section XI Non-mandatory Appendix Q, Paragraph Q-4100, except, as allowed by IWB-3132.3, any flaws that exceed the acceptance standards of Table IWB-3410-1 are acceptable for continued service, without repair, if an analytical evaluation, performed in accordance with IWB-3600, meets the acceptance criteria of IWB-3600~~. Full UT of the 1.5T band will not be performed. The weld overlay will extend into the blend radius of the nozzle beyond the length required by Code case N-504-2 for structural reinforcement. This extension onto the blend radius eliminates a stress riser on the nozzle and provides additional OD surface area for UT examination of the defect area. UT examination on the nozzle beyond the overlay will not provide any information regarding the area of the defect that required repair. Additionally, such UT would likely be unsatisfactory when applied to the nozzle blend radius, where the toe of the weld overlay resides. The UT return signal would be difficult to obtain and to interpret. Alternatively, surface examination will assure that no defects have been created at the toe of the weld overlay. Therefore, this alternative provides an acceptable level of quality and safety."

Request #7

Clarify whether the weld overlay will be applied multiple times to a specific weld.

FPL Energy Duane Arnold Response:

The DAEC will only apply one overlay to each weld RRF-F002 and RRC-F002.

Reference:

1) Letter, Gary Van Middlesworth (FPL Energy Duane Arnold) to Document Control Desk (USNRC) - Alternative to ASME Section XI Requirements to use Code Cases N-504-2 and N-638-1 for Weld Overlay Repairs at the Duane Arnold Energy Center, dated February 24, 2006

June 12, 2007

Mr. Gary Van Middlesworth
Site Vice President
Duane Arnold Energy Center
3277 DAEC Road
Palo, IA 52324-9785

SUBJECT: DUANE ARNOLD ENERGY CENTER - SAFETY EVALUATION FOR REQUEST TO USE CODE CASES N-504-2 AND N-638-1 FOR WELD OVERLAY REPAIRS FOR ALTERNATIVE TO ASME SECTION XI REPAIR REQUIREMENTS (TAC NO. MD4466)

Dear Mr. Van Middlesworth:

By letter dated February 24, 2007, as supplemented by letters dated February 26, and February 28, 2007, FPL Energy Duane Arnold, LLC (FPL Energy) submitted a request for relief from certain requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) at Duane Arnold Energy Center (DAEC). FPL Energy proposed to use ASME Code Cases N-638-1 and N-504-2, with modifications, specifically for the purpose of performing full structural weld overlays on certain reactor system welds.

The Nuclear Regulatory Commission (NRC).staff has completed its review of the relief request as documented in the enclosed Safety Evaluation (SE). The NRC staff concludes that the modifications proposed in the request for relief to perform full structural weld overlays on the Reactor Vessel N2C and N2F recirculation inlet nozzles, safe end-to-nozzle weld joint RRC-F002 and weld joint RRF-F002 dissimilar metal welds at DAEC will provide an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the NRC staff authorizes the proposed alternatives for the installation of full structural weld overlays, over the welds identified in the relief request, during refueling outage (RFO) 20.

All other ASME Code, Section XI requirements for which relief was not specifically requested and approved in this relief request remain applicable, including third party review by the Authorized Nuclear Inservice Inspector.

On March 6, 2007, prior to the completion of RFO 20, verbal authorization of the licensee's proposed alternatives were granted.

If you have any questions regarding this matter, please contact Mr. Karl Feintuch at

G. Van Middlesworth - 2 -

June 12, 2007

If you have any questions regarding this matter, please contact Mr. Karl Feintuch at (301) 415-3079.

Sincerely,

/RA/ Patrick Milano for

L. Raghavan, Chief
Plant Licensing Branch III-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-331

Enclosure:
Safety Evaluation

cc w/encl: See next page

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Duane Arnold Energy Center

cc:

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Revised May 4, 2007

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

REQUEST FOR RELIEF TO EXTEND

THE THIRD 10-YEAR INSERVICE INSPECTION INTERVAL AT THE

DUANE ARNOLD ENERGY CENTER

FPL ENERGY

DOCKET NO. 50-331

1.0 INTRODUCTION

By letter dated February 24, 2007, as supplemented by letters dated February 26, and February 28, 2007, FPL Energy Duane Arnold (the licensee), proposed to use, with modifications, the repair requirements of the American Society of Mechanical Engineers (ASME) Code Case N-504-2, "Alternative Rules for Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping, Section XI, Division 1" (N-504-2), and Code Case N-638-1, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique, Section XI, Division 1" (N-638-1), of ASME Code, Section XI. The code cases, with modifications, would be used to perform full structural weld overlays (WOLs) on the Reactor Vessel N2C and N2F recirculation inlet nozzle, safe-end-to-nozzle weld joint RRC-F002 and RRF-F002 dissimilar metal welds. The subject welds were fabricated using Alloy 82, with Alloy 182 buttering. This safety evaluation is for the configuration of full structural WOLs.

2.0 REGULATORY EVALUATION

Pursuant to Title 10 of the Code of Federal Regulations (10 CFR) 50.55a(g)(4), ASME Code Class 1, 2, and 3 components (including supports) will meet the requirements, except the design and access provisions and the preservice examination requirements, set forth in the ASME Code, Section XI, "Rules for Inservice Inspection (ISI) of Nuclear Power Plant Components," to the extent practical within the limitations of design, geometry, and materials of construction of the components. The regulations require that inservice examination of components and system pressure tests conducted during the first 10-year interval and subsequent intervals comply with the requirements in the latest edition and addenda of Section XI of the ASME Code incorporated by reference in 10 CFR 50.55a(b) 12 months prior to the start of the 120-month interval, subject to the limitations and modifications listed therein. The Duane Arnold Energy Center (DAEC) is in its fourth 10-year ISI interval, which began November 1, 2006, and will end concurrent with the DAEC Operating License on February 21,2014. The ISI Code of record for DAEC for the fourth 10-year ISI interval is the ASME Code Section XI, 2001 Edition, including Addenda through 2003.

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Pursuant to 10 CFR 50.55a(a)(3), alternatives to requirements may be authorized by the U.S. Nuclear Regulatory Commission (NRC) if the licensee demonstrates that: (I) the proposed alternatives provide an acceptable level of quality and safety, or (ii) compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety. The licensee submitted the subject relief request, pursuant to 10 CFR 50.55a(a)(3)(i), which proposed alternatives to the implementation of the ASME Code, Section XI, Code Cases N-638-1 and N-504-2 for the deposition of WOLs for the remaining service life of the affected components.

3.0 TECHNICAL EVALUATION

3.1 Code Requirements for which Relief is Requested

Under the rules of IWA-4220, repairs shall be performed in accordance with the licensee's design specification and the original Construction Code. Later editions and addenda of the Construction Code or of ASME Section III, either in their entirety or portions thereof, and Code Cases may be used.

The licensee has requested to use Code Cases N-504-2 and N-638-1, which were conditionally approved by the NRC as specified in Regulatory Guide (RG) 1.147, Revision 14, as modified by the following proposed alternatives.

3.2 Licensee's Proposed Alternatives to Code Case N-504-2

- Code Case N-504-2 was prepared specifically to apply a weld overlay to austenitic stainless steel material. An alternative was required to implement the N-504-2 weld overlay methodology due to the specific materials and configuration of the existing nickel-based alloy weld and buttering (Alloy 82 and Alloy 182) and Alloy 600 safe ends.

- Code Case N-504-2, Requirement (b) requires that the weld overlay shall be low carbon (0.035 percent maximum) austenitic stainless steel. An alternative was required since a nickel-based filler (Alloy 52M) has been selected to be used.

- Code Case N-504-2, Requirement (e) requires that the first two layers of the weld overlay shall have a ferrite content of at least 7.5 FN (Ferrite Number). The licensee does not intend to perform these measurements for this type of overlay on the basis that the nickel alloy filler is a fully austenitic material.

- Code Case N-504-2, Requirement (h) specifies that a system hydrostatic test shall be performed, in accordance with ASME Section XI, IWA-5000, if the flaw penetrates the original pressure boundary. In the event a flaw becomes through wall, leak testing, in accordance with IWA-5000, will be performed.

3.3 Licensee's Proposed Alternatives to Code Case N-638-1

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- Code Case N-638-1, paragraph 1.0(a) specifies that the maximum weld area on the finished low alloy steel surface shall be 100 square inches. Restoring the structural integrity of the safe end-to-nozzle weld will require application of the weld overlay on more than 100 square inches of surface on the low alloy steel base material.
- Code Case N-638-1, paragraph 4.0(b) specifies that the final weld surface and the band around the area (to a width of 1.5 times the thickness of the weld (1.5T) or 5 inches, whichever is less) shall be examined using surface and ultrasonic test (UT) methods, when the completed weld has been at ambient temperature for at least 48 hours. The UT shall be in accordance with ASME Section XI, Appendix I. Full UT examination of the 1.5T band will not be performed.
- Code Case N-638-1, paragraph 4.0© specifies that the area from which weld-attached thermocouples have been removed shall be ground and examined using a surface examination method. Thermocouples will not be used. Instead, calibrated pyrometers will be utilized to monitor preheat and interpass temperatures.

3.4 Licensee's Basis for Relief

A full structural weld overlay repair is proposed for the safe end-to-nozzle weldments. The nozzle material is SA-508 Class 2 low alloy steel. The safe end is Alloy 600 (SB-166). The existing weld material is Alloy 82 with Alloy 182 buttering.

The weld overlay will be designed consistent with the requirements of NUREG-0313, Revision 2 (which was implemented by Generic Letter 88-01), Code Case N-504- 2, Code Case N-638-1, and IWB-3640, and Appendix C from the 2001 Edition through 2003 Addenda of ASME Code Section XI.

The use of an overlay filler material that provides excellent resistance to stress corrosion cracking (SCC) creates an effective barrier to flaw extension. Also, temper bead welding techniques produce excellent toughness and ductility in the weld heat-affected zone (HAZ) of low alloy steel materials and, in this case, results in compressive residual stresses on the inside surface that help to inhibit further SCC of the original weldment. The design of the overlay for the safe end-to-nozzle weldment uses methods that are standard in the industry. There are no new or different approaches in this overlay design which would be considered either a first-of-a-kind or inconsistent with previous approaches.

The overlay will be designed as a full structural weld overlay in accordance with Code Case N-504-2. The temper bead welding technique, that will be implemented in accordance with Code Case N-638-1, will produce a tough, ductile, corrosion-resistant overlay.

3.5 Conditions for Code Case N-504-2 and N-638-1 accepted in RG 1.147

Use of Code Cases N-504-2 and N-638-1 has been accepted in RG 1.147, Revision 14, with the following conditions as limitations providing an acceptable level of quality and safety.
Code Case N-504-2 Limitation:

The provisions of Section XI, Non-Mandatory Appendix Q, "Weld Overlay Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping Weldments," must be met. DAEC intends to meet the associated requirements contained in this non-mandatory Appendix Q.

Code Case N-638-1 Limitation:

UT examinations shall be demonstrated for the repaired volume using representative samples which contain construction type flaws. The acceptance criteria of NB-5330 of the Section III edition and addenda approved in 10 CFR 50.55a apply to all flaws identified in the repair volume. The DAEC intends to implement this limitation.

3.6 Licensee's Basis for the Alternatives

Code Case N-504-2 Requirement (b) Alternative:

Code Case N-504-2, Requirement (b) requires that the weld overlay be low carbon (0.035 percent maximum) austenitic stainless steel. A consumable welding wire, highly resistant to SCC, was selected for the overlay material. This material, designated as UNS N06054, F-No. 43, is a nickel-based alloy weld filler material, commonly referred to as Alloy 52M, and will be deposited using the machine gas tungsten arc welding (GTAW) process, with cold wire feed. Alloy 52M contains about 30 percent by weight (wt percent) chromium, which imparts excellent corrosion resistance to the material. By comparison, Alloy 82 is identified as a SCC-resistant material in NUREG-0313, Revision 2 and contains nominally 20 wt percent chromium, while Alloy 182 has a nominal chromium content of 15 wt percent. With its higher chromium content than Alloy 82, Alloy 52M provides a level of resistance to SCC consistent with the requirements of the Code Case. Therefore, this alternative provides an acceptable level of quality and safety.

Code Case N-504-2, Requirement (e) Alternative:

Code Case N-504-2, Requirement (e) requires the first two layers of the weld overlay to have a ferrite content of at least 7.5 FN (Ferrite Number). The composition of nickel-based Alloy 52M is such that delta ferrite does not form during welding because Alloy 52M welds are 100 percent austenitic and contain no delta ferrite due to the high nickel composition (approximately 60 wt percent nickel). Consequently, delta ferrite measurements of the overlay are not intended to be performed by DAEC Therefore, this alternative provides an acceptable level of quality and safety.

Code Case N-504-2, Requirement (h) Alternative:

Code Case N-504-2, Requirement (h) specifies that a system hydrostatic test be performed, in accordance with IWA-5000, if the flaw penetrates the original pressure boundary. Leak testing, in accordance with ASME Section XI (2001 Edition with the 2003 Addenda), IWA-5000, will be performed. Precedence for use of a leak test at normal operating temperature and pressure in lieu of a hydrostatic test was established by Code Case N-416-1, which has been incorporated in ASME Section XI beginning in the 1998 Edition with the 1999 Addenda. Therefore, this alternative provides an acceptable level of quality and safety.

Code Case N-638-1, Paragraph 1.0(a) Alternative:

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Code Case N-638-1 paragraph 1.0(a) specifies that the maximum weld area on the finished surface shall be 100 square inches. Restoring the structural integrity of a safe end-to-nozzle weld will require application of the weld overlay on more than 100 square inches of surface on the low alloy steel base material. The weld overlay will cover approximately 180 square inches of the low alloy steel nozzle. Code Case N-432 "Repair Welding Using Automatic or Machine Gas Tungsten-Arc Welding (GTAW) Temper Bead Technique, Section XI, Division 1," (N-432), allows temper bead welding on low alloy steel nozzles, without limiting the temper bead weld surface area. The two additional conditions required by N-432, that are not required by Code Case N-638-1, are (1) that temper bead welds have preheat applied and (2) that the procedure qualification be performed on the same specification, type, grade and class of material. Elevated preheat necessitates draining of the reactor pressure vessel and a portion of the recirculation system piping. By removing the water in the pipe, nozzle area, and (in vessel) inlet riser, a large amount of shielding is removed. The radiation dose rates at the weld overlay location would increase, thereby significantly increasing personnel dose.

The ASME Code committees have recognized that the 100 square inches restriction on the surface area is unnecessarily limiting, and Code Case N-638-3 has been issued to increase the surface area limit to 500 square inches. The code case attempts to combine the features of Code Case N-432 and N-638 into a single code case. The supporting analysis for the code case is found in Electric Power Research Institute (EPRI) Technical Report 1008454, "Expansion of Temperbead Repair: Proposed Code Case," which concluded that the residual stresses are not detrimentally changed by increasing the surface area of the repair. The technical basis that justifies exceeding 100 square inches of surface area for repair welds is found in EPRI Technical Report 1003616, "Additional Evaluations to Expand Repair Limits for Pressure Vessels and Nozzles." This technical report describes an ANSYS Finite Element Analysis conducted on the Nine Mile Point, Unit 2 feedwater nozzle weld overlay repair. The analysis consisted of modeling the welding processes for both thermal and mechanical aspects. Two overlays were modeled: one was 100 square inches, the other was extended to blend into the nozzle radius to achieve greater than the 100 square inches surface area repair currently permitted by the ASME Code requirements. Comparison of the residual stresses of the two overlays showed that the effect of extending the overlay to the nozzle radius minimally impacted the residual stress profile and, in some cases, slightly increased the beneficial compressive stresses on the nozzle inner diameter. In this instance, the weld overlay on each of these two nozzles will not exceed 260 square inches on the low alloy nozzle. Therefore, this alternative provides an acceptable level of quality and safety.

Code Case N-638-1, Paragraph 4.0(b) Alternative:

Code Case N-638-1 Paragraph 4.0(b) specifies that the final weld surface and band area (1.5T width or 5 inches, whichever is less) shall be examined using surface and ultrasonic methods when the completed weld has been at ambient temperature for at least 48 hours. The UT shall be in accordance with ASME Section XI, Appendix I. Per this requirement, surface exams will be performed. Since ASME Section XI, IWA-4634 requires UT of the weld only, full UT of the 1.5T band will not be performed. The weld overlay will extend into the blend radius of the nozzle beyond the length required by Code Case N-504-2 for structural reinforcement. This extension onto the blend radius eliminates a stress riser on the nozzle and provides additional outside diameter surface area for UT examination of the defect area. UT examination on the nozzle beyond the overlay will not provide any information regarding the area of the defect that required repair. Additionally, such UT would likely be unsatisfactory when applied to the nozzle blend radius, where the toe of the weld overlay resides. The UT return signal would be difficult to obtain and to interpret. Alternatively, surface examination will assure that no defects have been created at the toe of the weld overlay. This surface examination will extend to 1.5 inches up on the nozzle. This alternative provides an acceptable level of quality and safety.

Code Case N-638, Paragraph 4.0© Alternative:

Code Case N-638-1 paragraph 4.0© specifies that the area from which weld-attached thermocouples have been removed shall be ground and examined using a surface examination method. Due to the personnel exposure associated with the installation and removal of the thermocouples, due to the nozzle configuration, and because the nozzle will be full of water, thermocouples will not be used to verify that the preheat and interpass temperature limits are met. In lieu of thermocouples, a contact pyrometer will be used to verify preheat temperature and interpass temperature compliance with the welding procedure specification (WPC) requirements. This alternative provides an acceptable level of quality and safety.

3.7 NRC Staff Evaluation of Modifications to N-504-2

Under the rules of ASME Section XI, IWA-4220, weld repairs shall be performed in accordance with the licensee's design specification and the original Construction Code. Later editions and addenda of the Construction Code or of ASME Section III, either in their entirety or portions thereof, and Code Cases may be used. Defects in welds shall be removed or reduced in size, in accordance with ASME Section XI, IWA-4400. Code Case N-504-2 is being used by the licensee to perform full structural WOLs on the Reactor Vessel N2C and N2F recirculation inlet nozzles, safe end-to-nozzle weld joint RRC-F002 and RRF-F002 dissimilar metal welds. Code Case N-504-2 was conditionally approved by the NRC staff for use under RG 1.147, Revision 14. Therefore, the use of N-504-2 as an alternative to the mandatory ASME Code repair provisions is acceptable to the NRC staff, provided that there is compliance with all conditions and provisions specified in RG 1.147, Revision 14.

The first proposed modifications to the N-504-2 provisions involve the use of a nickel-based alloy weld material, rather than the low carbon austenitic stainless steel. The licensee stated that Paragraph (b) of N-504-2 requires that the reinforcement weld material shall be low carbon (0.035 wt percent maximum) austenitic stainless steel. In lieu of the stainless steel weld material, Alloy 52M, a consumable welding wire highly resistant to SCC, was proposed for the overlay weld material. The NRC staff notes that the use of 52M material is consistent with weld filler material used to perform similar weld overlays at other operating boiling-water reactor (BWR) facilities. The NRC staff also notes that the licensee is performing full structural WOLs on dissimilar metal welds made of Alloy 182 material. For dissimilar material compatibility in welding, the NRC staff considers that Alloy 52M is a better choice of filler material than austenitic stainless steel material for this type of weld joint configuration. Alloy 52M contains about 30 percent chromium, which would provide excellent resistance to SCC, if exposed to the reactor coolant environment. This material is identified as having a F-No. 43 Grouping for Ni-Cr-Fe classification UNS N06052 Filler Metal and has been previously approved by the NRC staff for similar applications. Therefore, the licensee's proposed use of Alloy 52M for the weld overlays as a modification to the requirements of N-504-2, paragraphs (b) and (e) is acceptable as it will provide an acceptable level of quality and safety.

The next proposed modification to the N-504-2 provisions involves paragraph (e) of N-504-2 which requires as-deposited delta ferrite measurements of at least 7.5 FN for the weld reinforcement. The licensee proposed that delta ferrite measurements will not be performed for this overlay because the deposited Alloy 52M material is 100 percent austenitic and contains no delta ferrite due to the high nickel composition (approximately 60 wt percent nickel). N-504-2 allows the use of weld overlay repair by deposition of weld reinforcement on the outside surface of the pipe in lieu of mechanically reducing the defect to an acceptable flaw size. However, N-504-2 is designed for weld overlay repair of austenitic stainless steel piping. Therefore, the material requirements regarding the carbon content limitation (0.035 wt percent maximum) and the delta ferrite content of at least 7.5 FN, as delineated in N-504-2, paragraphs (b) and (e), apply only to austenitic stainless steel weld overlay materials, to ensure its resistance to SCC. These requirements are not applicable to Alloy 52M, a nickel-based material, which the licensee will use for the weld overlays.

The licensee's proposed modification to Paragraph (h) of N-504-2 is to perform leak testing in accordance with ASME Section XI (2001 Edition with the 2003 Addenda), IWA-5000. Precedence for use of a leak test at normal operating temperature and pressure in lieu of a hydrostatic test was established with Code Case N-416-1, which has been incorporated in ASME Section XI beginning in the 1998 Edition with the 1999 Addenda. The underlying rationale of Code Case N-416-1 is equally applicable to this instance. DAEC is currently in its fourth 10-year ISI interval, which began November 1, 2006, and will end concurrent with the DAEC Operating License expiration on February 21, 2014. The ISI Code of record for DAEC for the fourth 10-year ISI interval is the ASME Code Section XI, 2001 Edition, including Addenda through 2003. Therefore, this alternative provides an acceptable level of quality and safety.

3.8 Staff Evaluation of Modifications to N-638-1

The licensee is applying a 360-degree, full structural WOL to reduce the susceptibility of the original weld to the initiation and growth of SCC and ultimately to maintain weld integrity. The full structural WOL will fulfill all structural requirements, independent of the existing weld. Operational experience has also shown that SCC in Alloy 82/182 will blunt at the interface with stainless steel base metal, carbon steel base metal, or Alloy 52/152 weld metal, if cracking were to occur.

To eliminate the need for preheat and post-weld heat treatment under the Construction Code, the industry developed requirements for implementation of a temper bead welding technique which were published in N-638-1. The NRC endorsed N-638-1 in RG 1.147, Revision 14. The temper bead technique carefully controls heat input and bead placement, which allows subsequent welding passes to stress relieve and temper the HAZ's of the base material and preceding weld passes. The welding is performed with low hydrogen electrodes under a blanket of inert gas. The inert gas shields the molten metal from moisture and hydrogen. Therefore, the need for the preheat and post-weld heat treatment, specified by the ASME Construction Code, is not necessary to produce a sound weld, using a temper bead welding process, which meets the requirements of N-638-1.

The licensee intends to meet the requirements of N-638-1, except paragraph 1.0(a), which requires the maximum area of an individual weld, based on the finished surface, be limited to 100 square inches and the depth of the weld to exceed one-half of the ferritic base metal thickness. This condition is not being met because the design for the weld overlay covers an area up to approximately 260 square inches, which exceeds the limitations of N-638-1. The licensee will perform an evaluation to determine the effect of exceeding the 100 square inch area limitation for temper bead welding onto a low alloy steel nozzle. This evaluation will be conducted per N-504-2. Paragraphs (g)(2) and (g)(3) of N-504-2 require consideration of the effects of residual stresses produced by the weld overlay, when coupled with other applied loads on other welds and components throughout the system. The evaluation of other welds and components in the system is to consider potential increases in loading, including shrinkage effects, due to all weld overlays in the reactor coolant system. These welds and components must meet the applicable stress limits of the Construction Code.

The NRC staff considers this evaluation, which is a N-504-2 requirement, important in assuring that the reactor coolant system will not be adversely effected after WOLs are deposited. EPRI has performed studies to qualify weld overlays for application in BWRs, and in these applications, the studies have not identified any issues with shrinkage stresses or weld contraction stresses.

The NRC staff notes that several similar weld overlays have been applied to BWR facilities (such as Nine Mile Point 2, Perry, and Duane Arnold) with similar geometry and overlay dimensions. The DAEC weld overlay design is generally similar to the design applied to BWR feedwater, core spray, and recirculation nozzles. Information published in publicly available sources (Reference 1) shows that compressive stresses are generated on the inside surface of a pipe by weld overlays in excess of 100 square inches. In some cases, the extended overlay results in higher compressive stress than the 100 square-inch case. Thus, increasing the overlay area is acceptable for this specific application, i.e., to support the mitigation of the SCC degradation mechanism and in this geometry (piping). Based on the preceding discussions, the NRC staff concludes that the modification to increase the WOL to a maximum of 260 square inches will provide an acceptable level of quality and safety and is, therefore, acceptable.

The second modification requested by the licensee is that full UT of the 1.5T band, which is required under Paragraph 4.0(b), will not be performed. Using Code Case N-638-1, the temper bead weld is for filling a cavity in the base metal. The licensee's application, however, is for a structural weld overlay above the base metal, which results in a contour that is UT inspectible except for the edge taper where the overlay transitions to the nozzle surface and on the curvature of the nozzle. The proposed weld edge configuration has the same UT examination difficulties as are considered under ASME Section XI, Appendix Q. Appendix Q only requires a surface examination of the tapered area of the weld overlay. In addition to verifying the soundness of the weld, a purpose of the UT is to assure that delayed cracking due to hydrogen introduced during the temper bead welding process, or cracking in unannealed ferritic material, does not occur. In the unlikely event cracking does occur, it would be initiated on the surface on which the welding is actually performed or in the HAZ immediately adjacent to the weld.

The most appropriate technique to detect surface cracking is the surface examination technique. Per the foregoing, the use of a surface examination in the area of the weld overlay taper and band beyond the toe of the overlay on the ferritic material is acceptable in that it provides an acceptable level of safety and quality.

Code Case N-638-1 paragraph 4.0© specifies that the area from which weld-attached thermocouples have been removed shall be ground and examined using a surface examination method. The licensee has stated that, due to the personnel exposure associated with the installation and removal of the thermocouples, the nozzle configuration, and because the nozzle will be full of water, thermocouples will not be used to verify that the preheat and interpass temperature limits are met. In lieu of thermocouples, a contact pyrometer will be used to verify preheat temperature and interpass temperature compliance with the WPS requirements.

The preheat temperature required for this welding is 50 °F. The maximum interpass temperatures required for this welding are 150 °F for the first three layers, and 350 °F for the balance of welding. A contact pyrometer can be used to adequately monitor these preheat and interpass temperatures. Also, the large mass of the nozzle coupled with the low heat input gas tungsten arc weld (GTAW) process should help ensure that the maximum interpass temperature will not be exceeded. The alternate temperature measurement method will ensure that a close control will be maintained on these temperatures. Therefore, this type of temperature measurement will provide an acceptable level of quality and safety.

4.0 CONCLUSION

Based on the discussion above, the NRC staff concludes that the request to perform full structural weld overlays on the Reactor Vessel N2C and N2F recirculation inlet nozzles, safe end-to-nozzle weld joint RRC-F002 and weld joint RRF-F002 dissimilar metal welds at DAEC, with the modifications proposed in the request for alternative, will provide an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the NRC staff authorizes the proposed alternatives for the installation of full structural WOLs over the welds identified in the relief request during refueling outage RFO 20.

All other ASME Code, Section XI requirements for which relief was not specifically requested and approved in this relief request remain applicable, including third party review by the Authorized Nuclear Inservice Inspector.

5.0 REFERENCE

1. *Materials Reliability Program: Technical Basis for Preemptive Weld Overlays for Alloy 82/182 Butt Welds in PWRs (MRP-169),* EPRI, Palo Alto, CA, and Structural Integrity Associates, Inc., San Jose, CA: 2005. 1012843, ADAMS No. ML0525602200.

Principal Contributor: E. Andruszkiewicz
K. Feintuch

Date: June 12, 2007

A.10 Pilgrim Nozzles N2 and N9 (RR, RAI, and SER)

Entergy

Entergy Nuclear Operations, Inc.
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Plymouth, MA 02360

Stephen J. Bethay
Director, Nuclear Assessment

July 14, 2006

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

SUBJECT: Entergy Nuclear Operations, Inc.
Pilgrim Nuclear Power Station
Docket No. 50-293
License No. DPR-35

Response to NRC Request for Additional Information and Revised Pilgrim Relief Request, PRR-15, Rev.1 (TAC NO. MC8295)

REFERENCE:

1. NRC Request for Additional Information, dated May 11, 2006
2. Entergy Letter No. 2.05.045, Pilgrim Fourth Ten-Year Inservice Inspection Plan and the Associated Relief Requests for NRC Approval, dated June 29, 2005

LETTER NUMBER: 2.06.047

Dear Sir or Madam:

The Attachments to this letter provide information supporting the re-approval of the Contingency Repair Plan for RPV safe-end-welds, the response to the NRC Request for Additional Information (Reference 1) in support of Pilgrim Relief Request, PRR-15, (Reference 2) and PRR-15, Revision 1, which incorporates changes resulting from Entergy responses to the NRC RAI.

There are no commitments contained in this letter.

If you have any questions or require additional information, please contact Mr. Bryan Ford, Licensing Manager, at (508) 830-8403.

Sincerely,

for Stephen J. Bethay

WGL/dm

Attachment 1: Information to Support NRC Re-Approval of 10 CFR 50.55a(a)(3)(i) In-service Inspection Pilgrim Relief Request (4 pages)
Attachment 2: Pilgrim Response to NRC Request for Additional Information (15 pages)
Attachment 3: Pilgrim Relief Request, (PRR)-15, Revision 1 (9 pages)

A047

Entergy Nuclear Operations, Inc.
Pilgrim Nuclear Power Station

Letter Number: 2.06.047
Page 2

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Senior Resident Inspector
Pilgrim Nuclear Power Station

Attachment 1

Information to Support NRC Re-Approval of 10 CFR 50.55a(a)(3)(i)

In-service inspection Relief Request

(4 pages)

Information to Support NRC Re-Approval of 10 CFR 50.55a(a)(3)(i)
In-service inspection Relief Request

Fourth ISI Interval PRR-15, Rev. 1 for Use During
the Cumulative Duration of 120 months of NRC Approved PRR-39, Rev. 2

1. Previous 10 CFR 50.55a(a)(3)(i) Relief Request Approved by NRC

The NRC approved PRR-39, Rev. 2 (hereafter PRR-39) Contingency Repair Plan for use in the Third 10-Ten Year ISI interval, for use during succeeding 120 months from April 12, 2005 until the expiration of Pilgrim Operating License in 2012. The welds included in PRR-39 are identified in the Table 1 below and were selected for examination during Refueling Outage 15, which was the last refueling outage in the Third 10-year interval. RFO-15 took place in April/May 2005.

Table I: Welds Included in PRR-39, Rev. 2 Contingency Repair Plan.

Weld ID	Description	System	ISI Drawing
14-A-1	SAFE END TO NOZZLE	CS	ISI-I-14-1
14-B-1	SAFE END TO NOZZLE	CS	ISI-I-14-1
2R-N1B-1	SAFE END TO NOZZLE	RECIRC	ISI-I-2R-A
2R-N2D-1	SAFE END TO NOZZLE	RECIRC	ISI-I-2R-A
2R-N2E-1	SAFE END TO NOZZLE	RECIRC	ISI-I-2R-A
2R-N2F-1	SAFE END TO NOZZLE	RECIRC	ISI-I-2R-B
2R-N2G-1	SAFE END TO NOZZLE	RECIRC	ISI-I-2R-B
2R-N2J-1	SAFE END TO NOZZLE	RECIRC	ISI-I-2R-B
14-A-3	PIPE TO REDUCER	CS	ISI-I-14-1
14-B-3	PIPE TO REDUCER	CS	ISI-I-14-1
14-A-10A	VALVE TO PIPE	CS	ISI-I-14-1
14-B-10A	VALVE TO PIPE	CS	ISI-I-14-1

The above welds fall within the scope of GL 88-01 and BWRVIP-75A. The A version of BWRVIP-75 was approved by the NRC in a SER dated May 14, 2002.

PRR-39 (Table 1 above) included only those welds which were scheduled for inspection during RFO-15, but excluded all other RPV safe-end to nozzle welds, because the Table 2 welds had already been inspected during the previous refueling outages within the Third 10-year ISI interval. The Contingency Repair Plan was to preclude exigent reviews if a flaw was identified. Entergy opted for NRC approval of a Contingency Repair Plan before the start of the RFO-15 for the Table 1 welds that were scheduled for inspection during that outage.

By this application, Entergy requests NRC to include the remaining RPV safe-end welds identified in Table 2 in the Contingency Repair Plan for use within the 120-month duration that was approved by Reference 1 on April 12, 2005. These RPV safe-end welds fall within the material conditions, repair plan, and examination techniques already reviewed and approved by the NRC for PRR-39 with no material changes. These welds fall within the scope of GL 88-01 and BWRVIP-75A.

TABLE 2: RPV Safe-End to Nozzle Welds Included in PRR-15, Rev. 1

Weld ID	Description	System	ISI Drawing
2R-N2A-1	SAFE END TO NOZZLE	RPV	ISI-I-2R-A
2R-N2B-1	SAFE END TO NOZZLE	RPV	ISI-I-2R-A
2R-N2C-1	SAFE END TO NOZZLE	RPV	ISI-I-2R-A
2R-N2H-1	SAFE END TO NOZZLE	RPV	ISI-I-2R-B
2R-N2K-1	SAFE END TO NOZZLE	RPV	ISI-I-2R-B
RPV-N9B-1	SAFE END TO NOZZLE	RPV	ISI-1-54-4

As stated in Item 5 of the NRC SER Letter, dated April 12, 2005 (Page 12, Reference 1), NRC approved the Contingency Repair Plan for the remaining service life of Pilgrim Station, 8 years from 2005 to 2012, since the current Operating License would expire on June 8, 2012, and the cumulative duration for the Contingency Repair Plan would remain in effect for less than 120 months. Entergy plans to inspect all of the welds contained in Tables 1 and 2 within this 120-month period. If flaws are identified, they will be corrected in accordance with the approved alternative Contingency Repair Plan.

Entergy's request for approval of the Table 2 welds (PRR-15, Rev 1. welds) for inclusion within the previously approved alternative Contingency Repair Plan (PRR-39 welds) pursuant to 10 CFR 50.55a(a)(3(i) is based on the following.

NRC has approved up to 120 months for the applicability of approved 10 CFR 50.55a(a)(3)(i) relief request PRR-39 in transition from the Third to the Fourth ISI interval, limited by the expiration of Pilgrim's current Operating License in 2012. Such authorization is within the scope of the 10 CFR 50.12(a)(1), Specific Exemptions, whereby, the approval as authorized by law will not present an undue risk to the public health and safety, and is consistent with the common defense and security. NRC SER on PRR-39 is applicable in its entirety to PRR-15, Rev. 1, because Entergy will be using all the Code Cases previously approved by the NRC in the PRR-39 SER, as explained in item 2 below. Therefore, inclusion of Table 2 welds in the previously approved Contingency Repair Plan should be granted, because the Contingency Repair Plan remains valid and in effect.

2. Changes to the Applicable ASME Code Section and Code Cases

ASME Section XI Code Cases for the Contingency Repair Plan overlay design, repair, and testing, and the circumstances and basis of previous NRC approval for PRR-39 have not changed. The Contingency Repair Plan is based upon the requirements of ASME Code Cases N-638, N-504-2, N-416-2, and N-498-4. During the application of PRR-39, Entergy specified these Code Cases as approved in Regulatory Guide (R.G.) 1.147, Rev. 13. At this time, these Codes Cases have been revised and/or conditionally accepted in Table 2 of R.G. 1.147, Rev. 14, as presented below.

- ASME Code Cases N-638 (acceptable in R.G. 1.147, Rev. 13) and N-638-1 (conditionally acceptable in R. G. 1.147, Rev. 14).
- ASME Code Cases N-504-2 (acceptable in R.G. 1.147, Rev. 13) and N-504-2 (conditionally acceptable in R. G. 1.147, Rev. 14).
- ASME Code Case N-416-2 (acceptable in R.G.1.147, Rev. 13) and N-416-3 (conditionally acceptable in R.G.1.147, Rev. 14).

- ASME Code Case N-498-4 conditionally acceptable in both Rev. 13 and 14 of R.G. 1.147.

Entergy evaluated the changes in the above Code Cases that were approved in Table 1 and 2 of R.G.1.147, Rev. 13 or 14, as applicable, and confirmed that the requirements of these Code Cases did not change the design, fabrication, and testing of the overlay repair plan. Thus, Entergy has concluded that the previously NRC approved Code Cases for PRR-39 are applicable for PRR-15, Rev. 1, without exceptions.

Furthermore, R.G. 1.147, Rev. 13 and Rev. 14, in paragraphs 2 on page 3 both state that:

> *"If a Code Case is implemented by a licensee and a later version of the Code Case is approved by the NRC and listed in Tables 1 and 2 during licensee's present 120-month ISI program interval, that licensee may use either the later version or the previous version."*

Since Entergy is requesting approval of relief request within the previously approved cumulative 120-month duration granted for PRR-39, Entergy opts to continue to use the previously approved Code Cases for PRR-15, Rev. 1. There is added benefit in maintaining uniform design packages for the Contingency Repair Plan throughout the duration until the expiration of current Pilgrim Operating License. Accordingly, Entergy has concluded that NRC SER on PRR-39 is applicable in its entirety to PRR-15, Rev. 1.

3. Component Aging Factors

The welds included in the ISI Relief Request PRR-39 and PRR-15, Rev. 1 are subject to the aging effect of reactor operation. However, degradation of welds due to aging is no longer a factor since the implementation of hydrogen water chemistry to arrest IGSCC at Pilgrim, as discussed in Reference 3. Therefore, aging has no material impact on the purposed alternative Contingency Repair Plan within the scope of 10 CFR 50.55a(a)(3)(i).

4. Changes in Technology and Inspection and Testing of the Affected ASME Code Components

As stated in Reference 1, (also discussed in Reference 3) the NRC has approved the latest technology (PDI methodology for UT examination and system leakage test in lieu of radiography) for inspecting and testing the weld repairs to satisfy the ASME Code Case N-416-2 and N-504-2 as the Construction Code for the overlay design, fabrication, and testing.

5. Confirmation to Renewed Applicability of Previously Approved Contingency Repair Plan Pursuant to 10 CFR 50. 55a(a)(3)(i)

Entergy requests the approval of Pilgrim Relief Request PRR-15, Rev.1 in order to use the previously approved Contingency Repair Plan pursuant to 10 CFR 50.55a(a)(3)(i) since it was previously approved by the NRC as an alternative repair plan for ASME components (welds) in accordance with NRC approved applicable ASME Code Cases. All of the information Entergy docketed in support of the PRR-39 is applicable to PRR-15, Rev. 1 and all of the information included in the NRC Safety Evaluation approving the PRR-39 is applicable for PRR-15, Rev. 1. Therefore, Entergy concludes that the Contingency Repair Plan presents an acceptable level of quality and safety to satisfy the requirements of 10 CFR 50.55a(a)(3)(i). Similar proposed alternatives were approved by the NRC for James A Fitzpatrick (TAC No. MB0252, dated October 26, 2000), Duane Arnold Energy Center (NRC Staff's letter dated November 19, 1999), Nine Mile Point Unit 2 plant (NRC Staff's letter dated March 30, 2000) and for Pilgrim to repair the RPV N10 nozzle to safe-end weld (Third Interval PRR-36 and 38).

6. Duration of Re-Approved 10 CFR 50.55a(a)(3)(i) Contingency Repair Plan

   The Contingency Repair Plan for welds included in the Fourth Interval PRR-15, Rev. 1 and Third Interval PRR-39 would remain in effect till the expiration of current Pilgrim Operating License in 2012, for a cumulative duration not to exceed 120 months from April 12, 2005.

7. References

1. NRC Letter, Pilgrim Relief Request PRR-39, Rev. 2, Alternative Contingency Repair Plan for Reactor Pressure Vessel Nozzle Safe-End and Dissimilar Metal Piping Welds using Code cases N-638 and N-504-2, with Exceptions (TAC NO. MC 2496), dated April 12, 2005.

2. Entergy Letter, 2.05.024, Pilgrim Relief Request PRR-39, Rev. 2, Contingency Repair Plan Reactor Pressure Vessel Nozzle Safe-End and Dissimilar Metal Piping Welds using Code cases N-638 and N-504-2, with Exceptions, dated March 16, 2005.

3. Entergy Letter, 2.04.091, Response to NRC Request for Additional Information and Revised Pilgrim Relief Request PRR-39, Rev. 1 (TAC NO. MC 2496), dated October 12, 2004.

Attachment 2

Entergy Response to NRC Request for Additional Information

(3 pages)

Enclosure [1] to Attachment 2

(12 pages)

ENTERGY RESPONSE TO NRC REQUEST FOR ADDITIONAL INFORMATION

NRC QUESTIONS:

QUESTION 1

The Table on page 1 of the relief request states that the maximum diameter of the pipe to be overlaid is 13.38 inches yet on pages 3, 6 and 7 of the relief request, reference is made to a 29 inch O.D. nozzle. Since this overlay is for 13 inch diameter nozzles or smaller, delete all references to any size larger than 13 inches, i.e., 29 inches.

ENTERGY RESPONSE:

The revised Table 1 in the attached PRR-15, Rev. 1 provides corrected information. References to any size larger than 13 inches OD have been deleted from PRR-15, Rev. 1

QUESTION 2

The Table on page 1 should identify the area (in square inches) of the repair that is in contact with the low alloy steel (P-No. 3) material for each overlay.

ENTERGY RESPONSE:

The flaw indication would provide the information (depth and length) to determine the repair area in contact with the low alloy steel material (P-No. 3) area. Prior to the repair/replacement of the discovered or indicated flaw, Pilgrim will prepare the surface area (excavated or grinded) for overlay design of repair/replacement. The finished repaired areas will be less than 300 square inches.

QUESTION 3

In the relief request identify the original Code of Construction and Code of Record for the 4th interval.

ENTERGYRESPONSE

This information included in the revised PRR-15, Rev. 1 (Attachment 3)

QUESTION 4

Identify the start and end dates of the relevant inspection interval.

ENTERGY RESPONSE

Pilgrim is in the 4th ISI interval, that began on July 1, 2005 and ends on June 30, 2015.

QUESTION 5

On page 6 of the relief request the statement is made, "Alloy 52 with its high chromium content provides a high level of resistance to hot cracking." Provide a justification for this statement.

ENTERGY RESPONSE

Filler Metal 52 has been shown to be more hot-cracking resistant than Filler Metal 82 in two EWI solidification cracking studies [1]. Improved understanding of the welding processes have lead to a combination of these new consumables and optimum welding procedures that are resistant to hot cracking. Alloy 52 with its high chromium content provides a high level of resistance to hot cracking provided that the welding parameters are managed properly. This is also discussed in BWRVIP-75A as approved by the NRC.

QUESTION 6

The "Basis for the Alterative," as noted on page 6 and continuing on page 7 of the relief request under "Exception from Code Case N-504-2 Paragraph (h)," is inadequate. The relief request should discuss the basis in more detail to justify the performance of an ultrasonic examination in lieu of a radiographic examination of the weld overlay repair.

ENTERGY RESPONSE

The details of the performance of Ultrasonic Testing /Performance Demonstration Initiative (UT/PDI) examination and system leakage tests in lieu of radiographic examination have been discussed in Reference 3, as part of the 3rd Interval ISI Relief Request, PRR-39, and is hereby incorporated by Reference.

The overlay welding would be examined to 1998 with 2000 Addenda ASME Code, Section XI, Supplement 11 as modified by Fourth Interval Relief Request PRR-9 (TAC NO. MC8292, dated March 22, 2006) approved for specific PDI procedural details. The qualified procedures are in accordance with the ultrasonic acceptance standards included in Section III NB-5330. The ultrasonic procedures and personnel used for this examination result in a weld material assessment for an overlay that cannot be achieved by radiography. This is based on the special nature of the weld overlay, which is similar to that recognized in ASME Code Section III NB-5270 "Special Welds" and the allowance as described in NB-5279 that there are special exceptions requiring ultrasonic rather than radiographic examinations.

Pressure vessel and safe-end welded piping are filled with reactor water, which precludes use of radiography for weld material assessment. Removal of fuel and draining the vessel to accommodate radiography presents additional nuclear safety and personal hazards. Additionally, radiography is not qualified under PDI for weld overlay inspections. Thus UT/PDI examination is the preferred method for weld overlay assessment. The qualification process for the Supplement 11 ultrasonic examination, the ability to size flaws for length and depth, and the fact that the qualification includes flaws that may be created during fabrication, meets the ultrasonic procedural requirements of the cited ASME III paragraphs.

The final weld examination would be a complete ultrasonic volumetric examination (UT) using PDI procedure PDI-UT-8 in accordance with Relief Request PRR-9. The weld overlay would meet the requirements of the ASME Code Section XI repair plan and PDI-UT-8. There would be no deviations from ASME Code Section III methods as discussed above and acceptance criteria or UT/PDI procedures. ASME Section XI allows a repair to be performed by either removing a flaw or reducing it to an acceptable size, as documented for instance in Code Case N-504-2. The weld overlay approach does the latter. The allowable flaw size is defined in Table IWB-3641-1 (since Normal/Upset loads govern). The initial flaw is conservatively assumed to be entirely through wall and to extend entirely around the circumference of the repair location (through wall x 360 degrees around). The weld overlay approach applies additional thickness to the flawed location, such that the resulting as-repaired component meets the requirements of IWB-3640. This approach has been extensively used since the mid-1980's in repair of BWR piping. The weld overlay also imparts a compressive residual stress, which has been shown to reduce crack growth.

The weld overlay repairs will be completed as an ASME Code Section XI repair using Code Case N-504-2 as the construction code for the repair design, fabrication, and examination methods applicable to a structural overlay type of repair. This type of repair is not included in ASME Code Section III. The nondestructive examination (NDE) of weld overlays is not addressed in ASME Code Section III since it is a construction code used for the initial installation of welded joints. Welding performed under an ASME Code Section XI repair plan is typically examined in accordance with the code of construction, when applicable, and any Section XI baseline (preservice) inservice inspection (ISI) examinations.

For weld overlay repairs, the construction code is Code Case N-504-2 and the required examinations are by the liquid penetrant and ultrasonic methods. This Code Case is prescriptive about all aspects of the weld overlay repair including the overlay design, its fabrication, and the examinations performed before, during, and after the welding.

The type of weld examinations to be performed on the structural overlay weld would be based on ASME Code Case N-504-2 as the construction code for the overlay weld repair, rather than ASME Code Section III butt weld joint fabrication, such that the required volumetric examination of weld overlay would be by the UT/PDI rather than radiographic method. An initial liquid penetrant (PT) surface examination would be performed on the area to be welded in accordance with N-504-2. This examination will be performed if required after the localized seal welding is completed. A final PT examination in accordance with N-504-2 and ASME Code Section III would be performed after completing all weld overlay layers. An ultrasonic thickness examination will also be performed to demonstrate that the weld overlay met the thickness requirements of the repair plan.

In conclusion, the applicable weld fabrication and examination requirements of Code Cases N-504-2 and N-416-2, ASME Code Section III, and ASME Code Section XI (with PRR-9) will be met. Accordingly, performance of an UT/PDI in lieu of a radiographic examination of the weld overlay repair provides an acceptable level of quality and safety.

Enclosure [1]: B. B. Hood and W. Lin, "Weldability of INCONEL Filler Materials", Paper presented at 7th International Symposium on Environmental Degradation of Materials in Nuclear Power Systems, Breckenridge, CO, August 6 - 10, 1995 (12 pages).

Enclosure [1] to Attachment 2

B. B. Hood and W. Lin, "Weldability of INCONEL Filler Materials", Paper presented at 7th International Symposium on Environmental Degradation of Materials in Nuclear Power Systems, Breckenridge, CO, August 6 - 10, 1995

(12 pages)

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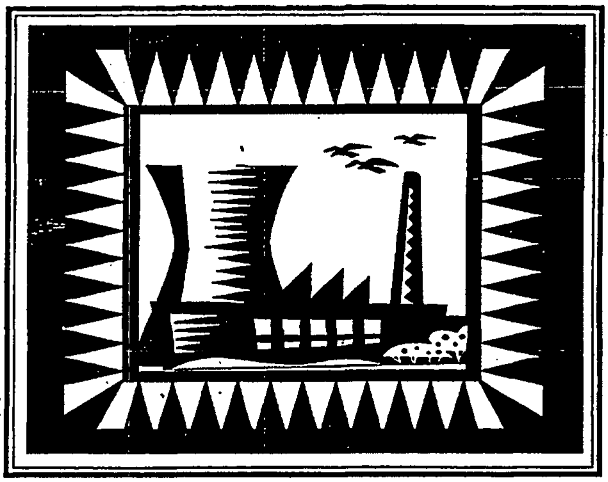

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Weldability Testing of Inconel™ Filler Materials

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Abstract

This paper presents the findings of a research program aimed at quantifying the weld solidification cracking susceptibility and weld metal liquation cracking susceptibility of Inconel™ filler materials 52, 82, 152 and 182 deposited on a variety of materials intended for pressurized water reactor applications. A cursory investigation on the repair weldability of Filler Metal 52 using the Gleeble™ thermo-mechanical simulation technique is also included. The brittle temperature range (BTR) in the fusion zone and HAZ was determined using the longitudinal-Varestraint test and spot-Varestraint test, respectively, and used as a weldability index for quantification of susceptibility to weld solidification cracking and HAZ liquation cracking. Results from this study showed that Filler Metals 52 exhibited the best resistance to both weld solidification cracking and weld metal liquation cracking followed by 82, 152 and 182 for the base metal combinations tested in this study. Repair weldability study suggested that the resistance to weld metal liquation cracking of 52 all weld metal would not be significantly reduced after ten times of weld simulation at peak temperatures of 900°C and 1300°C.

Introduction

Since their development over 20 years ago, Ni-Cr-Fe Filler Metal 82 and Welding Electrode 182 have been extensively utilized for welding nickel-based alloys and dissimilar combinations of materials including pressure vessel steels and stainless steels. Numerous incidents of stress corrosion cracking (SCC) with Ni-Cr-Fe Alloy 600 materials have been documented leading to the selection of Ni-Cr-Fe Alloy 690 as the material of choice for Nuclear Steam Generator Tubing. Over the past decade, Filler Metal 52 and Welding Electrode 152 have been either selected or considered as a prime candidate material for joining UNS N06690 (Alloy 690) materials for pressurized water reactors (PWRs) where primary water stress corrosion cracking (PWSCC) and intergranular stress corrosion cracking (IGSCC) have been encountered. As a result of the reported superior resistance to stress corrosion cracking (SCC) of 52 and 152 compared to 82 and 182 (Refs. 1 and 2), an implementation plan was developed to replace 82 and 182 filler materials with 52 and 152 filler materials for replacement steam generator (RSG) applications. In order to compare the weldability of 52 and 152 filler materials with 82 and 182 prior to their use, a research program was initiated to quantify the weld solidification cracking susceptibility of Inconel™ filler materials 52, 152, 82 and 182 using two welding processes, gas tungsten arc welding (GTAW) and shielded metal arc welding (SMAW). Various base metals including nickel-based alloys, stainless steels, Cr-Mo steels, and carbon steels, were selected representative of intended applications.

Experimental Procedure

Materials

Figure 1 illustrates the flow chart of experimental procedure for this test and evaluation program. Basically, a groove was prepared in the base metal or in the dissimilar joint. The filler materials were then deposited in the groove to create weld metal samples. A previous study (Ref. 3) has showed that this groove design resulted in about 20% dilution from the base metal. After filler metal deposition, the weld surface were machined flush and Varestraint tests were performed on the deposited weld metal. Table 1 lists the base metal and filler material combinations tested in this study. For Task 12, Gleeble™ samples were extracted from a weld pad deposited using Filler Metal 52. The chemical compositions of the base metal plates and filler materials are listed in Tables 2.

Weldability Evaluation

The newly developed longitudinal-Varestraint and spot-Varestraint test procedures were employed in this study to quantify weld solidification cracking susceptibility and weld metal liquation cracking susceptibility, respectively (Refs 4 and 5). These new methodologies provide the temperature range over which liquation-related cracking occurs during weld cooling. This cracking temperature range is referred to as the brittle temperature range (BTR). The concept of using the BTR to quantify weld solidification cracking is presented in Figure 2. The progression of temperature, microstructure, ductility and strain in the fusion zone during weld cooling is schematically illustrated. As shown, the weld fusion zone experiences a thermal cycle from a peak temperature above the liquidus (T_L) to room temperature (Figure 2a). The microstructure transforms from a liquid phase to liquid + solid and then completely to a solid phase upon cooling (Figure 2b). In the liquid + solid state, most engineering materials experience a microstructure consisting of solid grains surrounded by a thin layer of liquid at the grain boundaries. This microstructure is susceptible to cracking since its ability to accommodate thermally- and/or mechanically-induced strain is very low. Figure 2c illustrates the ductility of a material in a weld cooling cycle. As shown, the ductility drops to an extremely low value in the liquid + solid region and recovers rapidly after the material completely solidifies.

During weld cooling, the thermally-induced strain is accumulated gradually as illustrated in Figure 2d. On a microstructural level, when the accumulated strain exceeds the local ductility of the material, cracking occurs. The temperature range within which the material exhibits negligible ductility is defined as the BTR. A larger BTR allows more strain to be accumulated during weld cooling, thereby increasing the susceptibility to cracking. The actual value of the upper temperature bound of the BTR is very difficult to determine, but is generally approximated by the liquidus. This concept can also be applied to quantify liquation cracking susceptibility in the HAZ. The BTR is material-specific since it does not depend on conditions during weldability testing, thus, it is a true quantification of weldability.

The detailed procedure for using longitudinal-Varestraint test to determine the BTR in the fusion zone and using spot-Varestraint test to determine the BTR in the HAZ can be found in the paper previously published by the author (Refs. 4 and 5). The test conditions used in this study are listed in Tables 3. The repair weldability of Filler Metal 52 was studied using the Gleeble™ thermo-mechanical technique. For the repair conditions, test samples were reheated 10 times using thermal cycles described in Table 3. Two peak temperatures of 900°C and 1300°C were selected to cover a wide enough range of the heat-affected zone. The peak temperature of 1300°C represents a location in the HAZ which is about 0.1 mm from the fusion boundary of a weld with a heat input of 0.84 kJ/mm. The detailed methodology for using the Gleeble™ hot ductility test to quantify the material susceptibility to HAZ liquation cracking can be found in the a paper previously published by the author (Ref. 6). The conditions for hot ductility testing are listed in Table 3.

Results and Discussion

For the longitudinal-Varestraint test, the maximum crack distances (MCD) at augmented strain levels ranging from 1% to 7% were determined. Figure 3 shows typical test results. From these results, the saturated strain and the MCD at a saturated strain can be determined. The saturated strain is the strain level above which the MCD leveled off. The MCD at a saturated strain represents the entire region over which the material is susceptible to solidification cracking. By combining these MCD results and the cooling rate obtained from the weld cooling cycle, the BTR can be approximated. Results of the fusion zone BTR are listed in Table 4. A larger BTR represents a greater susceptibility to weld solidification cracking because a greater amount of strain can be accumulated during actual weld fabrication.

Results form this study suggested that the cracking resistance of these four filler materials deposited on 690 nickel-base alloy and A285 carbon steel is similar and better than 1¼Cr-½Mo and 690-316L combinations. Filler Metals 52 and 82 exhibited similar resistance to weld solidification cracking followed by 152 and 182. The 316LN/52 exhibited a better resistance than 690/52.

For the spot-Varestraint test, the MCD's at variable cooling times were determined. The cooling time is the time period between arc extinction and specimen bending. After testing, the HAZ crack susceptible region can be determined as typically shown in Figure 4. The HAZ crack susceptible region is the region in the HAZ in which the material is susceptible to HAZ liquation cracking. Cracking persistent for a longer cooling time would represent a greater cracking susceptibility due to a larger BTR in the HAZ. The magnitude of BTR at any locations in the HAZ can be determined by combining the cooling times and cooling rates during spot-Varestraint testing. The BTR in the HAZ adjacent to fusion boundary of all weld metal tested are listed in Table 5. For all the base metals tested, the cracking susceptibility of filler materials exhibited the same trend, with 52 showing the best cracking resistance followed by 82 and 152. 316LN/52 exhibited a better resistance to solidification cracking and weld metal liquation cracking than 690/52. Due to the inability to obtain a uniform spot weld on Electrode 182, the BTR of the 182 combinations could not be determined using the spot-Varestraint test.

The on-cooling Gleeble™ hot-ductility tests for Task 12 were performed from a peak temperature of 1330°C, which is the nil-strength temperature (NST) of the initial condition (no thermal simulation). Test results showed that the repair condition of 1300°C exhibited slightly higher ductility than the initial condition for the same temperature, as shown in Figure 5. Their nil-ductility temperature (NDT) and ductility recovery temperature (DRT) are essentially identical. The repair condition of 900°C exhibited a slightly lower NDT and DRT than the initial condition. A cursory metallurgical investigation revealed that repair simulations resulted in a more homogeneous microstructure as shown in Figures 6-8. Both the solidification grain and subgrain boundaries became less distinct, and migrated grain boundaries became sharper as the peak temperature for repair simulation increased from 900 to 1300°C. These results suggested that there were not significant difference in both the on-heating nil-ductility temperature range and BTR between the repair and initial conditions. Thus, the difference in the resistance to weld metal liquation cracking is negligible between initial condition and simulated repair conditions.

Conclusions

The weld solidification cracking susceptibility and weld metal liquation cracking susceptibility of Inconel™ filler materials 52, 82, 152, and 182 were quantified using the longitudinal- and spot-Varestraint tests, respectively. Filler Metals 52 exhibited the best resistance to both weld solidification cracking and weld metal liquation cracking followed by 82, 152 and 182 for the base metal combinations tested in this study. A cursory repair weldability study suggested that the resistance to weld metal liquation cracking of 52 all weld metal would not reduce after ten times of weld repair simulation.

Acknowledgements

This research program was partially supported through funding and materials provided by S.D. Kiser and T. Lemke of INCO Alloys International. U.A. Snyder and M.L. Carpenter supported the Westinghouse program and Wagen Lin, Edison Welding Institute was responsible for performing the actual test for Westinghouse.

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Table 1. Test matrix

Task	Base Metal	Filler Material	Task	Base Metal	Filler Material
1	690	52, 82, 152 & 182	7	600	52, 82, 152 & 182
2	1¼ Cr - ½ Mo	52, 82, 152 & 182	8	690 & 600	52, 82, 152 & 182
3	690 & 316L	52, 82, 152 & 182	9	690 & 316L	52, 82, 152 & 182
4	ASTM A285	52, 82, 152 & 182	10	600 & 316L	52, 82, 152 & 182
5	316LN	52	11	316LN	52
6	690	52, 82, 152 & 182	12	No	52

Task 1 - 5: Longitudinal-Varestraint test was employed to study weld solidification cracking susceptibility.
Task 6 - 11: Spot-Varestraint test was employed to study weld metal liquation cracking susceptibility.
Task 12: Gleeble™ thermal simulation and hot ductility test were employed to study weld metal liquation cracking susceptibility at multiple repair welding conditions.

Table 2. Chemical compositions of base metal plates and filler materials used.

	690	316L	1½Cr-½Mo	690	600	316L	316LN	A285	52	152	82	182
Task	1,3,6	3	2	8,9	7,8,10	9,10	5,11	4	1-12	1-12	1-12	1-12
C	0.03	0.020	0.08	0.030	0.07	0.017	0.014	0.18	0.03	0.041	0.04	0.04
Mn	0.24	1.62	0.51	0.12	0.32	1.66	1.54	0.46	0.24	3.92	2.89	8.29
Fe	9.50	68.63	96.63	10.07	6.77	Base	Base	Base	8.89	9.28	1.26	6.61
S	<0.001	0.009	0.005	<0.001	0.001	0.009	0.011	0.028	<0.001	0.006	0.004	0.009
Si	0.27	0.62	0.64	0.27	0.21	0.53	0.47	0.038	0.17	0.49	0.11	0.43
Cu	0.04	0.32	0.18	0.01	0.06	0.39	-	0.01	<0.01	0.01	0.11	0.02
Ni	59.31	10.12	0.20	58.66	77.43	10.83	10.89	0.01	60.37	55.36	71.89	68.93
Cr	30.06	18.27	1.26	29.85	14.60	17.12	16.61	0.01	28.95	28.87	20.80	13.80
Al	0.21	-	-	0.45	0.23	-	-	-	0.63	0.13	-	-
Ti	0.29	-	-	0.31	0.24	-	-	-	0.58	0.07	0.40	0.22
Mg	-	-	-	0.02	-	-	-	-	<0.01	-	-	-
Co	0.05	0.16	-	0.036	0.06	0.19	-	-	<0.01	0.01	-	0.06
Mo	-	2.16	0.48	0.02	-	2.11	2.20	0.01	<0.01	<0.01	-	-
Nb	-	-	0.001	0.01	-	-	-	<0.008	0.01	1.80	2.44	1.69
P	-	0.030	0.011	0.009	0.008	0.029	0.034	0.011	0.005	0.005	0.009	0.012
B	-	-	-	0.004	0.002	-	-	-	0.001	-	-	-
N	-	0.040	-	0.03	-	0.07	0.144	-				

Table 3. Conditions for weldability testing

Parameters	L-Varestraint	S-Varestraint	Parameters	Gleeble™ Simulation	Hot Ductility
Current	170 amps	90 amps	Heating Rate	111°C/sec	111°C/sec
Voltage	12.5 volts	12 volts	Hold Time	0.03 sec	0.03 sec
Travel Speed	6 in/min		Peak Temperature	900°C and 1300°C	1330°C
Electrode-Work Distance	0.109-in.	0.109-in.	Cooling Rate	55°C/sec	55°C/sec
Gas Flow Rate	Ar, 25 CFH	Ar, 25 CFH	Jaw Spacing	19 mm	19 mm
Augmented Strain	1-7%	4%	Atmosphere	Ar	Ar
Rate of Bend	10-in/sec.	10-in/sec	No. of Cycles	10	-
Power Supply	DCEN	DCEN	Stroke Rate	-	5 cm/sec
Weld Time	-	30 sec			

Table 4

BTR at fusion zone representing weld solidification cracking susceptibility of the weld metal tested

Weld Metal	BTR (°C)
690/52	111
690/82	123
690/152	193
690/182	227
1¼Cr-½Mo/52	139
1¼Cr-½Mo/82	162
1¼Cr-½Mo/152	213
1¼Cr-½Mo/182	287
690-316L/52	130
690-316L/82	179
690-316L/152	274
690-316L/182	300
A285/52	112
A285/82	121
A285/152	208
A285/182	269
316LN/52	87

Table 5

BTR in the HAZ adjacent to the fusion boundary representing weld metal liquation cracking susceptibility of the weld metal tested

Weld Metal	BTR (°C)
690/52	79
690/82	173
690/152	243
600/52	56
600/82	64
600/152	173
690-600/52	91
690-600/82	147
690-600/152	222
690-316L/52	97
690-316L/82	179
690-316L/152	220
600-316L/52	96
600-316L/82	147
600-316L/152	196
316LN/52	54

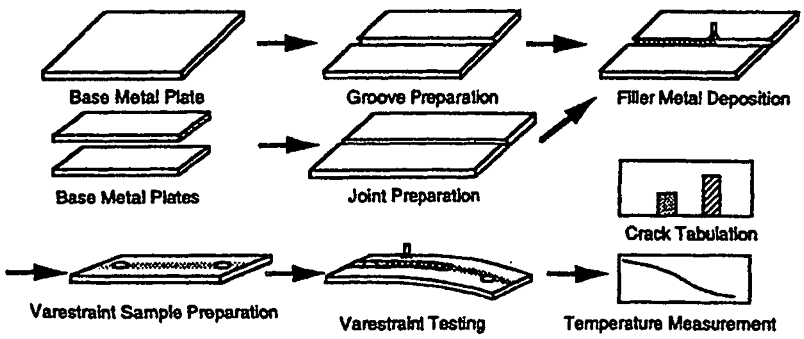

Figure 1. Flow chart of experimental procedure used in this study

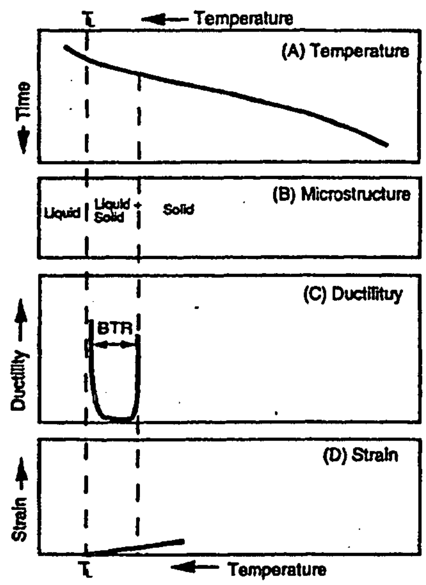

Figure 2. Theoretical basis for using BTR as a weldability index

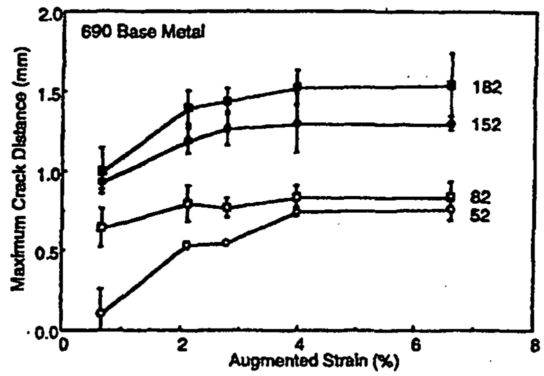

Figure 3. Typical longitudinal-Varestraint test results, MCD for the four filler materials with 690 base metal

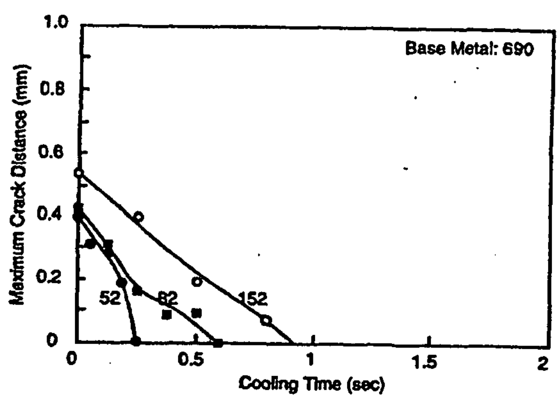

Figure 4. Typical spot-Varestraint test results, HAZ crack susceptible region of the three filler materials with 690 base metal

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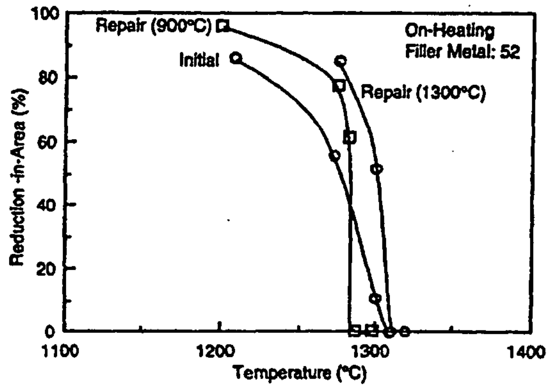
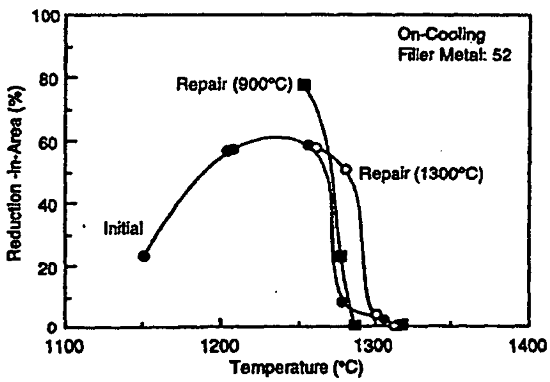


(A) On-Heating Hot-Ductility Curve



(B) On-Cooling Hot-Ductility Curves

Figure 5. Hot-ductility test results of the initial and repair conditions of Inconel™ 52 filler; (A) on-heating hot-ductility curves; (B) on-cooling hot-ductility curves.

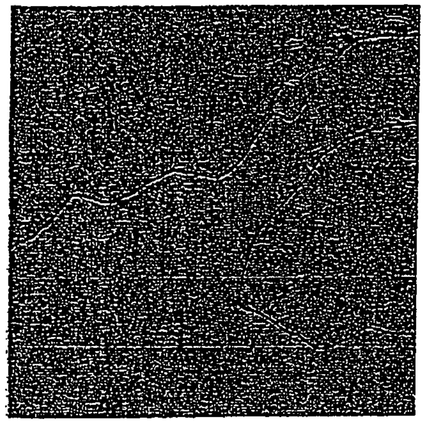


Figure 6.
Microstructure of the initial 52 weld metal.200X

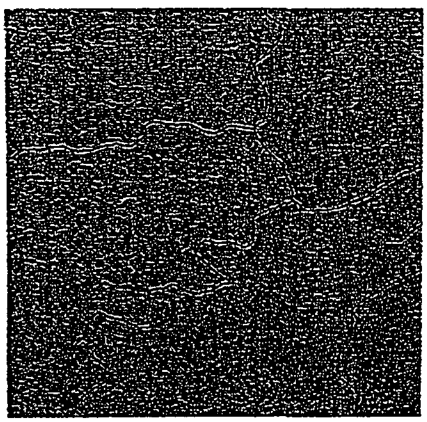


Figure 7
Microstructure of the 52 weld metal
after ten times repair simulations
at a peak temperature of 900° C. 200X

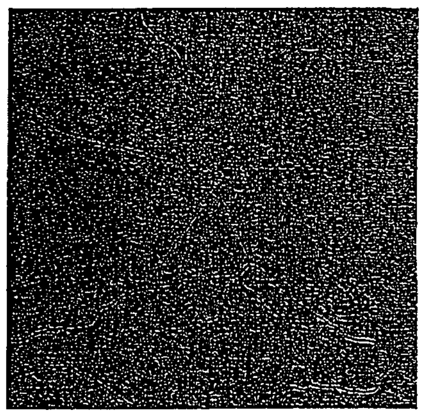


Figure 8
Microstructure of the 52 weld metal
after ten times repair simulations
at a peak temperature of 1300° C. 200X

DISCUSSION
Presenting Author: Ben Hood

Questioner: Allan McIlree, Electric Power Research Institute

Question/Comment: Would there be any benefit to adding a filler metal to a welded steam generator sleeve application which is now being made by an autogenous weld of alloy 690 sleeve?

Reply: Presently, autogenous welding of alloy 690 sleeving material has been successful. However, some benefit could be derived. The problem becomes a physical one for introducing a filler material.

Questioner: D.C. Agarwal, VDM Technologies

Question/Comment: What in the chemistry of filler metal 52 makes it so much better than 82, 152 and 182 as far as weld solidification cracking susceptibility?

Reply: It is not fully understood what the major reason is, however the Nb, Ti and Al levels are adjusted in the alloy 52, with more Al present in the 52. Typically the GTAW process with wire filler metal using 52 or 82 will be more crack resistant than the SMAW equivalent 152 and 182 alloy.

Attachment 3

Revised PRR-15, Rev. 1

(9 pages)

PILGRIM RELIEF REQUEST No. PRR-15, Rev. 1

A. COMPONENT IDENTIFICATION

A full structural weld overlay repair is proposed for the weldment associated with the six (6) austenitic reactor pressure vessel (RPV) nozzle safe-end and dissimilar metal (DM) piping welds identified in Table 1. This is proposed for contingency repair planning purposes only and will be used, if needed, during a refueling outage within the 4th ISI Interval up to the expiration of current Operating License in 2012. The 4th ISI Interval commenced July 1, 2005 and ends June 30, 2015.

TABLE 1

WELD ID	DESCRIPTION	SYSTEM	MATERIAL	SIZE / WALL THICKNESS	ISI DRAWING
2R-N2A-1	SAFE END TO NOZZLE	RPV	A-508 Cl. 2 Nozzle Forging, Inconel 182 Butter, SA-182 F316 (Nuclear Grade C .020%max) Safe End Forging	13.38" dia. / 1.31"	ISI-I-2R-A
2R-N2B-1	SAFE END TO NOZZLE	RPV	A-508 Cl. 2 Nozzle Forging, Inconel 182 Butter, SA-182 F316 (Nuclear Grade C .020%max) Safe End Forging	13.38" dia. / 1.31"	ISI-I-2R-A
2R-N2C-1	SAFE END TO NOZZLE	RPV	A-508 Cl. 2 Nozzle Forging, Inconel 182 Butter, SA-182 F316 (Nuclear Grade C .020%max) Safe End Forging	13.38" dia. / 1.31"	ISI-I-2R-A
2R-N2H-1	SAFE END TO NOZZLE	RPV	A-508 Cl. 2 Nozzle Forging, Inconel 182 Butter, SA-182 F316 (Nuclear Grade C .020%max) Safe End Forging	13.38" dia. / 1.31"	ISI-I-2R-B
2R-N2K-1	SAFE END TO NOZZLE	RPV	A-508 Cl. 2 Nozzle Forging, Inconel 182 Butter, SA-182 F316 (Nuclear Grade C .020%max) Safe End Forging	13.38" dia. / 1.31"	ISI-I-2R-B
RPV-N9B-1	SAFE END TO NOZZLE	RPV	A-508 Cl. 2 Nozzle Forging / SA-182 F304 Safe End Forging	5" NPS / 0.625"	ISI-I-54-4

These are ISI Class 1 welds which fall within the scope of GL 88-01 and BWRVIP-75-A.

These are proposed contingency repairs. The actual repaired area (in square inches) and actual repaired configuration in each case will depend on the specific conditions found at the time of the inspections. The finished repaired areas may range in size up to a maximum of 300 square inches at each location dependant on the actual crack location and may be anywhere along the axis of the nozzle. A 300 square inch limit was previously approved for Pilgirm via NRC SER dated April 12, 2005, page 16 (Reference 3).

A. COMPONENT IDENTIFICATION (cont'd)

This relief request is requested under the provisions of 10CFR50.55a(a)(3)(i), in that the proposed alternative would provide an acceptable level of quality and safety.

B. EXAMINATION AND REPAIR REQUIREMENTS

The Reactor Pressure Vessel Code of Construction used was the ASME Boiler and Pressure Vessel Code, Section III, 1965 Edition through Winter 1966 Agenda. The ISI and Repair/Replacement Code for the 4th Interval is the 1998 Edition of ASME Section XI with the 2000 Addenda.

The weld overlays will be designed consistent with the requirements of NUREG-0313, (which was implemented by Generic Letter 88-01), ASME Code Cases N-504-2, N-638, and ASME, Section XI, Paragraph IWB-3640.

Welder Qualification and Welding Procedures

All welders and welding procedures will be qualified in accordance with ASME Section XI including any special requirements from Section XI or applicable code cases. If necessary, a manual shielded metal arc weld (SMAW) procedure will be qualified to facilitate localized repairs and to provide a seal weld, prior to depositing the overlay. This procedure will make use of 152 SMAW electrodes consistent with the requirements of ASME Section XI. Only personnel qualified in accordance with the Welding Procedure Specification (WPS) for welding Alloy 52/152 will perform the repair activities.

Welding Wire Material

The weld overlay materials (weld wire) for the proposed repairs are as follows:

- For automated machine gas tungsten are welding (GTAW), the weld material will be ASME Section II, Part C, SFA-5.14 Filler Metal ERNiCrFe-7A (UNS N06052) ASME IX F-No. 43, known commercially as Alloy 52.
- For SMAW welding, the weld material will be ASME Section II, Part C, SFA-5.11 Welding Electrode ENiCrFe-7 (UNS W86152) ASME IX F-No. 43, known commercially as Alloy 152.

Inconel Weld Metal is recognized as an IGSCC resistant material in BWRVIP-75-A Section 5.5.1.1 and 3.5.2.1. This was approved by NRC SER in a letter dated May 14, 2002. The use of Inconel 52/152 was also previously approved for use at Pilgrim via an NRC SER dated April 12, 2005.

Weld Overlay Design

The weld overlay will extend around the full circumference of the weldment location in accordance with NUREG-0313, Code Case N-504-2, Generic Letter 88-01, and BWRVIP-75-A. The overlay will be performed using a standard overlay design as described in NUREG-0313, Section 4.4.1. This design assumes a crack completely through the wall for 360°. The calculation methods for design of the overlay will be in accordance with NUREG-0313, Section 4.1.

The specific thickness and length will be computed according to the guidance provided in ASME Section XI, Code Case N-504-2, and ASME Section XI. The overlay will completely cover any indication location and the existing Inconel 182 weld deposit butter with the highly corrosion resistant Inconel weld material. In order to accomplish this objective, it is necessary to weld on the low alloy steel (LAS) material. A temper bead welding approach will be used for this purpose according to the provisions of ASME Code Case N-638. This Code Case provides for GTAW temper bead weld repairs to P-No. 3 nozzle materials (SA 508 Cl. 2) at ambient temperatures. The temper bead approach was selected because temper bead welding supplants the requirement for post weld heat treatment (PWHT) of heat-affected zones in welded LAS material.

ASME Code Case N-638, General Requirements 1(a), limits the maximum finished surface area of the weld overlay repair to 100 sq. in. The overlay repair (design and fabrication) on large diameter (13-inch OD) recirculation nozzle safe-end welds would exceed the 100 sq. in. limit and requires NRC approval for a maximum finished weld repair surface area up to 300 sq. in. Analysis contained in EPRI Technical Report 1003616, "Additional Evaluations to Extend Repair Limits for Pressure Vessels and Nozzles", dated March 2004, allows for exceeding this limit and was used by Susquehanna Station as justification for the recent nozzle weld overlay repairs. If the weld overlay necessary for a nozzle exceeds 300 sq. in., additional relief will be requested, as previously approved by NRC SER for use at Pilgirm via NRC SER dated April 12, 2005.

Examination Requirements

The repair, pre-service inspection (PSI), and future in-service inspection (ISI) examinations of the weld overlay repair will be performed in accordance with the ISI Program and Plan, BWRVIP-75-A and approved plant procedures as specified by the ISI Repair / Replacement Program.

The weld overlay will be examined using the industry developed PDI procedure, as requested in PNPS 4th ISI Interval PRR-9 (Relief from ASME Code Section XI, Appendix VIII, Supplement 11, Qualification Requirements for Full Structural Overlaid Wrought Austenitic Piping Welds).

System leakage testing will be performed as allowed by Code Case N-416-3 in lieu of the system hydrostatic test required by Code Case N-504-2. Code Case N-416-3 is approved in the NRC R.G. 1.147, latest revision.

A description of the required examinations for the weld overlay is provided in Table 2

TABLE 2

Examination Description	Method	Technique	Reference
Weld Overlay Surface Area Preparation Exam	PT	Visible Dye	N-504-2
First Two Weld Overlay Layers Surface Exam	PT	Visible Dye	N-504-2
First Two Weld Overlay Layers Thickness Measurements	UT or Mechanical	0° Long. UT or Mechanical Height Measurement	N-504-2
Completed Overlay Thickness Measurements	UT or Mechanical	0° Long. UT or Mechanical Height Measurement	N-504-2
Surface Exam of Final Overlay Surface and Adjacent Band within 1.5t (7/8" Band) of Weld Overlay. This also serves as Preservice Surface Examination of completed overlay.	PT	Visible Dye	NB-5350 IWB-3514 N-638 N-504-2
Volumetric Exam of Final Overlay and Adjacent Band within 1.5t (7/8" Band) of Weld Overlay. This also serves as Preservice Volumetric Examination of completed overlay.	UT	PDI Procedure	ASME 1998, Section XI With 2000 Addenda, Appendix VIII; as modified by 10 CFR 50.55a
Preservice Baseline Exam of Final Overlay Outer 25% of the Underlying Pipe Wall to Identify the Original Flaws.	UT	PDI Procedure	N-504-2

The acceptance criteria for the volumetric examinations shall be ASME Code Section XI Paragraph IWB-3514, "Standards for Examination Category B-F, Pressure Retaining Dissimilar Metal Welds, and Examination Category B-J, Pressure Retaining Welds in Piping".

It is noted that the curvatures of reactor nozzles require an exception to the ultrasonic inspection requirement for a 1.5t adjacent band volumetric examination at the end of the overlay on the nozzle end. The PT examination of this surface will constitute the acceptance testing for the overlay deposit.

Thickness will be characterized at four (4) azimuths representing each of the four (4) pipe quadrants. Thickness measurements may be determined using UT techniques or by mechanical measurement. Liquid penetrant examinations will be performed at the same stages of the overlay application as the thickness measurements identified above.

The alternative, as described below, provides an acceptable level of quality and safety while neither draining the reactor vessel nor applying preheat and post weld heat treatments.

C. ALTERNATIVE TO REPAIR REQUIREMENTS

The repair will utilize ASME Code Case N-504-2, "Alternative Rules for Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping," and Code Case N-638, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique," with the following exceptions and clarifications.

Clarification of Code Case N-504-2 for Applicability to Nickel-Based Austenitic Alloy

Code Case N-504-2 was prepared specifically for austenitic stainless steel material. An alternate application to use nickel-based austenitic materials (i.e., Alloy 52/152) is requested due to the specific configuration of the nickel-based austenitic weldment.

Exception from Code Case N-504-2 Paragraph (b)

Code Case N-504-2 paragraph (b) requires that the reinforcement weld metal shall be low carbon (0.035 % maximum) austenitic stainless steel. In this application, a nickel-based filler is required and Alloy 52/152 has been selected in place of low carbon austenitic stainless steel.

Exception from Code Case N-504-2 Paragraph (e)

Code Case N-504-2 paragraph (e) requires as-deposited delta ferrite measurements of at least 7.5% for the weld reinforcement. These measurements have no meaning for nickel-based materials and will not be performed for these overlays.

Note for (b) and (e) above:

The composition of nickel-based Alloy weld metals (Inconel) is such that delta ferrite is not formed during welding. Ferrite measurement requirements were developed for welding of 300 series stainless steels. Welds using Inconel are 100% austenitic and contain no delta ferrite due to the high nickel composition (approximately 60% Ni and low iron content). Alloy 52/152 with its high chromium content provides a high level of resistance to IGSCC. Therefore, this alternative provides an acceptable level of quality and safety.

Exception from Code Case N-504-2 Paragraph (h)

Code Case N-504-2 paragraph (h) requires a system hydrostatic test of completed repairs if the repaired flaw penetrated the original pressure boundary or if there is any observed indication of the flaw penetrating the pressure boundary during repairs. A system leak test of completed repairs will be used in lieu of a hydrostatic test in accordance with ASME Code N416-3 which is approved in NRC R.G. 1.147 latest revision.

Use of Code Case N-638 Applicability

Code Case N-638 shall be applied to the nozzle material.

Exception from Code Case N-638 Paragraph 1(a)

The Code case N-638, General Requirements, 1(a) limits the maximum finished surface area of the weld overlay repair to 100 sq. inches. Relief is requested to extend the size of the repairs up to 300 sq. in. finished area to accommodate overlay repair on large diameter (13-inch OD) recirculation nozzle safe-end welds. This was previously approved by NRC SER for use at Pilgirm via NRC SER dated April 12, 2005.

D. BASIS FOR THE ALTERNATIVE

Clarification of Code Case N-504-2 for Applicability to Nickel-Based Austenitic Steel

The weldments being addressed are austenitic material having a mechanical behavior similar to austenitic stainless steel. The weldment is designed to be highly resistant to IGSCC and is compatible with the existing weldment and base metal materials. Accordingly, this alternative provides an acceptable level of quality and safety. Therefore, Code Case N-504-2 should be interpreted to apply equally to both materials.

Exception from Code Case N-504-2 Paragraph (b)

A consumable welding wire highly resistant to IGSCC was selected for the overlay material. This material is a nickel-based alloy weld filler material, commonly referred to as Alloy 52, and will be applied using the GTAW process. Alloy 52 contains approximately 30% chromium, which imparts excellent stress corrosion cracking resistance. Alloy 52 which had been used extensively in the construction of many nuclear plants, is identified as an IGSCC resistant material in BWRVIP-75A. Alloy 52 with its high chromium content provides a high level of resistance to IGSCC consistent with the requirements of the code case. Therefore, this alternative provides an acceptable level of quality and safety.

Exception from Code Case N-504-2 Paragraph (e)

The composition of nickel-based Alloy 52 is such that delta ferrite is not formed during welding. Ferrite measurement requirements were developed for welding of 300 series stainless steels. Weld using Alloy 52 is 100% austenitic and contains no delta ferrite due to the high nickel composition (approximately 60% Ni and low iron content). Alloy 52 with its high chromium content provides a high level of resistance to hot cracking and IGSCC. Therefore, this alternative provides an acceptable level of quality and safety.

Exception from Code Case N-504-2 Paragraph (h)

In lieu of the hydrostatic pressure test requirements defined in Code Case N-504-2, the required pressure test shall be performed in accordance with Case N-416-3 with the exception that the volumetric examination performed shall be an ultrasonic examination of the weld overlay.

The weld overlay will be examined using the industry developed PDI procedure, as requested in PNPS 4th ISI Interval PRR-9 (Relief from ASME Code Section XI, Appendix VIII, Supplement 11, and Qualification Requirements for Full Structural Overlaid Wrought Austenitic Piping Welds).

Radiography examination would be not be meaningful since the IGSCC flaw is not removed and the piping in filled with water during the weld overlay process. The water backing provides a heat sink which imparts a compressive residual stress which retards future crack growth. This has been noted in EPRI research (EPRI reports NP-7103-D and NP-7085-D). In addition, the water back reduces radiation exposure (ALARA) to the personnel performing the weld overlay.

These alternative requirements are sufficient to demonstrate that the overlay is of adequate quality to ensure the pressure boundary integrity. Accordingly, this alternative provides an acceptable level of quality and safety.

Use of Code Case N-638 Applicability

Code Case N-638 was developed to address temper bead applications for similar and dissimilar metals. It permits the use of machine GTAW process at ambient temperature without the use of preheat or PWHT on Class 1, 2, and 3 components.

Temper bead welding methodology is not new. Numerous applications over the past decade have demonstrated the acceptability of temper bead technology in nuclear environments. Temper bead welding achieves heat affected zone (HAZ) tempering and grain refinement without subsequent PWHT. Excellent HAZ toughness and ductility are produced. Use of Code Case N-638 has been accepted in Regulatory Guide 1.147 as providing an acceptable level of quality and safety.

The overlay repair on large diameter (13-inch nominal OD) recirculation nozzle safe-end welds would exceed the 100 sq. in. limit specified in Code Case N-638, paragraph 1(a). EPRI Technical Report 1003616, "Additional Evaluations to Extend Repair Limits for Pressure Vessels and Nozzles", dated March 2004, justifies extending the size of the temper bead repair finished area. The ASME Code Committees have recognized that the 100 sq. in. restriction on the overlay surface area is excessive and a draft code case, RRM-04, is currently being progressed within ASME Section XI to increase the area limit. Furthermore, Three Mile Island and V. C. Summer have completed weld overlay repairs involving approximately 200 and 300 sq. inches respectively. Susquehanna Station in its Relief Request No.31 has used the EPRI Report, ASME proposed draft code case, V. C. Summer and Three Mile Island expanded repairs as justifications for recent expanded nozzle weld overlay repairs. As discussed in the EPRI Report, increasing the allowed areas for ambient temper bead repairs did not detrimentally change the residual stresses, thereby providing an acceptable level of quality and safety.

Use of Code Case N-638 applicability as discussed above was previously approved by the NRC SER for use at Pilgirm via NRC SER dated April 12, 2005 (Reference 3).

E. CONCLUSION

Weld overlays involve the application of weld metal circumferentially over and in the vicinity of the flawed weld to restore ASME Section XI margins as required by ASME Code Case N-504-2. Weld overlays have been used in the nuclear industry as an acceptable method to repair flawed weld. Use of overlay filler material that provides excellent resistance to IGSCC provides an effective barrier to crack extension.

The design of the overlay uses methods that are standard in the industry for size determination of pipe-to-pipe overlays. There are no new or different approaches used in these overlay designs that would be 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, which was forwarded by Generic Letter 88-01, and Code Case N-504-2 and ASME Section XI Paragraph IWB-3640.

Temper bead techniques, as defined by Code Case N-638, will produce a tough corrosion resistant overlay deposit that meets or exceeds all code requirements for the weld overlay.

Pilgrim concludes that the contingency repair plan presents an acceptable level of quality and safety to satisfy the requirements of 10CFR50.55a(a)(3)(i). Similar proposed alternatives to the requirements have been previously approved by the NRC for James A Fitzpatrick (TAC No. MB0252, dated October 26, 2000), Duane Arnold Energy Center (NRC Staff's letter dated November 19, 1999), Nine Mile Point Unit 2 plant (NRC Staff's letter dated March 30, 2000) and for Pilgrim to repair the RPV N10 nozzle to safe-end weld (3rd ISI Interval PRR-36 and 38).

Inconel Weld Metal Overlays are recognized as an IGSCC resistant material in BWRVIP 75-A Section 5.5.1.1 and 3.5.2.1. This was approved by NRC SER in a letter dated May 14, 2002

F. DURATION OF THE PROPOSED ALTERNATIVE

The proposed alternative applies to the repairs of the identified RPV nozzle safe-end and piping welds for all scheduled refueling outages during the 4th ISI Interval until the expiration of the current Operating License on June 8, 2012. Re-inspection will in accordance with the BWRVIP-75-A Guidelines. The 4th ISI Interval commenced on July 1, 2005 and ends on June 30, 2015.

G. PRECEDENTS

The six welds specified in this relief request (PRR-15) were not included in the NRC approved PRR-39 from the 3rd ISI Interval (TAC No. MC2496). The weld overlay scope, examinations, and repair requirements for the six welds in PRR-15 are identical to those specified for the welds included in the approved PRR-39.

PRR-39 was approved for the current licensed life of the plant (2012); accordingly, PRR-39 is carried forward to the 4th Interval for all the welds already approved in that relief request until the expiration of the current Operating License on June 8, 2012. Like PRR-39, PRR-15 is also a contingency repair plan for the specified welds, would remain in effect until the expiration current Operating License.

H. ATTACHMENTS

None

I. REFERENCES

1. Entergy Letter No. 2.04.091, Response to NRC Request for Additional Information and Revised Pilgrim Relief Request, PRR-39, Rev. 1 (3rd ISI Interval), TAC No. MC 2496, dated October 12, 2004.

2. Entergy Letter No. 2.05.024, Pilgrim Relief Request, PRR-39, Rev. 2 (TAC NO. MC2496) (This revision limits the weld overlay finished area to 300 sq. in. based

on EPRI Technical Report 1003616, "Additional Evaluations to Extend Repair Limits for Pressure Vessels and Nozzles", dated March 2004), March 16, 2005.

3. NRC Letter, Pilgrim Relief Request PRR-39, Alternative Contingency Repair Plan for Reactor Pressure Vessel Nozzle Safe-end and Dissimilar Metal Piping Welds Using ASME Code Cases N-638 and N-504-2, with Exceptions (TAC No. MC2496), dated April 12, 2005.

April 2, 2007

Mr. Michael Kansler
President
Entergy Nuclear Operations, Inc.
440 Hamilton Avenue
White Plains, NY 10601

SUBJECT: PILGRIM NUCLEAR POWER STATION - RELIEF REQUEST NO. PRR-15 REV. 01, APPROVAL TO INCLUDE REMAINING REACTOR PRESSURE VESSEL (RPV) SAFE-END WELDS IN CONTINGENCY REPAIR PLAN FOR FULL STRUCTURAL WELD OVERLAYS (TAC NO. MD2663)

Dear Mr. Kansler:

By letter dated June 29, 2005 (Agencywide Documents and Management System (ADAMS) Accession No. ML051920157), as supplemented by letter dated July 14, 2006 (ML062010210), Entergy Nuclear Operations, Inc. (the licensee) submitted Relief Request PRR-15, Rev. 01, which added RPV safe-end welds under Table 1, to the welds subject to the contingency repair plan under Relief Request PRR-39, Rev. 02 (PRR-39), for the Pilgrim Nuclear Power Station (Pilgrim).

In its safety evaluation dated April 12, 2005 (ML050880137), the Nuclear Regulatory Commission (NRC) staff approved the contingency repair plan for specific welds in PRR-39, for the remaining service life of Pilgrim, 8 years from 2005 to 2012. By letter dated July 14, 2006, *the licensee submitted its response to the staff's request for additional information dated* May 11, 2006 (ML06120140). In letter dated July 14, 2006, the licensee stated that it had evaluated the changes in the code cases in Tables 1 and 2 of Regulatory Guide (RG) 1.147, Rev. 13 and 14, and confirmed that the code cases approved under PRR-39 did not change the design, fabrication, and testing of the overlay repair plan under PRR-39.

RG 1.147, Rev. 14 states that if a code case is implemented by a licensee and a later version of the code case is approved by the NRC staff and listed in Tables 1 and 2 during the licensee's present 120-month inservice inspection (ISI) program interval, that licensee may use either the later version or the previous version. In addition to the above, the licensee is committing to using a repair plan approved by the staff under PRR-39 pursuant to 10 CFR 50.55a(a)(3)(i) for the additional RPV safe-end welds listed under PRR-15, Rev. 01 (see attached Background information).

Based on the information provided by the licensee, the NRC staff approves Relief Request PRR-15, Rev. 01, for the remainder of the fourth ISI interval, pursuant to 10 CFR 50.55a(a)(3)(i).

M. Kansler - 2 -

If you have any questions regarding this approval, please contact the Pilgrim Project Manager, James Kim, at 301-415-4125.

Sincerely,

/RA/

John P. Boska, Chief (Acting)
Plant Licensing Branch I-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-293

cc: See next page

BACKGROUND

The NRC approved PRR-39, Rev. 2 (hereafter PRR-39) Contingency Repair Plan for use in the Third 10-Ten Year inservice inspection (ISI) interval, for use during succeeding 120 months from April 12, 2005 until the expiration of Pilgrim Operating License in 2012. The welds included in PRR-39 are identified in the table below and were selected for examination during Refueling Outage (RFO) 15, which was the last refueling outage in the Third 10-year interval. RFO-15 took place in April and May of 2005.

Welds included in PRR-39, Rev. 2 Contingency Repair Plan

WELD IDENTIFICATION	DESCRIPTION	SYSTEM
14-A-1	Safe-End to Nozzle	Core Spray
14-B-1	Safe-End to Nozzle	Core Spray
2R-N1B-1	Safe-End to Nozzle	Recirculation
2R-N2D-1	Safe-End to Nozzle	Recirculation
2R-N2E-1	Safe-End to Nozzle	Recirculation
2R-N2F-1	Safe-End to Nozzle	Recirculation
2R-N2G-1	Safe-End to Nozzle	Recirculation
2R-N2J-1	Safe-End to Nozzle	Recirculation
14-A-3	Pipe to Reducer	Core Spray
14-B-3	Pipe to Reducer	Core Spray
14-A-10A	Valve to Pipe	Core Spray
14-B-10A	Valve to Pipe	Core Spray

The above PRR-39 welds included only those welds which were scheduled for inspection during RFO-15, but excluded all other reactor pressure vessel (RPV) safe-end to nozzle welds, because these RPV welds had already been inspected during the previous refueling outages within the Third 10-year ISI interval. The Contingency Repair Plan was to preclude exigent reviews if a weld flaw was identified. Pilgrim opted for NRC approval of a Contingency Repair Plan before the start of the RFO-15 for the PRR-39 welds that were scheduled for inspection during that outage.

By the relief request (PRR-15, Rev.01) dated June 29, 2005, the licensee requested NRC to include the remaining RPV safe-end welds identified in the table below in the Contingency Repair Plan for use within the 120-month duration that was approved by NRC on April 12, 2005. These RPV safe-end welds fall within the material conditions, repair plan, and examination techniques already reviewed and approved by the NRC for PRR-39 with no material changes.

Attachment

RPV Safe-End to Nozzle Welds Included in PRR-15, Rev.01

WELD IDENTIFICATION	DESCRIPTION	SYSTEM
2R-N2A-1	Safe-End to Nozzle	Reactor Pressure Vessel
2R-N2B-1	Safe-End to Nozzle	Reactor Pressure Vessel
2R-N2C-1	Safe-End to Nozzle	Reactor Pressure Vessel
2R-N2D-1	Safe-End to Nozzle	Reactor Pressure Vessel
2R-N2H-1	Safe-End to Nozzle	Reactor Pressure Vessel
2R-N2K-1	Safe-End to Nozzle	Reactor Pressure Vessel
RPV-N9B-1	Safe-End to Nozzle	Reactor Pressure Vessel

As stated in the NRC safety evaluation (SE), dated April 12, 2005, NRC approved the Contingency Repair Plan for the remaining service life of Pilgrim, 8 years from 2005 to 2012, since the current Operating License would expire on June 8, 2012, and the cumulative duration for the Contingency Repair Plan would remain in effect for less than 120 months. The licensee plans to inspect all of the welds contained in PRR-39 and PRR-15 within this 120-month period. If flaws are identified, they will be corrected in accordance with the approved alternative Contingency Repair Plan.

NRC has approved up to 120 months for the applicability of approved 10 CFR 50.55a(a)(3)(i) relief request PRR-39 in transition from the Third to the Fourth ISI interval, limited by the expiration of Pilgrim's current Operating License in 2012. NRC's SE on PRR-39 dated April 12, 2005, is applicable in its entirety to PRR-15, Rev. 01, because the licensee will be using all the Code Cases previously approved by the NRC in the PRR-39 SE.

Therefore, inclusion of PRR-15, Rev 01. welds in the previously approved Contingency Repair Plan is acceptable because the Contingency Repair Plan remains valid and in effect.

Attachment

M. Kansler - 2 -

If you have any questions regarding this approval, please contact the Pilgrim Project Manager, James Kim, at 301-415-4125.

Sincerely,

/RA/

John P. Boska, Chief (Acting)
Plant Licensing Branch I-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-293

cc: See next page

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OFFICE	LPLI-1/PM	LPLI-1/LA	CFEB/BC	CPNB/BC	OGC	LPL1-1/BC (A)
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DATE	3/2/07	3/5/07	3/14/07	3/19/07	3/30/07	4/2/07

OFFICIAL RECORD COPY

Pilgrim Nuclear Power Station

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Pilgrim Nuclear Power Station

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Entergy

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Kevin H. Bronson
Site Vice President

June 25, 2007

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

SUBJECT: Entergy Nuclear Operations, Inc.
Pilgrim Nuclear Power Station
Docket No: 50-293
License No. DPR-35

Licensee Event Report 2007-003-00

LETTER NUMBER: 2.07.059

Dear Sir or Madam:

The enclosed Licensee Event Report (LER) 2007-003-00, "Reactor Coolant Boundary Leakage due to Reactor Vessel Nozzle Weld Crack Propagation," is submitted in accordance with 10 CFR 50.73.

This letter contains no commitments.

Please contact Bryan Ford, (508) 830-8403, if there are questions regarding this submittal.

Sincerely,

Kevin H. Bronson

FXM/dl
Enclosure

cc: Mr. James Kim, Project Manager
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Senior Resident Inspector
Pilgrim Nuclear Power Station

IE22

NRR

1. NRC Form 366 U.S. NUCLEAR REGULATORY COMMISSION **LICENSEE EVENT REPORT (LER)**	Estimated burden per response to comply with this mandatory information collection request: 50 hrs. Reported lessons learned are incorporated into the licensing process and fed back to industry. Forward comments regarding burden estimate to the Records Management Branch (T-6 F33), U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, and to the Paperwork Reduction Project (3150-0104), Office of Management and Budget, Washington, DC 20503.	
FACILITY NAME (1) PILGRIM NUCLEAR POWER STATION	**DOCKET NUMBER (2)** 05000-293	**PAGE(3)** 1 of 5

TITLE (4)
Reactor Coolant Pressure Boundary Leakage due to Reactor Vessel Nozzle Weld Crack Propagation

EVENT DATE (5)			LER NUMBER (6)			REPORT DATE (7)			OTHER FACILITIES INVOLVED (8)	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	MONTH	DAY	YEAR	FACILITY NAME N/A	DOCKET NUMBER 05000
04	26	2007	2007	003	00	06	25	2007	FACILITY NAME N/A	DOCKET NUMBER 05000

OPERATING MODE (9)	N	THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR: (Check one or more) (11)							
			20.2201(b)		22.2203(a)(3)(i)		50.73(a)(2)(i)(C)		50.73(a)(2)(vii)
POWER LEVEL (10)	0%		22.2202(d)		20.2203(a)(3)(ii)	X	50.73(a)(2)(ii)(A)		50.73(a)(2)(viii)(A)
			20.2203(a)(1)		20.2203(a)(4)		50.73(a)(2)(ii)(B)		50.73(a)(2)(viii)(B)
			20.2203(a)(2)(i)		50.36(3)(1)(i)(A)		50.73(a)(2)(iii)		50.73(a)(2)(ix)(A)
			20.2203(a)(2)(ii)		50.36(3)(1)(ii)(A)		50.73(a)(2)(iv)(A)		50.73(a)(2)(x)
			20.2203(a)(2)(iii)		50.36(c)(2)		50.73(a)(2)(v)(A)		73.71(a)(4)
			20.2203(a)(2)(iv)		50.46(a)(3)(ii)		50.73(a)(2)(v)(B)		73.71(a)(5)
			20.2203(a)(2)(v)		50.73(a)(2)(i)(A)		50.73(a)(2)(v)(C)		OTHER Specify in Abstract below or in NRC Form 366A
			20.2203(a)(2)(vi)		50.73(a)(2)(i)(B)		50.73(a)(2)(v)(D)		

LICENSEE CONTACT FOR THIS LER (12)	
NAME Bryan Ford, Licensing Manager	TELEPHONE NUMBER (Include Area Code) (508) 830-8403

COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (13)									
CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO EPIX	CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO EPIX
B	AD	NZL		Y					

SUPPLEMENTAL REPORT EXPECTED (14)				EXPECTED SUBMISSION DATE(15)	MONTH	DAY	YEAR
	YES (If yes, complete EXPECTED SUBMISSION DATE)	X	NO				

ABSTRACT (Limit to 1400 spaces, i.e., approximately 15 single-spaced typewritten lines) (16)

On April 26, 2007, at approximately 1930 hours, the N2K recirculation system inlet nozzle experienced slight water seepage while repairs were being performed to install a full structural weld overlay.

The cause of the leakage is attributed to a planar-type, circumferential flaw in N2K safe-end-to-nozzle weld. The weld was installed in 1984 and included Inconel 182 butter and filler which is a material now known to be susceptible to interdentritic stress corrosion cracking (IDSCC). Subsequent to the weld repair, crack propagation continued via IDSCC due to high residual weld stresses in the weld material. Ultra-sonic testing performed in Refueling Outage 16 (RFO 16) detected planar indication in the Inconel weld material that was indicative of cracking. This prompted the installation of the weld overlay.

Corrective action taken included nozzle weld repair consisting of a full structural weld overlay.

The event posed no threat to public health and safety.

NRC FORM 366

NRC Form 366A — U.S. NUCLEAR REGULATORY COMMISSION

LICENSEE EVENT REPORT (LER)
TEXT CONTINUATION

FACILITY NAME (1)	DOCKET NUMBER (2)	LER NUMBER (6)			PAGE (3)
		YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	
PILGRIM NUCLEAR POWER STATION	05000-293	2007	003	00	2 of 5

TEXT (If more space is required, use additional copies of NRC Form 366A) (17)

BACKGROUND

The N2K safe-end-to-nozzle weld is located at the inlet to the reactor vessel from the "B" recirculation loop. This section of the piping system supplies drive water for two jet pumps. There are 10 similar N2 safe-end-to-nozzle welds in the reactor coolant pressure boundary.

During RFO 16, a scheduled ultrasonic test (UT) was performed on the N2K safe-end-to-nozzle weld. A weld discontinuity was recorded.

Construction records were reviewed and repairs in the area of the flaw were noted to have been performed in 1984 during the recirculation pipe replacement project. Lack of detailed documentation prevented determining the amount of grinding that was performed (e.g., depth, length). The limited documentation that is available indicates that grinding for weld repair was required and took place at most 0.75 inches from the outside diameter (OD). However, RFO 16 UT tests revealed indications were present nearer to the inside diameter (ID) of the pipe. The discrepancy between the repair records and UT test results caused elevated concern by the Level III inspector.

A third party review was solicited and an evaluation of construction radiographs, 1997 UT data, and 2007 UT data was performed. The detailed evaluation of the N2K flaw determined that the weld discontinuity was a subsurface planar flaw per IWB-3320. A conservative estimate concluded that the flaw was a planar-type circumferential flaw within the Alloy 82/182 weld that was inside surface connected. The review characterized a flaw depth of 1.02 inches with 0.13 inches remaining (89% through-wall flaw).

Based on the weld examinations performed, a weld repair was determined to be necessary.

EVENT DESCRIPTION

On April 26, 2007, at approximately 1930 hours during initial welding activities associated with installation of the full weld overlay, water seepage occurred at the outside diameter of the existing weld in the vicinity of the flaw on the N2K recirculation system inlet nozzle. The seepage confirmed that the weld flaw was inside surface connected. The crack in the weld material was peened and seal welded to stop the seepage.

The weld was subsequently repaired via the installation of a full structural weld overlay. The weld repair methodology was approved by the NRC in relief request PRR-15, Rev. 01.

NRC FORM 366A

NRC Form 366A — U.S. NUCLEAR REGULATORY COMMISSION

LICENSEE EVENT REPORT (LER)
TEXT CONTINUATION

FACILITY NAME (1)	DOCKET NUMBER (2)	LER NUMBER (6)			PAGE (3)
		YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	
PILGRIM NUCLEAR POWER STATION	05000-293	2007	003	00	3 of 5

TEXT (If more space is required, use additional copies of NRC Form 366A) (17)

CAUSE

The cause of leakage from the reactor coolant pressure boundary was due to welding preparation activities taken to repair the N2K safe-end-to-nozzle weld. The cause of the almost through-wall flaw found on the N2K nozzle is a small crevice condition most likely from lack of fusion at the pipe ID, which created a crack initiation site (likely crevice corrosion) in the Inconel 182 butter. The crack propagated outward through the Inconel 182 butter and into the weld. Given the crack is entirely within the Inconel weld, the mechanism for crack propagation is Interdendritic Stress Corrosion Cracking (IDSCC). IDSCC differs from Intergranular Stress Corrosion Cracking (IGSCC) in that the crack occurs entirely within the weld material whereas IGSCC occurs within the base metal heat affected zone. The IDSCC mechanism propagated the crack due to high residual weld stresses.

CORRECTIVE ACTION

Corrective action taken included an automated, full structural weld overlay. The weld overlay was installed with Inconel 52M weld metal, which is highly resistant to stress corrosion cracking. The weld overlay process also imparts a compressive residual stress due to the welding process, which prevents further crack growth. The weld overlay was installed under an NRC approved relief request.

After the N2K nozzle-to-safe-end weld flaw was identified, additional UT examinations were performed on an expanded scope of four Category D welds. All other Category D welds had already been examined using the EPRI Performance Demonstration Initiative (PDI) requirements during prior outages. Three of the welds in the expanded scope are N2 nozzle-to-safe-end welds. No unacceptable flaws were identified in the four expanded scope UT examinations performed in RFO 16.

An extent of condition evaluation was also performed. The evaluation assessed critical attributes related to the N2K nozzle weld flaw. The evaluation identified that 34 Category D welds at PNPS are in the BWRVIP-75 Program. Of those 34 welds, 17 are welds that contain Inconel. All 17 of the welds with Inconel were UT examined during the last two outages (RFO 15 and RFO 16). However, not all sections of each weld could be UT inspected because of transducer lift off resulting from irregular weld and pipe configurations. Best efforts have been made to contour the surface of the welds to meet EPRI PDI requirements and to maximize weld volume coverage without violating minimum wall requirements. Ongoing corrective actions for the event includes a review of weld repair records for SSC susceptible Inconel 182 welds to determine if the repaired weld sections were fully covered by the UT examinations.

NRC FORM 366A

NRC Form 366A — U.S. NUCLEAR REGULATORY COMMISSION

LICENSEE EVENT REPORT (LER)
TEXT CONTINUATION

FACILITY NAME (1)	DOCKET NUMBER (2)	LER NUMBER (6)			PAGE (3)
		YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	
PILGRIM NUCLEAR POWER STATION	05000-293	2007	003	00	4 of 5

TEXT (If more space is required, use additional copies of NRC Form 366A) (17)

SAFETY CONSEQUENCES

The event posed no threat to public health and safety.

The leakage from the N2K safe-end to-nozzle weld was identified while work was being performed to repair the weld. The weld repair was necessary based on the results of scheduled ultrasonic testing in accordance with the PNPS ISI Program which identified weld discontinuity in the form of a subsurface planar flaw. Only slight water seepage was reported in the area of the welding flaw. The crack was sealed by peening and seal welding before a full structural overlay was installed.

At the time that the leakage was noted, the reactor was shutdown for refueling. All required control rods were in the fully inserted position. The reactor vessel was at atmospheric pressure. The reactor vessel water temperature was less than 212 degrees Fahrenheit. Reactor water level was flooded up for refueling and being maintained at the 116' elevation.

The flaw in the N2K safe-end–to-nozzle weld was not through-wall when it was identified during a scheduled UT examination. The flaw length noted in the N2K weld is 2.87 inches wide; with an inside surface connected crack located 0.13 inches from the outside diameter. Reactor coolant leakage did not occur until weld repairs were initiated.

Since September 1991, PNPS has been operating with Hydrogen Water Chemistry (HWC). HWC arrests stress corrosion cracking initiation sites and slows existing crack growth rates. During RFO 16 the first application of Noble Metal Chemical Addition (NMCA) was completed. NMCA used in combination with Hydrogen Water Chemistry (HWC) is also effective at arresting crack initiation and slowing crack growth rates. In addition, the N2 nozzle design loads result in relatively low primary stress levels and as such fatigue is not considered to be a significant degradation factor. Therefore, if this flaw had remained in-service slow growth crack rates would be expected during future operating cycles.

The flaw length is a small fraction of the overall pipe circumference and therefore, if the flaw had breached the outside diameter, some leakage would have occurred. This leakage would be detected by installed drywell leak detection systems. Limits on unidentified leakage in the drywell would force reactor shutdown before there is any threat of crack growth that would jeopardize the overall structural integrity of the reactor coolant boundary piping (i.e., guillotine failure).

NRC FORM 366A

NRC Form 366A | U.S. NUCLEAR REGULATORY COMMISSION

LICENSEE EVENT REPORT (LER)
TEXT CONTINUATION

FACILITY NAME (1)	DOCKET NUMBER (2)	LER NUMBER (6)			PAGE (3)
		YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	
PILGRIM NUCLEAR POWER STATION	05000-293	2007	003	00	5 of 5

TEXT (If more space is required, use additional copies of NRC Form 366A) **(17)**

REPORTABILITY

This report was submitted in accordance with 10 CFR 50.73(a)(2)(ii)(A), because the N2K weld leak represents a condition of the nuclear power plant, including its principle safety barriers, that was seriously degraded.

SIMILARITY TO PREVIOUS EVENTS

A review was conducted of Pilgrim Station LERs submitted since 2000. The review focused on reactor coolant boundary leakage and welding flaws. The review identified that LER 03-06-00 reported a similar event which involved a nozzle-to-cap weld on the N10 nozzle.

ENERGY INDUSTRY IDENTIFICATION SYSTEM (EIIS) CODES

The EIIS codes for this report are as follows:

COMPONENTS	CODES
Nozzle (N2K Nozzle)	NZL
SYSTEMS	CODES
Reactor Recirculation	AD

NRC FORM 366A

A.11 Pilgrim Various Nozzles (RR, RAI, and SER)

Entergy

Entergy Nuclear Operations, Inc.
Pilgrim Station
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Plymouth, MA 02360

Stephen J. Bethay
Director, Nuclear Assessment

March 16, 2005

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

SUBJECT: Entergy Nuclear Operations, Inc.
Pilgrim Nuclear Power Station
Docket No. 50-293
License No. DPR-35

Pilgrim Relief Request, PRR-39, Revision 2 (TAC NO. MC2496)

REFERENCE: 1. Entergy Letter No. 2.04.091, Response to NRC Request for Additional Information and PRR-39, Rev. 1, Alternative Contingency Repair Plan for Reactor Pressure Vessel Nozzle Safe-End and Dissimilar Metal Piping Welds Using ASME Code Cases N-638 and N-504-2 with Exceptions, dated, October 12, 2004.

LETTER NUMBER: 2.05.024

Dear Sir or Madam:

This letter provides Pilgrim revised PRR-39, Revision 2 (Attachment 1). Revision 2 to PRR-39 limits the maximum weld overlay repair area to 300 sq. in.

There are no commitments contained in this letter.

If you have any questions or require additional information, please contact Mr. Bryan Ford, Licensing Manager, at (508) 830-8403.

Sincerely,

Stephen J. Bethay

WGL/dm
Attachment 1: Pilgrim Relief Request, (PRR)-39, Revision 2 (7 pages)

2.05.024

A047

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King of Prussia, PA 19406

Senior Resident Inspector
Pilgrim Nuclear Power Station

ATTACHMENT 1

PILGRIM RELIEF REQUEST (PRR) NO. – 39, Rev. 2

Alternative Repair Plan for

Reactor Pressure Vessel Nozzle Safe-End and Dissimilar Metal (DM) Piping Welds

A. COMPONENT IDENTIFICATION

A full structural weld overlay repair is proposed for the weldment associated with the following austenitic reactor pressure vessel nozzle safe-end and dissimilar metal (DM) piping welds. This is a contingency repair plan to be used if needed during the upcoming refueling outage-15.

WELD ID	DESCRIPTION	SYSTEM	DRAWING
14-A-1	SAFE END TO NOZZLE	CS	ISI-I-14-1
14-B-1	SAFE END TO NOZZLE	CS	ISI-I-14-1
2R-N1B-1	SAFE END TO NOZZLE	RECIRC	ISI-I-2R-A
2R-N2D-1	SAFE END TO NOZZLE	RECIRC	ISI-I-2R-A
2R-N2E-1	SAFE END TO NOZZLE	RECIRC	ISI-I-2R-A
2R-N2F-1	SAFE END TO NOZZLE	RECIRC	ISI-I-2R-B
2R-N2G-1	SAFE END TO NOZZLE	RECIRC	ISI-I-2R-B
2R-N2J-1	SAFE END TO NOZZLE	RECIRC	ISI-I-2R-B
14-A-3	PIPE TO REDUCER	CS	ISI-I-14-1
14-B-3	PIPE TO REDUCER	CS	ISI-I-14-1
14-A-10A	VALVE TO PIPE	CS	ISI-I-14-1
14-B-10A	VALVE TO PIPE	CS	ISI-I-14-1

These welds fall within the scope of GL 88-01 and BWRVIP-75.

The weld overlay material for the proposed repair is as follows:

- For machine gas tungsten arc welding (GTAW), the weld material is ASME Section II, Part C, SFA 5-14 Filler Wire ER NiCrFe-7 UNS NO6052 F-No. 43 known commercially as Alloy 52.
- For manual shielded metal arc weld (SMAW) welding, the weld material is ASME Section II, Part C, SFA 5-11 Weld Electrode E NiCrFe-7 UNS W86152 known commercially as Alloy 152.

B. EXAMINATION AND REPAIR REQUIREMENTS

Weld overlay will be designed consistent with the requirements of NUREG-0313, (which was implemented by Generic Letter 88-01), ASME Code Cases N-504-2, N-638, and ASME, Section XI, Paragraph IWB-3640.

Welder Qualification and Welding Procedures

All welders and welding procedures will be qualified in accordance with ASME Section XI and any special requirements from Section XI or applicable code cases.

If necessary, a manual SMAW procedure will be qualified to facilitate localized repairs and to provide a seal weld, prior to the overlay. This procedure uses UNS W86152 SMAW electrodes consistent with ASME Section XI requirements. Personnel qualified in accordance with the Welding Procedure Specification for welding Alloy 52/152 will perform the repair activities.

Welding Wire Material

A consumable welding wire highly resistant to intergranular stress corrosion cracking (IGSCC) will be used for the overlay material. This material, designated UNS N06052, is a nickel-based weld filler material (commonly referred to as Alloy 52), and will be applied using the GTAW process. Alloy 52 is identified as F-No. 43 Grouping for Ni-Cr-Fe, classification UNS N06052 Filler Metal. Alloy 52 contains about 30% chromium, which imparts excellent corrosion resistance to this material. Alloy 152 welding wire will be used for manual (SMAW) seal welding activities.

Weld Overlay Design

The weld overlay will extend around the full circumference of the weldment location in accordance with NUREG-0313, Code Case N-504-2, Generic Letter 88-01, and BWRVIP-75. The overlay will be performed using a standard overlay design as described in NUREG-0313, Section 4.4.1. This design assumes a crack completely through the wall for 360°. The calculation methods for design of the overlay will be in accordance with NUREG-0313, Section 4.1.

The specific thickness and length will be computed using the guidance provided in ASME Section XI, Code Case N-504-2, and ASME Section XI, Paragraph IWB-3640, 1989 Edition. The overlay will completely cover any flaw location and the existing Inconel 182 weld deposit butter with the highly corrosion resistant Alloy 52 material. In order to accomplish this objective, it is necessary to weld on the low alloy steel (LAS) material. A temper bead welding approach will be used for this purpose according to the provisions of ASME Code Case N-638. This code case provides for machine GTAW temper bead weld repairs to P No. 3 nozzle materials (SA 508 Cl. 2) at ambient temperature. The temper bead approach was selected because temper bead welding supplants the requirement for post weld heat treatment (PWHT) of heat-affected zones in welded LAS material.

The Code case N-638, General Requirements, 1(a) limits the maximum finished surface area of the weld overlay repair to 100 sq. in. The overlay repair (design and fabrication) on large diameter (13 and 29-inch OD) recirculation nozzle safe-end welds would exceed the 100 sq. in. limit and requires NRC approval for a maximum finished weld repair surface area up to 300 sq. in. on the basis of analysis in EPRI Technical Report 1003616, "Additional Evaluations to Extend Repair Limits for Pressure Vessels and Nozzles", dated March 2004. Susquehanna Station has used the EPRI Report as justification for recent nozzle weld overlay repairs. If the weld overlay necessary for a nozzle exceeds 300 sq. in., additional relief will be requested.

Examination Requirements

The repair, pre-service inspection (PSI), and in-service inspection (ISI) examinations of the weld overlay repair will be performed in accordance with the ISI Program and Plan along with NUREG-0313, Generic Letter 88-01, and approved plant procedures as specified by the ISI Repair/Replacement Program.

The weld overlay will be examined using the industry developed PDI procedure, as approved in PRR-38 (Relief from ASME Code Section XI, Appendix VIII, Supplement 11, Qualification Requirements for Full Structural Overlaid Wrought Austenitic Piping Welds, TAC No. MC0961, dated February 26, 2004).

System leakage testing will be performed as allowed by Code Case N-416-2 with the additional condition that hold times specified in IWA-5213 (d) be observed, in lieu of the system hydrostatic test required by Code Case N-504-2. This complies with Regulatory Guide 1.147, Revision 13, relative to the NRC's conditional acceptance of Code Case N-416-2. The VT-2 inspections will be performed with the insulation removed from the locations where the proposed weld overlays are performed. This will allow a 10 minute hold before the VT-2 is performed.

The examinations and acceptance criteria, as identified below, will be in accordance with ASME Code, Section III, 1992 Edition, Subsection NB for Class 1 Components, ASME Code Section XI, 1989 Edition, and Code Cases N-504-2 and N-638.

A description of the required examinations for the weld overlay is provided in the following table.

Examination Description	Method	Technique	Reference
Weld Overlay Surface Area Preparation Exam	PT	Visible Dye	N-504-2
First Two Weld Overlay Layers Surface Exam	PT	Visible Dye	N-504-2
First Two Weld Overlay Layers Thickness Measurements	UT or Mechanical	0° Long. UT or Mechanical Height Measurement	N-504-2
Completed Overlay Thickness Measurements	UT or Mechanical	0° Long. UT or Mechanical Height Measurement	N-504-2
Surface Exam of Final Overlay Surface and Adjacent Band within 1.5t (7/8" Band) of Weld Overlay. This also serves as Preservice Surface Examination of completed overlay.	PT	Visible Dye	NB-5350 IWB-3514 N-638 N-504-2
Volumetric Exam of Final Overlay and Adjacent Band within 1.5t (7/8" Band) of Weld Overlay. This also serves as Preservice Volumetric Examination of completed overlay.	UT	PDI procedure	ASME 1995, Section XI Appendix VIII; ASME 1989 Section XI
Preservice Baseline Exam of Final Overlay Outer 25% of the Underlying Pipe Wall to Identify the Original Flaws.	UT	PDI Procedure	N-504-2

The acceptance criteria for the volumetric examinations shall be ASME Code Section XI, Paragraph IWB-3514, "Standards for Examination Category B-F, Pressure Retaining Dissimilar Metal Welds, and Examination Category B-J, Pressure Retaining Welds in Piping".

It is noted that the curvatures of reactor nozzles require an exception to the ultrasonic inspection requirement for a 1.5t adjacent band volumetric examination at the end of the overlay on the nozzle end. The PT examination of this surface will constitute the acceptance testing for the overlay deposit.

Thickness will be characterized at four (4) azimuths representing each of the four (4) pipe quadrants. Thickness measurements will be determined using UT techniques or by mechanical measurement. Liquid penetrant examinations will be performed at the same stages of the overlay application as the thickness measurements identified above.

The alternative, as described below, provides an acceptable level of quality and safety while neither draining the reactor vessel nor applying preheat and post weld heat treatments.

C. ALTERNATIVE TO REPAIR REQUIREMENTS

The repair will utilize ASME Code Case N-504-2, "Alternative Rules for Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping," and Code Case N-638, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique," with the following exceptions and clarifications.

Clarification of Code Case N-504-2 for Applicability to Nickel-Based Austenitic Alloy

Code Case N-504-2 was prepared specifically for austenitic stainless steel material. An alternate application to use nickel-based austenitic materials (i.e., Alloy 52) is requested due to the specific configuration of the nickel-based austenitic weldment.

Exception from Code Case N-504-2 Paragraph (b)

Code Case N-504-2 paragraph (b) requires that the reinforcement weld metal shall be low carbon (0.035 % maximum) austenitic stainless steel. In this application, a nickel-based filler is required and Alloy 52 has been selected in place of low carbon austenitic stainless steel.

Exception from Code Case N-504-2 Paragraph (e)

Code Case N-504-2 paragraph (e) requires as-deposited delta ferrite measurements of at least 7.5% for the weld reinforcement. These measurements have no meaning for nickel-based materials and will not be performed for this overlay.

Exception from Code Case N-504-2 Paragraph (h)

Code Case N-504-2 paragraph (h) requires a system hydrostatic test of completed repairs if the repaired flaw penetrated the original pressure boundary or if there is any observed indication of the flaw penetrating the pressure boundary during repairs. A system leak test of completed repairs will be used in lieu of a hydrostatic test.

Use of Code Case N-638 Applicability

Code Case N-638 shall be applied to the nozzle material.

Exception from Code Case N-638 Paragraph 1 (a)

The Code case N-638, General Requirements, 1(a) limits the maximum finished surface area of the weld overlay repair to 100 sq. in. Relief is requested to extend the size of the repairs up to 300 sq. in. finished area to accommodate overlay repair on large diameter (13 and 29 -inch OD) recirculation nozzle safe-end welds.

D. BASIS FOR THE ALTERNATIVE

Clarification of Code Case N-504-2 for Applicability to Nickel-Based Austenitic Steel

The weldment being addressed is austenitic material having a mechanical behavior similar to austenitic stainless steel. The weldment is designed to be highly resistant to IGSCC and is compatible with the existing weldment and base metal materials. Accordingly, this alternative provides an acceptable level of quality and safety. Therefore, Code Case N-504-2 should be interpreted to apply equally to both materials.

Exception from Code Case N-504-2 Paragraph (b)

A consumable welding wire highly resistant to IGSCC was selected for the overlay material. This material, designated UNS N06052, is a nickel-based alloy weld filler material, commonly referred to as Alloy 52, and will be applied using the GTAW process. Alloy 52 contains about 30% chromium, which imparts excellent stress corrosion cracking resistance to this material. By comparison, Alloy 82 is identified as an IGSCC resistant material in NUREG 0313 and contains about 18 to 22% chromium while Alloy 182 has a nominal chromium composition of 13 to 17%. Alloy 52 with its high chromium content provides a high level of resistance to IGSCC consistent with the requirements of the code case. Therefore, this alternative provides an acceptable level of quality and safety.

Exception from Code Case N-504-2 Paragraph (e)

The composition of nickel-based Alloy 52 is such that delta ferrite is not formed during welding. Ferrite measurement requirements were developed for welding of 300 series stainless steels that required delta ferrite to develop corrosion resistance. Weld using Alloy 52 is 100% austenitic and contains no delta ferrite due to the high nickel composition (approximately 60% Ni and low iron content). Alloy 52 with its high chromium content provides a high level of resistance to hot cracking and IGSCC consistent with the purpose for the delta ferrite requirements for stainless steels of the code case. Therefore, this alternative provides an acceptable level of quality and safety.

Exception from Code Case N-504-2 Paragraph (h)

In lieu of the hydrostatic pressure test requirements defined in Code Case N-504-2, the required pressure test shall be performed in accordance with the Third Interval ISI

Program and Plan and Code Case N-416-2 with the exception that the volumetric examination performed shall be an ultrasonic examination of the weld overlay. These alternative requirements are sufficient to demonstrate that the overlay is of adequate quality to ensure the pressure boundary integrity. Accordingly, this alternative provides an acceptable level of quality and safety.

Use of Code Case N-638 Applicability

Code Case N-638 was developed for temper bead applications for similar and dissimilar metals. It permits the use of machine GTAW process at ambient temperature without the use of preheat or PWHT on Class 1, 2, and 3 components.

Temper bead welding methodology is not new. Numerous applications over the past decade have demonstrated the acceptability of temper bead technology in nuclear environments. Temper bead welding achieves heat affected zone (HAZ) tempering and grain refinement without subsequent PWHT. Excellent HAZ toughness and ductility are produced. Use of Code Case N-638 has been accepted in Regulatory Guide 1.147 Revision 13 as providing an acceptable level of quality and safety.

The overlay repair on large diameter (13 and 29-inch OD) recirculation nozzle safe-end welds would exceed the 100 sq. in. limit specified in Code Case N-638, paragraph 1(a). EPRI Technical Report 1003616, "Additional Evaluations to Extend Repair Limits for Pressure Vessels and Nozzles", dated March 2004, justifies extending the size of the temper bead repair finished area. The ASME Code Committees have recognized that the 100 sq. in. restriction on the overlay surface area is excessive and a draft code case, RRM-04, is currently being progressed within ASME Section XI to increase the area limit. Furthermore, Three Mile Island and V. C. Summer have completed weld overlay repairs involving approximately 200 and 300 sq. inches respectively. Susquehanna Station in its Relief Request No. 31 has used the EPRI Report, ASME proposed draft code case, V. C. Summer and Three Mile Island expanded repairs as justifications for recent expanded nozzle weld overlay repairs. As discussed in the EPRI Report, increasing the allowed areas for ambient temper bead repairs did not detrimentally change the residual stresses, thereby providing an acceptable level of quality and safety.

E. CONCLUSION

Weld overlays involve the application of weld metal circumferentially over and in the vicinity of the flawed weld to restore ASME Section XI margins as required by ASME Code Case N-504-2. Weld overlays have been used in the nuclear industry as an acceptable method to repair flawed weld. The use of overlay filler material that provides excellent resistance to IGSCC provides an effective barrier to crack extension.

The design of the overlay uses methods that are standard in the industry for size determination of pipe-to-pipe overlays. There are no new or different approaches used in these overlay designs that would be considered first of a kind or inconsistent with previous approaches. The overlay is designed as a full structural overlay in accordance with the recommendation of NUREG-0313, which was forwarded by Generic Letter 88-01, and Code Case N-504-2 and ASME Section XI Paragraph IWB-3640.

Temper bead techniques, as defined by Code Case N-638, will produce a tough corrosion resistant overlay deposit that meets or exceeds all code requirements for the weld overlay.

Pilgrim concludes that the contingency repair plan presents an acceptable level of quality and safety to satisfy the requirements of 10CFR50.55a(a)(3)(i). Similar proposed alternatives to the requirements of 10CFR50.55a(c)(3) have been previously approved by the NRC for James A Fitzpatrick (TAC No. MB0252, dated October 26, 2000), Duane Arnold Energy Center (NRC Staff's letter dated November 19, 1999), Nine Mile Point Unit 2 plant (NRC Staff's letter dated March 30, 2000) and for Pilgrim to repair the RPV N10 nozzle to safe-end weld (PRR-36 and 38).

F. DURATION OF THE PROPOSED ALTERNATIVE

The proposed alternative applies to the repairs of RPV nozzle safe-end and piping welds for the scheduled outage and for the remaining service life of this weld. Re-inspection will be per BWRVIP-75 Guidelines.

Entergy

Entergy Nuclear Operations, Inc.
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Stephen J. Bethay
Director, Nuclear Assessment

October 12, 2004

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

SUBJECT: Entergy Nuclear Operations, Inc.
Pilgrim Nuclear Power Station
Docket No. 50-293
License No. DPR-35

Response to NRC Request for Additional Information and Revised Pilgrim Relief Request, PRR-39, Rev.1 (TAC NO. MC2496)

REFERENCE:

1. Entergy Letter No. 2.04.015, PRR-39, Alternative Contingency Repair Plan for Reactor Pressure Vessel Nozzle Safe-End and Dissimilar Metal Piping Welds Using ASME Code Cases N-638 and N-504-2 with Exceptions, dated, March 15, 2004.

2. NRC Request for Additional Information, dated June 28, 2004.

LETTER NUMBER: 2.04.091

Dear Sir or Madam:

Attachment 1 to this letter provides Pilgrim response to the NRC Request for Additional Information in support of PRR-39 (Reference 1). Attachment 2 provides revised PRR-39, Rev. 1, which incorporates changes in the weld overlay examination requirements and an additional relief from the maximum finished surface area as specified in Code Case N-638.

There are no commitments contained in this letter.

If you have any questions or require additional information, please contact Mr. Bryan Ford, Licensing Manager, at (508) 830-8403.

Sincerely,

Stephen J. Bethay

Stephan J. Bethay

Attachment 1: Pilgrim Response to NRC Request for Additional Information (10 pages)
Attachment 2: Pilgrim Relief Request, (PRR)-39, Revision 1 (7 pages)

2.04.091

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Entergy Nuclear Operations, Inc.
Pilgrim Nuclear Power Station

Letter Number: 2.04.091
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Pilgrim Nuclear Power Station

ATTACHMENT 1

Pilgrim Response to NRC Request for Additional Information

Pilgrim Relief Request (PRR) - 39

Alternative Contingency Repair Plan
for Reactor Pressure Vessel Nozzle Safe-End and Dissimilar Metal Piping Welds
Using ASME Code Cases N-638 and N-504-2 with Exceptions

NRC QUESTION NO. 1

Discuss whether hydrogen water chemistry as discussed in BWRVIP-75 has been implemented in the primary water system to mitigate the potential of stress corrosion cracking in the recirculation and core spray piping. Discuss whether there have been any chemical excursions occurred in the primary water system that would affect the welds in the proposed relief request. Discuss whether corrective actions have been implemented to minimize the chemical excursions.

PILGRIM RESPONSE

PNPS has maintained an average hydrogen water chemistry (HWC) availability of 90.7 % for the past five operating cycles since June 1993, as shown in Table 1 below. The HWC availability for the current operating cycle (15) is 93.0%. HWC availability should be 80% or greater for the weld inspection interval for a moderate HWC plant in accordance with the SER for BWRVIP-75.

Only one chemical intrusion from a condensate polisher in December 2000 has occurred while above 200° F. This has been accounted for in the availability calculation. The intrusion was due to a failed condensate polisher lateral and underdrain. This problem was subsequently corrected for all the condensate polishers by a redesign of the laterals and underdrains.

A review of the welds in Pilgrim Relief Request-39 showed that 6 safe end to nozzle welds receive protection from Hydrogen Water Chemistry (HWC). The 6 Core Spray (CS) welds are not protected by HWC. This is summarized in Table 2.

TABLE 1:PILGRIM OPERATING CYCLE HWC AVAILABILITY

Operating Cycle	Dates	% HWC Availability
10	6/93 – 3/95	89.3
11	6/95 – 2/97	86.7
12	4/97 – 5/99	94.0
13	7/99 – 4/01	91.4
14	5/01 – 4/03	92.3
Average for 10 to 14	6/93 to 4/03	90.7 Average
15	5/03 - 9/04 (to date)	93.0

TABLE 2: INSPECTION HISTORY OF PILGRIM IGSCC CATEGORY "D" INCONEL 182 WELDS

PIPE / NOZZLE WELD ID	HWC PROTECTED	LAST INSPECTION	INSPECTION METHOD	INSPECTION FREQUENCY
14-A-1	NO	1999	AUTO	100% every 6 years
14-B-1	NO	1999	AUTO	100% every 6 years
2R-N1B -1	YES	1995	AUTO	100% every 10 years
2R-N2D -1	YES	1995	AUTO	100% every 10 years
2R-N2E -1	YES	1995	AUTO	100% every 10 years
2R-N2F -1	YES	1995	AUTO	100% every 10 years
2R-N2G -1	YES	1997	AUTO	100% every 10 years
2R-N2J -1	YES	1995	AUTO	100% every 10 years
14-A-3	NO	1999	AUTO	100% every 6 years
14-B-3	NO	1999	AUTO	100% every 6 years
14-A-10A	NO	1999	MANUAL	100% every 6 years
14-B-10A	NO	1999	MANUAL	100% every 6 years

Note: 2R-N1A-1 is a Category A weld

NRC QUESTION NO. 2

Request the following:

a. Identify the materials for the welds, nozzles, safe ends, pipe, reducers, and valves of the core spray and recirculation systems that are listed in the relief request, Section A, Component Identification.

b. Identify the corresponding P-Number and Group number of the base metal per Code Case N-638, subsection 2.1(a).

c. Provide the wall thickness and diameter of the pipes covered in the relief request.

d. Provide the thickness of nozzles, safe ends, reducers, and valves where the weld overlay will be made.

PILGRIM RESPONSE:

Table 3 below provides the above requested information.

TABLE 3: RPV NOZZLE SAFE END AND DISSIMILAR METAL PIPE WELDS MATERIAL DATA

NOZZLE/ WELD ID	WELD DESCRIPTION	SYSTEM	MATERIALS	WALL THICKNESS (in.)	DIAMETER (in.)	BASE METAL P-Number	BASE METAL GROUP Number	INSPECTION METHOD	BWRVIP-75 INSPECTION SCHEDULE REFERENCE	WATER CHEMISTRY	BWRVIP-75 INSPECTION FREQUENCY
N1B	NOZZLE TO SAFE END	RECIRC	A-508 CL.2 NOZZLE FORGING, INCONEL 182 BUTTER, SA 182 F316 (Nuclear Grade C .020%max) SAFE END FORGING	2.15	29.31	3 8	3 1	Auto UT per PDI/App. VIII Suppl. 10	PAGES 3-6,3-7 & 3-12, CATEGORY D, SECTION 3.4	HWC	ONCE EVERY 10 YEARS
N2D	SAFE END TO NOZZLE	RECIRC	A-508 CL.2 NOZZLE FORGING, INCONEL 182 BUTTER, SA 182 F316 (Nuclear Grade C .020%max) SAFE END FORGING	1.31	13.38	3 8	3 1	Auto UT per PDI/App. VIII Suppl. 10	BWRVIP-75 PAGES 3-6,3-7 & 3-12, CATEGORY D, SECTION 3.4	HWC	ONCE EVERY 10 YEARS
N2E	SAFE END TO NOZZLE	RECIRC	A-508 CL.2 NOZZLE FORGING, INCONEL 182 BUTTER, SA 182 F316 (Nuclear Grade C .020%max) SAFE END FORGING	1.31	13.38	3 8	3 1	Auto UT per PDI/App. VIII Suppl. 10	BWRVIP-75 PAGES 3-6,3-7 & 3-12, CATEGORY D, SECTION 3.4	HWC	ONCE EVERY 10 YEARS
N2F	SAFE END TO NOZZLE	RECIRC	A-508 CL.2 NOZZLE FORGING, INCONEL 182 BUTTER, SA 182 F316 (Nuclear Grade C .020%max) SAFE END FORGING	1.31	13.38	3 8	3 1	Auto UT per PDI/App. VIII Suppl. 10	BWRVIP-75 PAGES 3-6,3-7 & 3-12, CATEGORY D, SECTION 3.4	HWC	ONCE EVERY 10 YEARS
N2J	SAFE END TO NOZZLE	RECIRC	A-508 CL.2 NOZZLE FORGING, INCONEL 182 BUTTER, SA 182 F316 (Nuclear Grade C .020%max) SAFE END FORGING	1.315	13.38	3 8	3 1	Auto UT per PDI/App. VIII Suppl. 10	BWRVIP-75 PAGES 3-6,3-7 & 3-12, CATEGORY D, SECTION 3.4	HWC	ONCE EVERY 10 YEARS

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NOZZLE/ WELD ID	WELD DESCRIPTION	SYSTEM	MATERIALS	WALL THICKNESS (in.)	DIAMETER (in.)	BASE METAL P-Number	BASE METAL GROUP Number	INSPECTION METHOD	BWRVIP-75 INSPECTION SCHEDULE REFERENCE	WATER CHEMISTRY	BWRVIP-75 INSPECTION FREQUENCY
N2G	SAFE END TO NOZZLE	RECIRC	A-508 CL.2 NOZZLE FORGING, INCONEL 182 BUTTER, SA 182 F316 (Nuclear Grade C .020%max) SAFE END FORGING	1.31	13.38	3 8	3 1	Auto UT per PDI/App. VIII Suppl. 10	BWRVIP-75 PAGES 3-6,3-7 & 3-12, CATEGORY D, SECTION 3.4	HWC	ONCE EVERY 10 YEARS
N6A	SAFE END TO NOZZLE	CORE SPRAY	A-508 CL.2 NOZZLE FORGING, INCONEL 182 BUTTER, SA 182 Gr. F316 (C<.025%) SAFE END FORGING	1.13	12.88	3 8	3 1	Auto UT per PDI/App. VIII Suppl. 10	BWRVIP-75 PAGES 3-6,3-7 & 3-12, CATEGORY D, SECTION 3.4	NWC	ONCE EVERY 6 YEARS
N6B	SAFE END TO NOZZLE	CORE SPRAY	A-508 CL.2 NOZZLE FORGING, INCONEL 182 BUTTER, SA 182 Gr. F316 (C<.025%) SAFE END FORGING	1.13	12.88	3 8	3 1	Auto UT per PDI/App. VIII Suppl. 10	BWRVIP-75 PAGES 3-6,3-7 & 3-12, CATEGORY D, SECTION 3.4	NWC	ONCE EVERY 6 YEARS
14-A-3	PIPE TO REDUCER	CORE SPRAY	SA 333 Gr. 6 CS seamless PIPE*, Inconel 182 butter, SA 182 Gr. F316 S.S. REDUCER	0.55	10.78	1 8	1 1	Auto UT per PDI/App. VIII Suppl. 10	BWRVIP-75 PAGES 3-6,3-7 & 3-12, CATEGORY D, SECTION 3.4	NWC	ONCE EVERY 6 YEARS
14-B-3	PIPE TO REDUCER	CORE SPRAY	SA 333 Gr. 6 CS seamless PIPE*, Inconel 182 butter, SA 182 Gr. F316 S.S. REDUCER	0.55	10.78	1 8	1 1	Auto UT per PDI/App. VIII Suppl. 10	BWRVIP-75 PAGES 3-6,3-7 & 3-12, CATEGORY D, SECTION 3.4	NWC	ONCE EVERY 6 YEARS
14-A-10A	VALVE TO PIPE (1400-6A)	CORE SPRAY	CAST S.S. ASTM A351 GR CF8M VALVE BODY, INCONEL 182 BUTTER, SA 333 Gr. 6 CS seamless PIPE*	0.59 (valve ends taper to ~1.2" away from weld)	10.78	8 1	1 1	Manual UT per PDI/App. VIII Suppl. 10	BWRVIP-75 PAGES 3-6,3-7 & 3-12, CATEGORY D, SECTION 3.4	NWC	ONCE EVERY 6 YEARS

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NOZZLE/ WELD ID	WELD DESCRIPTION	SYSTEM	MATERIALS	WALL THICKNESS (In.)	DIAMETER (In.)	BASE METAL P-Number	BASE METAL GROUP Number	INSPECTION METHOD	BWRVIP-75 INSPECTION SCHEDULE REFERENCE	WATER CHEMISTRY	BWRVIP-75 INSPECTION FREQUENCY
14-B-10A	VALVE TO PIPE (1400-6B)	CORE SPRAY	CAST S.S. ASTM A351 GR CF8M VALVE BODY, INCONEL 182 BUTTER, SA 333 Gr. 6 CS seamless PIPE*	0.59 (valve ends taper to ~1.2" away from weld)	10.78	8 1	1 1	Manual UT per PDI/App. VIII Suppl. 10	BWRVIP-75 PAGES 3-6,3-7 & 3-12, CATEGORY D, SECTION 3.4	NWC	ONCE EVERY 6 YEARS
			* with requirements of SA652 paragraphs RL, RM, RW, RX and RZ.								

NRC QUESTION NO. 3

The licensee specified in the table in Section B, Examination and Repair Requirements, Subsection labeled Examination Requirements that either ultrasonic testing or mechanical height measurement will be used to measure the thickness of the weld overlay.

a. Discuss the subsection in Code Case N-504-2 that specifies these requirements.

b. Discuss which method most likely be used and the reasons for preferring one method over the other method in terms of reliability, sensitivity, and accuracy.

PILGRIM RESPONSE

Code Case N-504-2, paragraphs (c) and (g) provide examination requirements to verify the integrity of the overlay. A PT surface examination will be performed on the area to be welded in accordance with ASME Code Section III, NB, 1992. If localized seal welding is required, this examination will be performed after the localized seal welding is completed. A final PT examination in accordance with ASME Code Section III, NB, 1992 and ASME Code Section XI, 1989 will be performed after completing all weld overlays.

Code Case N-504-2 does not specify the method for measuring overlay thickness. A UT thickness examination will be performed to demonstrate that the weld overlay meets the thickness requirements of the repair plan. UT is the preferred method for determining the thickness of the weld overlay. The Table in PRR-39 includes mechanical measurements as an alternative to UT where suitable reference surfaces are available. If for any reason the UT method is not used to provide thickness data, mechanical measurements will be used where a suitable reference surface is available. Both methods provide reliable and accurate thickness measurement results, but UT method is more sensitive to the surface roughness and requires a smooth surface for the UT probe. The final examination, in addition to a VT-2, will be a PDI/UT volumetric examination using procedure PDI-UT-8 in accordance with PRR-38.

A UT of the weld overlay volume will be performed to demonstrate that the repair volume is unflawed and meets thickness requirements of the design following application of the repair. Since the weld repair material is highly resistant to on going crack propagation and provides compressive residual stress, this examination assures continued integrity and adequacy of the weld overlay.

NRC QUESTION NO. 4

In Sections C and D, the licensee stated that the system leak test is adequate to ensure the pressure boundary integrity; however, supporting basis was not provided. Code Case N-504-2, paragraph (h) specifies, in part, that if a flaw penetrates the original pressure boundary prior to or during the welding operation, a system hydrostatic test shall be performed. If the system pressure boundary has not been penetrated, a system leakage, in-service, or functional test shall be performed. Code Case N-416-2 allows a system leakage test in lieu of a hydrostatic pressure test in weld repairs if a nondestructive examination is performed in accordance with the 1992 Edition of ASME Section III, which specifies that radiographic examination be performed. The staff has the following questions:

a. Clarify whether a radiographic examination will be performed on the weld repair per the 1992 Edition of ASME Section III, if a flaw penetrates the pressure boundary prior to or during the welding process. If a radiographic examination will not be performed, discuss the basis and justify the performance of a ultrasonic examination in lieu of a radiographic examination of the weld overlay repair.

b. Discuss technical basis why the system leak test is adequate as compared to a hydrostatic test in demonstrating the structural and leakage integrity of the weld overlay repair.

c. In Section C, fifth paragraph, last sentence, the licensee stated that a system leak test of completed repairs may be used in lieu of hydrostatic test. Discuss whether a system leak test will be performed after each completed repair.

PILGRIM RESPONSE

Response to item a:

The overlay welding would be examined to Supplement 11 as modified by Relief Request PRR-38 for specific Performance Demonstration Initiative (PDI) procedural details. The qualified procedures are in accordance with the ultrasonic acceptance standards included in Section III NB-5330. The ultrasonic procedures and personnel used for this examination, result in a weld material assessment for an overlay that cannot be achieved by radiography. This is based on the special nature of the weld overlay, which is similar to that recognized in ASME Code Section III NB-5270 "Special Welds" and the allowance as described in NB-5279 that there are special exceptions requiring ultrasonic rather than radiographic examinations. Pressure vessel and safe-end welded piping are filled with reactor water, which precludes use of radiography for weld material assessment. Removal of fuel and draining the vessel to accommodate radiography presents additional nuclear safety and personal hazards. Radiography is not qualified under PDI for weld overlay inspections. Thus UT PDI examination is the preferred method for weld method assessment. The qualification process for the Supplement 11 ultrasonic examination, the ability to size flaws for length and depth, and the fact that the qualification includes flaws that may be created during fabrication, meets the ultrasonic procedural requirements of the cited ASME III paragraphs.

The final weld examination would be a complete ultrasonic volumetric examination (UT) using EPRI Performance Demonstration Initiative (PDI) procedure PDI-UT-8 in accordance with Relief Request PRR-38. The weld overlay would meet the requirements of the ASME Code Section XI repair plan and PDI-UT-8. There would be no deviations from ASME Code Section III 1992 methods as discussed above and acceptance criteria or PDI/UT procedures.

ASME Section XI allows a repair to be performed by either removing a flaw or reducing it to an acceptable size, as documented for instance in Code Case N-504-2. The weld overlay approach does the latter. The allowable flaw size is defined in Table IWB-3641-1 (since Normal/Upset loads govern). The initial flaw is conservatively assumed to be entirely through wall and to extend entirely around the circumference of the repair location (through wall x 360 degrees around). The weld overlay approach applies additional thickness to the flawed location, such that the resulting as-repaired component meets the requirements of IWB-3640. This approach has been extensively used since the mid-1980's in repair of BWR piping. The weld overlay also imparts a compressive residual stress, which has been shown to reduce crack growth.

The weld overlay repairs will be completed as an ASME Code Section XI repair using Code Case N-504-2 as the construction code for the repair design, fabrication, and examination methods applicable to a structural overlay type of repair. This type of repair is not included in ASME Code Section III.

The nondestructive examination (NDE) of weld overlays is not addressed in ASME Code Section III since it is a construction code used for the initial installation of welded joints. Welding performed under an ASME Code Section XI repair plan is typically examined in accordance with the code of construction, when applicable, and any Section XI baseline (preservice) inservice inspection (ISI) examinations.

For weld overlay repairs, the construction code is Code Case N-504-2 and the required examinations are by the liquid penetrant and ultrasonic methods. This Code Case is prescriptive about all aspects of the weld overlay repair including the overlay design, its fabrication, and the examinations performed before, during, and after the welding.

The type of weld examinations to be performed on the structural overlay weld would be based on ASME Code Case N-504-2 as the construction code for the overlay weld repair, rather than ASME

Code Section III butt weld joint fabrication, such that the required volumetric examination of weld overlay would be by the ultrasonic rather than radiographic method. An initial liquid penetrant (PT) surface examination would be performed on the area to be welded in accordance with N-504-2. This examination will be performed if required after the localized seal welding is completed. A final PT examination in accordance with N-504-2 and ASME Code Section III 1992 would be performed after completing all weld overlay layers. An ultrasonic thickness examination will also be performed to demonstrate that the weld overlay met the thickness requirements of the repair plan.

In conclusion, the applicable weld fabrication and examination requirements of Code Cases N-504-2 and N-416-2, ASME Code Section III, and ASME Code Section XI (with PRR-38) will be met.

<u>Response to Items b and c</u>:

The Code Case N-504-2 includes the following pressure test requirements:

> "The completed repair shall be pressure tested in accordance with IWA-5000. If the flaw penetrated the original pressure boundary prior to welding, or if any evidence of the flaw penetrating the pressure boundary is observed during the welding operation, a system hydrostatic test shall be performed in accordance with IWA-5000. If the system pressure boundary has not been penetrated, a system leakage, inservice, or functional test shall be performed in accordance with IWA-5000."

The above pressure testing requirements are consistent with ASME Code Section XI Subarticle IWA-4700 "Pressure Test" rules that are applicable to all pressure boundary weld repairs performed under Section XI as follows:

> "After repairs by welding on the pressure retaining boundary, a system hydrostatic test shall be performed in accordance with IWA-5000."

Code Case N-416-2 is routinely used to allow a system leakage test to be performed in lieu of a system hydrostatic pressure test in most all cases of weld repairs to existing piping, pump, and valve components at PNPS and other plants, including repairs that entirely replace components or penetrate the pressure boundary. Code Case N-416-2 is approved in Table 2 of Regulatory Guide 1.147, Rev. 13, which requires that:

> " (a) NDE shall be performed on welded repairs and fabrication and installation joints in accordance with the methods and acceptance criteria of the applicable Subsection of the 1992 Edition of Section III."

Section III applies to the original welds and is not applicable to weld overlays as discussed earlier. Accordingly, PNPS continued to apply paragraph (b) of Code Case N-416-2, which directs system leakage test using the 1992 Edition of Section XI in accordance with IWA-5000 at nominal operating pressure and temperature, in lieu of hydrostatic testing requirement.

With respect to hydrostatic pressure testing, an additional consideration is that ASME Code Case N-498-4 (approved in Table 2, RG 1.147, Rev. 13) is used at PNPS and other plants to allow a system leakage test to be performed in lieu of a system hydrostatic pressure test performed at the 10-year interval as required by ASME Code Section XI. Furthermore, the difference in the required test pressure between the system leakage test and a system hydrostatic pressure test in accordance with Section XI Article IWB-5000 is no greater than 10%. Therefore, there is essentially little difference in the actual test conditions that are experienced between the system leakage test and a system hydrostatic pressure test per Section XI, which is part of the basis for the exemption allowed by the Code Cases.

A system leak test will not be performed after each completed repair. After all repairs are completed, the system leakage test performed in accordance with the NRC approved Code Cases N-416-2 and N-498-4, surface examinations per ASME III and ASME XI, and UT examination performed using PDI process in accordance with ASME Code Section XI, Appendix

VIII, Supplement 11 and PRR-38, provide assurance that the weld overlay design, fabrication, and examinations met Code Cases N-504-2 and N-416-2, ASME Code Section III, and ASME Code Section XI.

NRC QUESTION NO. 5

The licensee stated that re-inspection of the welds will be conducted in accordance with the guidance in the industry topical report, BWRVIP-75.

a. Discuss the exact inspection schedule for the welds in the proposed relief request. Identify the page, category, and section in BWRVIP-75 that discusses the inspection schedule that the licensee will follow.

b. Discuss the inspection method that will be used in the re-inspection of the welds.

PILGRIM RESPONSE

Pilgrim intends to inspect any overlaid DM welds in accordance with the requirements for Category E overlaid welds as described in BWRVIP-75 Table 3-1 and section 3.5.1.1, which states in part "For weld overlays applied in the future, a preservice examination followed by an inservice examination within three outages is required".

After this initial inservice examination within 3 outages of the repair, the inspection schedule would then revert to the sample frequency shown in Table 3-1, i.e. either 25% or 10% every 10 years depending on water chemistry classification.

The re-inspection of the welds will be conducted using VT-2 and PDI/UT methods in the re-inspection of the welds.

NRC QUESTION NO. 6

In Section F, the licensee stated, "The proposed alternative applies to the repairs of RPV nozzle safe-end and piping welds for the scheduled outage and for the remaining service life of this weld." The staff has reservation about approving a relief request on a long-term basis. In general, the staff approves relief requests for one inspection interval with certain fixed starting and end calendar dates. In Section D, fourth paragraph, the licensee alludes to the third interval in-service inspection program; however, the staff is not clear to which inspection interval the proposed relief request will be applied. The licensee is requested to:

a. Identify to which inspection interval(s) this relief request will be applicable.

b. Identify the current inspection interval.

c. Provide the end date of the operating license of the plant and the starting and the starting and end dates of the relevant inspection intervals (i.e., 3rd and the 4th intervals).

PILGRIM RESPONSE:

Pilgrim is in the 3rd in-service inspection interval, which began on July 1, 1995, and will end on June 30, 2005.

The 4th in-service inspection interval would begin on July 1, 2005 and would end on June 30, 2015.

Pilgrim Operating License expires on June 8, 2012.

PRR-39 is applicable to the 3rd in-service inspection interval and Entergy intends to apply it to the remaining service life of this weld, i.e., 4th interval as discussed below.

The upcoming RFO-15 is the last remaining refueling outage in this 3rd interval. The 4th interval is short by 3 years since the license expires on June 8, 2012. The service life available for these welds is 8 years, less than the normal ISI interval duration of 10 years. Thus, it is the intent of Entergy to apply the relief request for the remaining duration of 3rd and 4th intervals until the expiration of Operating License on June 8, 2012. Upon approval of PRR-39, Entergy intends to incorporate it into the 4th ISI interval program to conserve Pilgrim and NRC staff resources.

ATTACHMENT 2

PILGRIM RELIEF REQUEST (PRR) NO. – 39, Rev. 1

Alternative Repair Plan for

Reactor Pressure Vessel Nozzle Safe-End and Dissimilar Metal (DM) Piping Welds

A. COMPONENT IDENTIFICATION

A full structural weld overlay repair is proposed for the weldment associated with the following austenitic reactor pressure vessel nozzle safe-end and dissimilar metal (DM) piping welds. This is a contingency repair plan to be used if needed during the upcoming refueling outage-15.

WELD ID	DESCRIPTION	SYSTEM	DRAWING
14-A-1	SAFE END TO NOZZLE	CS	ISI-I-14-1
14-B-1	SAFE END TO NOZZLE	CS	ISI-I-14-1
2R-N1B-1	SAFE END TO NOZZLE	RECIRC	ISI-I-2R-A
2R-N2D-1	SAFE END TO NOZZLE	RECIRC	ISI-I-2R-A
2R-N2E-1	SAFE END TO NOZZLE	RECIRC	ISI-I-2R-A
2R-N2F-1	SAFE END TO NOZZLE	RECIRC	ISI-I-2R-B
2R-N2G-1	SAFE END TO NOZZLE	RECIRC	ISI-I-2R-B
2R-N2J-1	SAFE END TO NOZZLE	RECIRC	ISI-I-2R-B
14-A-3	PIPE TO REDUCER	CS	ISI-I-14-1
14-B-3	PIPE TO REDUCER	CS	ISI-I-14-1
14-A-10A	VALVE TO PIPE	CS	ISI-I-14-1
14-B-10A	VALVE TO PIPE	CS	ISI-I-14-1

These welds fall within the scope of GL 88-01 and BWRVIP-75.

The weld overlay material for the proposed repair is as follows:

- For machine gas tungsten arc welding (GTAW), the weld material is ASME Section II, Part C, SFA 5-14 Filler Wire ER NiCrFe-7 UNS NO6052 F-No. 43 known commercially as Alloy 52.
- For manual shielded metal arc weld (SMAW) welding, the weld material is ASME Section II, Part C, SFA 5-11 Weld Electrode E NiCrFe-7 UNS W86152 known commercially as Alloy 152.

B. EXAMINATION AND REPAIR REQUIREMENTS

Weld overlay will be designed consistent with the requirements of NUREG-0313, (which was implemented by Generic Letter 88-01), ASME Code Cases N-504-2, N-638, and ASME, Section XI, Paragraph IWB-3640.

Welder Qualification and Welding Procedures

All welders and welding procedures will be qualified in accordance with ASME Section XI and any special requirements from Section XI or applicable code cases.

If necessary, a manual SMAW procedure will be qualified to facilitate localized repairs and to provide a seal weld, prior to the overlay. This procedure uses UNS W86152 SMAW electrodes consistent with ASME Section XI requirements. Personnel qualified in accordance with the Welding Procedure Specification for welding Alloy 52/152 will perform the repair activities.

Welding Wire Material

A consumable welding wire highly resistant to intergranular stress corrosion cracking (IGSCC) will be used for the overlay material. This material, designated UNS N06052, is a nickel-based weld filler material (commonly referred to as Alloy 52), and will be applied using the GTAW process. Alloy 52 is identified as F-No. 43 Grouping for Ni-Cr-Fe, classification UNS N06052 Filler Metal. Alloy 52 contains about 30% chromium, which imparts excellent corrosion resistance to this material. Alloy 152 welding wire will be used for manual (SMAW) seal welding activities.

Weld Overlay Design

The weld overlay will extend around the full circumference of the weldment location in accordance with NUREG-0313, Code Case N-504-2, Generic Letter 88-01, and BWRVIP-75. The overlay will be performed using a standard overlay design as described in NUREG-0313, Section 4.4.1. This design assumes a crack completely through the wall for 360°. The calculation methods for design of the overlay will be in accordance with NUREG-0313, Section 4.1.

The specific thickness and length will be computed using the guidance provided in ASME Section XI, Code Case N-504-2, and ASME Section XI, Paragraph IWB-3640, 1989 Edition. The overlay will completely cover any flaw location and the existing Inconel 182 weld deposit butter with the highly corrosion resistant Alloy 52 material. In order to accomplish this objective, it is necessary to weld on the low alloy steel (LAS) material. A temper bead welding approach will be used for this purpose according to the provisions of ASME Code Case N-638. This code case provides for machine GTAW temper bead weld repairs to P No. 3 nozzle materials (SA 508 Cl. 2) at ambient temperature. The temper bead approach was selected because temper bead welding supplants the requirement for post weld heat treatment (PWHT) of heat-affected zones in welded LAS material.

The Code case N-638, General Requirements, 1(a) limits the maximum finished surface area of the weld overlay repair to 100 sq. in. The overlay repair (design and fabrication) on large diameter (13 and 29-inch OD) recirculation nozzle safe-end welds would exceed the 100 sq in. limit. EPRI Technical Report 1003616, "Additional Evaluations to Extend Repair Limits for Pressure Vessels and Nozzles", dated March 2004, justifies extending the size of the temper bead repairs up to 500 sq. in finished area. Susquehanna Station has used the EPRI Report as justification for recent nozzle weld overlay repairs.

Examination Requirements

The repair, pre-service inspection (PSI), and in-service inspection (ISI) examinations of the weld overlay repair will be performed in accordance with the ISI Program and Plan along with NUREG-0313, Generic Letter 88-01, and approved plant procedures as specified by the ISI Repair/Replacement Program.

The weld overlay will be examined using the industry developed PDI procedure, as approved in PRR-38 (Relief from ASME Code Section XI, Appendix VIII, Supplement 11, Qualification Requirements for Full Structural Overlaid Wrought Austenitic Piping Welds, TAC No. MC0961, dated February 26, 2004).

System leakage testing will be performed as allowed by Code Case N-416-2 with the additional condition that hold times specified in IWA-5213 (d) be observed, in lieu of the system hydrostatic test required by Code Case N-504-2. This complies with Regulatory Guide 1.147, Revision 13, relative to the NRC's conditional acceptance of Code Case N-416-2. The VT-2 inspections will be performed with the insulation removed from the locations where the proposed weld overlays are performed. This will allow a 10 minute hold before the VT-2 is performed.

The examinations and acceptance criteria, as identified below, will be in accordance with ASME Code, Section III, 1992 Edition, Subsection NB for Class 1 Components, ASME Code Section XI, 1989 Edition, and Code Cases N-504-2 and N-638.

A description of the required examinations for the weld overlay is provided in the following table.

Examination Description	Method	Technique	Reference
Weld Overlay Surface Area Preparation Exam	PT	Visible Dye	N-504-2
First Two Weld Overlay Layers Surface Exam	PT	Visible Dye	N-504-2
First Two Weld Overlay Layers Thickness Measurements	UT or Mechanical	0° Long. UT or Mechanical Height Measurement	N-504-2
Completed Overlay Thickness Measurements	UT or Mechanical	0° Long. UT or Mechanical Height Measurement	N-504-2
Surface Exam of Final Overlay Surface and Adjacent Band within 1.5t (7/8" Band) of Weld Overlay. This also serves as Preservice Surface Examination of completed overlay.	PT	Visible Dye	NB-5350 IWB-3514 N-638 N-504-2
Volumetric Exam of Final Overlay and Adjacent Band within 1.5t (7/8" Band) of Weld Overlay. This also serves as Preservice Volumetric Examination of completed overlay.	UT	PDI procedure	ASME 1995, Section XI Appendix VIII; ASME 1989 Section XI
Preservice Baseline Exam of Final Overlay Outer 25% of the Underlying Pipe Wall to Identify the Original Flaws.	UT	PDI Procedure	N-504-2

The acceptance criteria for the volumetric examinations shall be ASME Code Section XI, Paragraph IWB-3514, "Standards for Examination Category B-F, Pressure Retaining Dissimilar Metal Welds, and Examination Category B-J, Pressure Retaining Welds in Piping".

It is noted that the curvatures of reactor nozzles require an exception to the ultrasonic inspection requirement for a 1.5t adjacent band volumetric examination at the end of the overlay on the nozzle end. The PT examination of this surface will constitute the acceptance testing for the overlay deposit.

Thickness will be characterized at four (4) azimuths representing each of the four (4) pipe quadrants. Thickness measurements will be determined using UT techniques or by mechanical measurement. Liquid penetrant examinations will be performed at the same stages of the overlay application as the thickness measurements identified above.

The alternative, as described below, provides an acceptable level of quality and safety while neither draining the reactor vessel nor applying preheat and post weld heat treatments.

C. <u>ALTERNATIVE TO REPAIR REQUIREMENTS</u>

The repair will utilize ASME Code Case N-504-2, "Alternative Rules for Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping," and Code Case N-638, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique," with the following exceptions and clarifications.

<u>Clarification of Code Case N-504-2 for Applicability to Nickel-Based Austenitic Alloy</u>

Code Case N-504-2 was prepared specifically for austenitic stainless steel material. An alternate application to use nickel-based austenitic materials (i.e., Alloy 52) is requested due to the specific configuration of the nickel-based austenitic weldment.

<u>Exception from Code Case N-504-2 Paragraph (b)</u>

Code Case N-504-2 paragraph (b) requires that the reinforcement weld metal shall be low carbon (0.035 % maximum) austenitic stainless steel. In this application, a nickel-based filler is required and Alloy 52 has been selected in place of low carbon austenitic stainless steel.

<u>Exception from Code Case N-504-2 Paragraph (e)</u>

Code Case N-504-2 paragraph (e) requires as-deposited delta ferrite measurements of at least 7.5% for the weld reinforcement. These measurements have no meaning for nickel-based materials and will not be performed for this overlay.

<u>Exception from Code Case N-504-2 Paragraph (h)</u>

Code Case N-504-2 paragraph (h) requires a system hydrostatic test of completed repairs if the repaired flaw penetrated the original pressure boundary or if there is any observed indication of the flaw penetrating the pressure boundary during repairs. A system leak test of completed repairs will be used in lieu of a hydrostatic test.

Use of Code Case N-638 Applicability

Code Case N-638 shall be applied to the nozzle material.

Exception from Code Case N-638 Paragraph 1 (a)

The Code case N-638, General Requirements, 1(a) limits the maximum finished surface area of the weld overlay repair to 100 sq. in. Relief is requested to extend the size of the repairs up to 500 sq. in finished area to accommodate overlay repair on large diameter (13 and 29 -inch OD) recirculation nozzle safe-end welds.

D. BASIS FOR THE ALTERNATIVE

Clarification of Code Case N-504-2 for Applicability to Nickel-Based Austenitic Steel

The weldment being addressed is austenitic material having a mechanical behavior similar to austenitic stainless steel. The weldment is designed to be highly resistant to IGSCC and is compatible with the existing weldment and base metal materials. Accordingly, this alternative provides an acceptable level of quality and safety. Therefore, Code Case N-504-2 should be interpreted to apply equally to both materials.

Exception from Code Case N-504-2 Paragraph (b)

A consumable welding wire highly resistant to IGSCC was selected for the overlay material. This material, designated UNS N06052, is a nickel-based alloy weld filler material, commonly referred to as Alloy 52, and will be applied using the GTAW process. Alloy 52 contains about 30% chromium, which imparts excellent stress corrosion cracking resistance to this material. By comparison, Alloy 82 is identified as an IGSCC resistant material in NUREG 0313 and contains about 18 to 22% chromium while Alloy 182 has a nominal chromium composition of 13 to 17%. Alloy 52 with its high chromium content provides a high level of resistance to IGSCC consistent with the requirements of the code case. Therefore, this alternative provides an acceptable level of quality and safety.

Exception from Code Case N-504-2 Paragraph (e)

The composition of nickel-based Alloy 52 is such that delta ferrite is not formed during welding. Ferrite measurement requirements were developed for welding of 300 series stainless steels that required delta ferrite to develop corrosion resistance. Weld using Alloy 52 is 100% austenitic and contains no delta ferrite due to the high nickel composition (approximately 60% Ni and low iron content). Alloy 52 with its high chromium content provides a high level of resistance to hot cracking and IGSCC consistent with the purpose for the delta ferrite requirements for stainless steels of the code case. Therefore, this alternative provides an acceptable level of quality and safety.

Exception from Code Case N-504-2 Paragraph (h)

In lieu of the hydrostatic pressure test requirements defined in Code Case N-504-2, the required pressure test shall be performed in accordance with the Third Interval ISI

Program and Plan and Code Case N-416-2 with the exception that the volumetric examination performed shall be an ultrasonic examination of the weld overlay. These alternative requirements are sufficient to demonstrate that the overlay is of adequate quality to ensure the pressure boundary integrity. Accordingly, this alternative provides an acceptable level of quality and safety.

Use of Code Case N-638 Applicability

Code Case N-638 was developed for temper bead applications for similar and dissimilar metals. It permits the use of machine GTAW process at ambient temperature without the use of preheat or PWHT on Class 1, 2, and 3 components.

Temper bead welding methodology is not new. Numerous applications over the past decade have demonstrated the acceptability of temper bead technology in nuclear environments. Temper bead welding achieves heat affected zone (HAZ) tempering and grain refinement without subsequent PWHT. Excellent HAZ toughness and ductility are produced. Use of Code Case N-638 has been accepted in Regulatory Guide 1.147 Revision 13 as providing an acceptable level of quality and safety.

The overlay repair on large diameter (13 and 29-inch OD) recirculation nozzle safe-end welds would exceed the 100 sq. in. limit specified in Code Case N-638, paragraph 1(a). EPRI Technical Report 1003616, "Additional Evaluations to Extend Repair Limits for Pressure Vessels and Nozzles", dated March 2004, justifies extending the size of the temper bead repairs up to 500 sq. in. finished area. The ASME Code Committees have recognized that the 100 sq. in. restriction on the overlay surface area is excessive and a draft code case, RRM-04, is currently being progressed within ASME Section XI to increase the area limit to 500 sq. in. Furthermore, Three Mile Island and V. C. Summer have completed weld overlay repairs involving approximately 200 and 300 sq. inches respectively. Susquehanna Station in its Relief Request No. 31 has used the EPRI Report, ASME proposed draft code case, V. C. Summer and Three Mile Island expanded repairs as justifications for recent expanded nozzle weld overlay repairs. As discussed in the EPRI Report, increasing the allowed areas for ambient temper bead repairs did not detrimentally change the residual stresses, thereby providing an acceptable level of quality and safety.

E. CONCLUSION

Weld overlays involve the application of weld metal circumferentially over and in the vicinity of the flawed weld to restore ASME Section XI margins as required by ASME Code Case N-504-2. Weld overlays have been used in the nuclear industry as an acceptable method to repair flawed weld. The use of overlay filler material that provides excellent resistance to IGSCC provides an effective barrier to crack extension.

The design of the overlay uses methods that are standard in the industry for size determination of pipe-to-pipe overlays. There are no new or different approaches used in these overlay designs that would be considered first of a kind or inconsistent with previous approaches. The overlay is designed as a full structural overlay in accordance with the recommendation of NUREG-0313, which was forwarded by Generic Letter 88-01, and Code Case N-504-2 and ASME Section XI Paragraph IWB-3640.

Temper bead techniques, as defined by Code Case N-638, will produce a tough corrosion resistant overlay deposit that meets or exceeds all code requirements for the weld overlay.

Pilgrim concludes that the contingency repair plan presents an acceptable level of quality and safety to satisfy the requirements of 10CFR50.55a(a)(3)(i). Similar proposed alternatives to the requirements of 10CFR50.55a(c)(3) have been previously approved by the NRC for James A Fitzpatrick (TAC No. MB0252, dated October 26, 2000), Duane Arnold Energy Center (NRC Staff's letter dated November 19, 1999), Nine Mile Point Unit 2 plant (NRC Staff's letter dated March 30, 2000) and for Pilgrim to repair the RPV N10 nozzle to safe-end weld (PRR-36 and 38).

F. DURATION OF THE PROPOSED ALTERNATIVE

The proposed alternative applies to the repairs of RPV nozzle safe-end and piping welds for the scheduled outage and for the remaining service life of this weld. Re-inspection will be per BWRVIP-75 Guidelines.

April 12, 2005

Mr. Michael R. Kansler, President
Entergy Nuclear Operations, Inc.
440 Hamilton Avenue
White Plains, NY 10601

SUBJECT: PILGRIM NUCLEAR POWER STATION - PILGRIM RELIEF REQUEST PRR-39 ALTERNATIVE CONTINGENCY REPAIR PLAN FOR REACTOR PRESSURE VESSEL NOZZLE SAFE-END AND DISSIMILAR METAL PIPING WELDS USING ASME CODE CASES N-638 AND N-504-2 WITH EXCEPTIONS (TAC NO. MC2496)

Dear Mr. Kansler:

By letter dated March 15, 2004, as supplemented by letters dated October 12, 2004, and March 16, 2005, Entergy Nuclear Operations, Inc. (Entergy) requested relief from certain requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, pertaining to flaw removal, heat treatment, and nondestructive examination at the Pilgrim Nuclear Power Station (PNPS). Specifically, Entergy requested that the Nuclear Regulatory Commission (NRC) review and approve Pilgrim Relief Request (PRR) No. 39, "Alternative Contingency Repair Plan for Reactor Pressure Vessel Nozzle Safe-end and Dissimilar Metal Piping Welds."

The proposed PRR uses the weld overlay method based on the methodology of the ASME Code, Section XI, Code Case N-504-2, "Alternative Rules for Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping," and Code Case N-638, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW [gas tungsten arc weld] Temper Bead Technique." PRR-39 is related to the repair of reactor pressure vessel nozzle safe-end welds and dissimilar metal piping welds in the core spray and recirculation systems.

The NRC staff has reviewed the proposed alternatives. The results of this review are provided in the enclosed safety evaluation. The NRC staff has concluded that the proposed alternatives to ASME Code requirements provided in PRR-39 provide reasonable assurance of structural integrity, and an acceptable level of quality and safety. Therefore, pursuant to Title 10 of the *Code of Federal Regulations*, Section 50.55a(a)(3)(i), the NRC staff authorizes the use of ASME Code Case N-504-2, as modified, and the use of ASME Code Case N-638, to perform weld overlay repairs at PNPS for the third 10-year inservice inspection interval.

All other ASME Code, Section XI requirements for which relief was not specifically requested and approved in this relief request remain applicable, including third-party review by the Authorized Nuclear Inservice Inspector.

M. Kansler -2-

If you have any questions regarding this approval, please contact the PNPS Project Manager, John Boska, at 301-415-2901.

Sincerely,

/RA by Victor Nerses for/

Darrell J. Roberts, Chief, Section 2
Project Directorate I
Division of Licensing Project Management
Office of Reactor Regulation

Docket No. 50-293

Enclosure: As stated

cc w/encl: See next page

M. Kansler -2-

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELIEF REQUEST FOR REPAIR OF SAFE-END AND DISSIMILAR WELDS

OF REACTOR VESSEL NOZZLES

ENTERGY NUCLEAR OPERATIONS, INC

PILGRIM NUCLEAR POWER STATION

DOCKET NO. 50-293

1.0 INTRODUCTION

By letter dated March 15, 2004, as supplemented by letters dated October 12, 2004, and March 16, 2005, Entergy Nuclear Operations, Inc. (Entergy) requested relief from certain requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, pertaining to flaw removal, heat treatment, and nondestructive examination (NDE) at the Pilgrim Nuclear Power Station (PNPS). Specifically, Entergy requested that the Nuclear Regulatory Commission (NRC or the Commission) review and approve Pilgrim Relief Request (PRR) No. 39, "Alternative Contingency Repair Plan for Reactor Pressure Vessel Nozzle Safe-End and Dissimilar Metal Piping Welds."

The proposed PRR uses the weld overlay method based on the methodology of the ASME Code, Section XI, Code Case N-504-2, "Alternative Rules for Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping," and Code Case N-638, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW [gas tungsten arc weld] Temper Bead Technique." PRR-39 is related to the repair of reactor pressure vessel nozzle safe-end welds and dissimilar metal piping welds in the core spray and recirculation systems.

2.0 REGULATORY EVALUATION

The inservice inspection (ISI) of the ASME Code Class 1, 2, and 3 components is to be performed in accordance with Section XI of the ASME Code and applicable edition and addenda as required by Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.55a(g), except where specific written relief has been granted by the Commission pursuant to 10 CFR 50.55a(g)(6)(i). Section 50.55a(a)(3) of 10 CFR states, in part, that alternatives to the requirements of paragraph (g) may be used, when authorized by the NRC, if Entergy demonstrates that: (i) the proposed alternatives would provide an acceptable level of quality and safety, or (ii) compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Enclosure

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Pursuant to 10 CFR 50.55a(g)(4), ASME Code Class 1, 2, and 3 components (including supports) will meet the requirements, except the design and access provisions and the preservice examination requirements, set forth in ASME Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," to the extent practical within the limitations of design, geometry, and materials of construction of the components. The regulations require that inservice examinations of components and system pressure tests conducted during the first 10-year ISI interval, and subsequent intervals, comply with the requirements in the latest edition and addenda of Section XI of the ASME Code, incorporated by reference in 10 CFR 50.55a(b), 12 months prior to the start of the 120-month interval, subject to the limitations and modifications listed therein. The ISI code of record for PNPS's third 10-year ISI interval, which began on July 1, 1995, and ends on June 30, 2005, is the 1989 Edition of the ASME Code, Section XI.

3.0 LICENSEE'S PROPOSED ALTERNATIVE

3.1 Components for Which Relief is Requested

Entergy proposed a full structural weld overlay repair for the austenitic reactor vessel nozzle safe-end and dissimilar metal piping welds in the core spray and recirculation systems as shown in the table below. This request is applicable for the welds which fall within the scope of Generic Letter (GL) 88-01, "NRC Position on IGSCC [intergranular stress-corrosion cracking] in BWR [boiling-water reactor] Austenitic Stainless Steel Piping," and BWRVIP-75, "BWR Vessel and Internals Project Technical Basis for Revisions to GL 88-01 Inspection Schedules."

WELD IDENTIFICATION	DESCRIPTION	SYSTEM
14-A-1	Safe-End to Nozzle	Core Spray
14-B-1	Safe-End to Nozzle	Core Spray
2R-N1B-1	Safe-End to Nozzle	Recirculation
2R-N2D-1	Safe-End to Nozzle	Recirculation
2R-N2E-1	Safe-End to Nozzle	Recirculation
2R-N2F-1	Safe-End to Nozzle	Recirculation
2R-N2G-1	Safe-End to Nozzle	Recirculation
2R-N2J-1	Safe-End to Nozzle	Recirculation
14-A-3	Pipe to Reducer	Core Spray
14-B-3	Pipe to Reducer	Core Spray
14-A-10A	Valve to Pipe	Core Spray
14-B-10A	Valve to Pipe	Core Spray

3.2 Code Requirements for which Relief is Requested

Entergy will design the weld overlay consistent with the requirements of NUREG-0313 which was implemented by GL 88-01; ASME Code Section XI, Code Cases N–504-2 and N–638; and ASME Code Section XI, Paragraph IWB-3640. Entergy will follow the examination and acceptance criteria in accordance with ASME Code Section III, 1992 Edition, subsection NB for class 1 components; ASME Code Section XI, 1989 Edition; and ASME Code Cases N–504-2 and N–638.

3.3 Welder Qualification and Welding Procedures

Entergy stated that all welders and welding procedures will be qualified in accordance with ASME Code Section XI, and any special requirements from Section XI or applicable code cases. If necessary, a manual shielded metal arc weld procedure will be qualified to facilitate localized repairs and to provide a seal weld, prior to depositing the overlay. This procedure uses UNS W86152 shielded metal arc weld electrodes consistent with the requirements of ASME Code Section XI. Personnel qualified in accordance with the welding procedure specification for welding Alloy 52/152 will perform the repair activities.

3.4 Welding Wire Material

Entergy stated that for machine GTAW, the weld material is ASME Code Section II, Part C, SFA 5-14 Filler Wire ER Nickel-Chromium-Iron-7 UNS N06052 F-No. 43, known commercially as Alloy 52. This weld material is resistant to IGSCC. Alloy 52 contains about 30% chromium and is corrosion resistant.

For manual shielded metal arc weld welding, the weld material is ASME Code Section II, Part C, SFA 5-11 Weld Electrode E Nickel-Chromium-Iron-7 UNS W86152, known commercially as Alloy 152.

3.5 Weld Overlay Design

Entergy stated that the weld overlay will extend around the full circumference of the weldment location in accordance with NUREG-0313, ASME Code Case N–504-2, GL 88-01, and BWRVIP-75. The overlay will be performed using a standard overlay design as described in NUREG-0313, Section 4.4.1. This design assumes a crack completely through the pipe wall for 360 degrees in circumferential extent. The calculation methods for design of the overlay will be in accordance with NUREG-0313, Section 4.1. The specific thickness and length will be computed according to ASME Code Section XI, Code Case N–504-2, and ASME Code Section XI, Paragraph IWB-3640, 1989 Edition.

The overlay will completely cover any indication location and the existing Inconel 182 weld deposit butter with the corrosion-resistant Alloy 52 material. In order to accomplish this objective, it is necessary to weld on the low alloy steel material. A temper bead welding approach will be used for this purpose according to provisions of ASME Code Case N–638. This code case provides requirements for weld repair using machine GTAW based on the temper bead process of P No. 3 nozzle materials (SA 508, Class 2) at ambient temperature. Entergy selected the temper bead approach because temper bead welding supplants the requirement for post-weld heat treatment of heat-affected zones in welded low alloy steel material.

ASME Code Case N–638, paragraph 1(a), limits the maximum finished surface area of the weld overlay repair to 100 square inches. The overlay repair (design and fabrication) on large diameter (13 and 29-inch outside diameter) recirculation nozzle safe-end welds would exceed the 100 square-inch limit and requires NRC approval for a maximum finished weld repair surface area up to 300 square inches on the basis of analysis in Electric Power Research Institute (EPRI) Technical Report 1003616, "Additional Evaluations to Extend Repair Limits for Pressure Vessels and Nozzles", dated March 2004. Susquehanna Station has used the EPRI Report as justification for recent nozzle weld overlay repairs. If the weld overlay necessary for a nozzle exceeds 300 square inches, additional relief will be requested.

3.6 Examination Requirements

Entergy stated that the repair, preservice inspection, and ISI examinations of the weld overlay repair will be performed in accordance with the ISI program and plan along with NUREG-0313, GL 88-01, and plant procedures as specified by its Inservice Inspection Repair/Replacement Program. The weld overlay will be examined using the industry-developed performance demonstration initiative (PDI) procedure, which the staff approved in PNPS PRR-38 on February 26, 2004.

Entergy will perform system leakage testing as allowed by ASME Code Case N–416-2 with the additional condition that hold times specified in IWA-5213(d) be observed, in lieu of the system hydrostatic test required by ASME Code Case N–504-2. This complies with Regulatory Guide (RG) 1.147, Revision 13, relative to the NRC's conditional acceptance of Code Case N–416-2. Entergy will perform the VT-2 visual inspection with the insulation removed from the locations where the proposed weld overlays are performed. This will allow a 10-minute hold before the VT-2 visual inspection is performed.

The examinations and acceptance criteria will follow ASME Code Section III, 1992 Edition, Subsection NB for Class 1 Components; ASME Code Section XI, 1989 Edition; and ASME Code Cases N–504-2 and N–638. Entergy proposed the following examinations for the weld overlay:

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EXAMINATION DESCRIPTION	METHOD	TECHNIQUE	REFERENCE
Weld overlay surface area preparation exam	Penetrant Test (PT)	Visible Dye	N–504-2
First two weld overlay layers surface exam	PT	Visible Dye	N–504-2
First two weld overlay layers thickness measurements	Ultrasonic Test (UT) or Mechanical	0° Longitudinal UT or Mechanical Height Measurement	N–504-2
Completed overlay or thickness measurements	UT or Mechanical	0° Longitudinal UT or Mechanical Height Measurement	N–504-2
Surface exam of final overlay surface and adjacent band within 1.5t (7/8" band) of weld overlay. This also serves as preservice surface examination of completed overlay.	PT	Visible Dye	NB-5350 IWB-3514 N–638 N–504-2
Volumetric exam of final overlay and adjacent band within 1.5t (7/8" band) of weld overlay. This also serves as preservice volumetric examination of completed overlay.	UT	PDI Procedure	ASME Code 1995, Section XI Appendix VIII; ASME Code 1989 Section XI
Preservice baseline exam of final overlay outer 25% of the underlying pipe wall to identify the original flaws.	UT	PDI Procedure	N–504-2

The acceptance criteria for the volumetric examinations shall be ASME Code Section XI Paragraph IWB-3514, "Standards for Examination Category B-F, Pressure Retaining Dissimilar Metal Welds, and Examination Category B-J, Pressure Retaining Welds in Piping".

Entergy noted that the curvatures of reactor nozzles require an exception to the ultrasonic inspection requirement for a 1.5t (7/8-inch band) adjacent band volumetric examination at the end of the overlay on the nozzle end. The liquid penetrant examination of this surface will constitute the acceptance testing for the overlay deposit. Thickness will be characterized at four azimuths representing each of the four pipe quadrants. Thickness measurements may be determined using ultrasonic techniques or by mechanical measurement. Liquid penetrant examinations will be performed at the same stages of the overlay application as the thickness measurements identified above.

3.7 Licensee's Proposed Alternative and Associated Basis

For the proposed repair, Entergy will use ASME Code Case N–504-2 and ASME Code Case N–638 with the following exceptions and clarifications.

Clarification of Asme Code Case N–504-2 for Applicability to Nickel-Based Austenitic Alloy

ASME Code Case N–504-2 was prepared specifically for austenitic stainless steel material. An alternate application to use nickel-based austenitic materials (i.e., Alloy 52) is requested due to the specific configuration of the nickel-based austenitic weldment.

Basis: The weldment being addressed is austenitic material having a mechanical behavior similar to austenitic stainless steel. The weldment is designed to be highly resistant to IGSCC and is compatible with the existing weldment and base metal materials. ASME Code Case N–504-2 should be interpreted to apply equally to both weldment and base metal materials.

Exception from ASME Code Case N–504-2 Paragraph (b)

ASME Code Case N–504-2 paragraph (b) requires that the reinforcement weld metal shall be low carbon (0.035% maximum) austenitic stainless steel. In the proposed application, a nickel-based filler is required and Alloy 52 has been selected in place of low carbon austenitic stainless steel.

Basis: Entergy selected a consumable welding wire resistant to IGSCC for the overlay material. This material, designated UNS N06052, is a nickel-based alloy weld filler material, commonly referred to as Alloy 52, and will be applied using the GTAW process. Alloy 52 contains about 30% chromium that provides stress corrosion cracking resistance to this material. By comparison, Alloy 82 is identified as an IGSCC-resistant material in NUREG-0313 and contains about 18 to 22% chromium, while Alloy 182 has a nominal chromium composition of 13 to 17%. Alloy 52, with its high chromium content, provides a high level of resistance to IGSCC consistent with the requirements of the code case.

Exception from ASME Code Case N–504-2 Paragraph (e)

ASME Code Case N–504-2 paragraph (e) requires as-deposited delta ferrite measurements of at least 7.5% for the weld reinforcement. These measurements have no meaning for nickel-based weld materials and will not be performed for this overlay.

Basis: The composition of nickel-based Alloy 52 is such that delta ferrite is not formed during welding. Ferrite measurement requirements were developed for welding of 300 series stainless steels that required delta ferrite to develop corrosion resistance. The Alloy 52 weld is 100% austenitic and contains no delta ferrite due to the high nickel composition (approximately 60% nickel and low iron content). The Alloy 52 weld, with its high chromium content, provides a high

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level of resistance to hot cracking and IGSCC. This characteristic is consistent with the purpose for the delta ferrite requirements for stainless steels of the code case.

Exception from ASME Code Case N–504-2 Paragraph (h)

ASME Code Case N–504-2 paragraph (h) requires a system hydrostatic test of completed repairs if the repaired flaw penetrated the original pressure boundary or if there is any observed indication of the flaw penetrating the pressure boundary during repairs. A system leak test of completed repairs will be used in lieu of a hydrostatic test.

Basis: In lieu of the hydrostatic pressure test requirements defined in ASME Code Case N–504-2, Entergy stated that the required pressure test shall be performed in accordance with the third interval ISI program and plan and ASME Code Case N–416-2 with the exception that the volumetric examination performed shall be an ultrasonic examination of the weld overlay.

Exception from ASME Code Case N–638 Paragraph 1(a)

ASME Code Case N–638 paragraph 1(a) limits the maximum finished surface area of the weld overlay repair to 100 square inches. Relief is requested to extend the size of the repairs up to a 300 square-inch finished area to accommodate overlay repair on large diameter (13 and 29-inch outside diameter) recirculation nozzle safe-end welds.

Basis: Entergy stated that ASME Code Case N–638 was developed for temper bead applications to similar and dissimilar metals. It permits the use of machine GTAW at ambient temperature without the use of preheat or post-weld heat treatment on ASME Code Class 1, 2, and 3 components.

Numerous applications over the past decade have demonstrated the acceptability of temper bead technology in nuclear environments. Temper bead welding achieves heat-affected zone tempering and grain refinement without subsequent post-weld heat treatment. Excellent heat affected zone toughness and ductility are produced. The use of ASME Code Case N–638 has been accepted in RG 1.147, Revision 13, as providing an acceptable level of quality and safety.

The overlay repair on large diameter (13 and 29-inch outside diameter) recirculation nozzle safe-end welds would exceed the 100 square inch limit specified in ASME Code Case N–638, paragraph 1(a). EPRI Technical Report 1003616 justifies extending the size of the temper bead repairs up to a 500 square-inch finished area. Entergy stated that the ASME Code Committees has recognized that the 100 square inches on the overlay surface area is too restrictive and a draft code case, RRM-04, is currently being processed within ASME Code Section XI to increase the area limit to 500 square inches.

3.8 Duration of the Proposed Alternative

Entergy stated that the proposed alternative applies to the repairs of reactor pressure vessel nozzle safe-end and piping welds for the scheduled outage and for the remaining service life of the welds. Re-inspection of the welds will be conducted in accordance with the guidelines in BWRVIP-75.

4.0 TECHNICAL EVALUATION

The staff evaluated the following issues:

1. The staff asked Entergy to discuss: (1) whether hydrogen water chemistry in BWRVIP-75 has been implemented in the primary water system to mitigate the potential of stress corrosion cracking in the recirculation and core spray piping at PNPS; (2) whether there have been any chemical intrusions which have occurred in the primary water system that would affect the welds in the proposed PRR; and (3) whether corrective actions have been implemented to minimize the chemical intrusions.

In its October 12, 2004, letter, Entergy responded that PNPS has maintained an average hydrogen water chemistry availability of 90.7% for the past five operating cycles since June 1993. The hydrogen water chemistry availability for the current operating cycle (15) is 93.0%. Hydrogen water chemistry availability should be 80% or greater for the weld inspection interval for a moderate hydrogen water chemistry plant in accordance with the staff's safety evaluation report for BWRVIP-75.

Only one chemical intrusion from a condensate polisher in December 2000 has occurred while above 200 degrees F. Entergy included this intrusion in the hydrogen water chemistry availability calculation. The intrusion was due to a failed condensate polisher lateral and under-drain. This problem was subsequently corrected for all the condensate polishers by a redesign of the laterals and under-drains. A review of the welds in PRR-39 showed that six safe-end-to-nozzle welds receive protection from hydrogen water chemistry. The six core spray welds are not protected by hydrogen water chemistry; however, Entergy will inspect the six core spray welds every 6 years in accordance with the guidelines in BWRVIP-75. The welds in recirculation systems that are protected by the hydrogen water chemistry will be inspected every 10 years.

The staff finds Entergy's management of those welds affected by water chemistry acceptable because Entergy follows the inspection frequency specified in BWRVIP-75. The periodic inspection provides adequate monitoring of potential degradation in the affected welds.

2. In PRR-39, Entergy specified that either UT or mechanical height measurement will be used to measure the thickness of the weld overlay. The staff asked Entergy to discuss the subsection in ASME Code Case N-504-2 that specifies these measurement requirements and which method will most likely be used in terms of reliability, sensitivity, and accuracy.

In its October 12, 2004, letter, Entergy responded that ASME Code Case N-504-2, paragraphs (c) and (g) provide examination requirements to verify the integrity of the weld overlay. A PT will be performed on the area to be welded in accordance with ASME Code Section III, NB Sections, 1992 Edition. If localized seal welding is required, this examination will be performed after the localized seal welding is completed. A final PT, in accordance with ASME Code Section III, NB Sections, 1992 Edition, and ASME Code Section XI, 1989 Edition, will be performed after completing all weld overlays.

ASME Code Case N–504-2 does not specify the method for measuring overlay thickness. A thickness examination using UT will be performed to demonstrate that the weld overlay meets the thickness requirements of the repair plan. UT is the preferred method for determining the thickness of the weld overlay. Mechanical measurements are included as an alternative to UT where suitable reference surfaces are available. If for any reason the UT method is not used to provide thickness data, mechanical measurements will be used where a suitable reference surface is available. Both methods provide reliable and accurate thickness measurement results, but the UT method is more sensitive to the surface roughness and requires a smooth surface for the UT probe. The final examination, in addition to a VT-2 visual inspection, will be a volumetric examination based on PDI/UT procedures in accordance with PRR-38.

Entergy will perform UT of the weld overlay volume to demonstrate that the repair volume is unflawed and meets thickness requirements of the design following application of the repair. Since the weld repair material is resistant to ongoing crack propagation and provides compressive residual stress, this examination assures continued integrity and adequacy of the weld overlay.

The staff finds that Entergy provides an acceptable strategy because it considered both UT and mechanical measurements in the measurement of weld overlay thickness.

3. In Sections C and D of PRR-39, Entergy stated that the system leakage test is adequate to ensure the pressure boundary integrity. However, ASME Code Case N–504-2, paragraph (h) specifies that if a flaw penetrates the original pressure boundary prior to or during the welding operation, a system hydrostatic test shall be performed. If the system pressure boundary has not been penetrated, a system leakage, in-service, or functional test shall be performed. ASME Code Case N–416-2 allows a system leakage test in lieu of a hydrostatic pressure test in weld repairs if an NDE is performed in accordance with the 1992 Edition of ASME Code Section III, which specifies that radiographic examination be performed.

Considering the above, the staff asked Entergy to: (a) Clarify whether a radiographic examination will be performed on the weld repair per the 1992 Edition of ASME Code Section III, if a flaw penetrates the pressure boundary prior to or during the welding process. If a radiographic examination will not be performed, discuss the basis and justify the performance of a ultrasonic examination in lieu of a radiographic examination of the weld overlay repair; (b) Discuss the technical basis why the system leakage test is adequate as compared to a hydrostatic test in demonstrating the structural integrity of the weld overlay repair; and (c) Discuss whether a system leakage test will be performed after each completed repair.

In response to Item (a), Entergy stated that the overlay welding would be examined to Supplement 11 as modified by PRR-38 for specific PDI procedures. The qualified procedures are in accordance with the ultrasonic acceptance standards included in ASME Code Section III NB-5330. The ultrasonic procedures and personnel used for this examination result in a weld material assessment for an overlay that cannot be achieved by radiography. This is based on the special nature of the weld overlay, which is similar to that recognized in ASME Code Section III NB-5270 "Special Welds" and the allowance as described in NB-5279 that there are special exceptions requiring ultrasonic rather than radiographic examinations. Pressure vessel and safe-end welded piping are filled with reactor water, which precludes use of radiography for weld material assessment. Removal of fuel and draining the vessel to accommodate radiography presents additional nuclear safety and personal hazards. Radiography is not qualified under PDI for weld overlay inspections. Thus, UT under the PDI examination is the preferred method for weld method assessment. The qualification process for the Supplement 11 ultrasonic examination, the ability to size flaws for length and depth, and the fact that the qualification includes flaws that may be created during fabrication, meets the ultrasonic procedural requirements of the cited ASME Code Section III paragraphs.

The final weld examination would be a complete UT using EPRI PDI procedures in accordance with PRR-38. The weld overlay would meet the requirements of the ASME Code Section XI repair plan and PDI procedures. There would be no deviations from ASME Code Section III 1992 methods, as discussed above, and acceptance criteria or PDI and UT procedures.

ASME Code Section XI allows a repair to be performed by either removing a flaw or reducing it to an acceptable size, as documented in ASME Code Case N–504-2. The weld overlay approach does the latter. The allowable flaw size is defined in Table IWB-3641-1 of ASME Code Section XI. The initial flaw is conservatively assumed to be entirely through-wall and to extend entirely around the circumference of the repair location (through-wall x 360 degrees around). The weld overlay approach applies additional thickness to the flawed location, such that the repaired component meets the requirements of IWB-3640. This approach has been extensively used since the mid-1980's in repair of piping in BWRs. The weld overlay also imparts a compressive residual stress, which has been shown to reduce crack growth.

The weld overlay repairs will be completed using ASME Code Case N–504-2 for the repair design, fabrication, and examination methods applicable to a structural overlay type of repair. This type of repair is not included in ASME Code Section III. The NDE of weld overlays is not addressed in ASME Code Section III because Section III is a construction code used for the initial installation of welded joints. Welding performed under an ASME Code Section XI repair plan is typically examined in accordance with the code of construction, when applicable, and any Section XI baseline (preservice) ISI examinations.

For weld overlay repairs, the repair rules are provided by ASME Code Case N–504-2 which states that the required examinations are by the liquid penetrant and ultrasonic methods. This ASME Code Case is prescriptive about all aspects of the weld overlay repair including the overlay design, its fabrication, and the examinations performed before, during, and after the welding.

The type of weld examinations to be performed on the structural overlay weld would be based on ASME Code Case N–504-2, rather than ASME Code Section III, such that the required volumetric examination of weld overlay would be by the ultrasonic rather than radiographic method. An initial liquid penetrant examination would be performed on the area to be welded in accordance with ASME Code Case N–504-2. This examination will be performed, if required, after the localized seal welding is completed. A final liquid penetrant examination, in accordance with N–504-2 and ASME Code Section III 1992, would be performed after completing all weld overlay layers. An ultrasonic thickness examination will also be performed to demonstrate that the weld overlay met the thickness requirements of the repair plan.

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The staff finds that Entergy provided sufficient basis to justify the use of liquid PT and UT in lieu of radiographic examination.

In response to Items (b) and (c), Entergy stated that the pressure test requirements in ASME Code Case N–504-2 are consistent with ASME Code Section XI Subarticle IWA-4700 "Pressure Test" rules that are applicable to all pressure boundary weld repairs performed under Section XI.

ASME Code Case N–416-2 is routinely used to allow a system leakage test to be performed in lieu of a system hydrostatic pressure test in most cases of weld repairs to existing piping, pump, and valve components at PNPS and other plants, including repairs that entirely replace components or penetrate the pressure boundary. ASME Code Case N–416-2 requires NDE be performed on welded repairs, fabrication and installation joints in accordance with the methods and acceptance criteria of the applicable Subsection of the 1992 Edition of Section III. As discussed above, the staff has determined that the performance of an ultrasonic examination in lieu of radiographic examination of the overlay is acceptable. Therefore, PNPS's use of AMSE Code Case N–416-2, which allows system leakage testing in accordance with IWA-5000 at nominal operating pressure and temperature, in lieu of a hydrostatic testing, continues to be acceptable.

4. Entergy stated that re-inspection of the welds will be conducted in accordance with the guidance in BWRVIP-75. The staff asked Entergy to (a) discuss the exact inspection schedule for the welds in the proposed relief request, identify the page, category, and section in BWRVIP-75 that discusses the inspection schedule that the licensee will follow; and (b) discuss the inspection method that will be used in the re-inspection of the welds.

In the October 12, 2004, letter, Entergy responded that PNPS intends to inspect any overlaid dissimilar welds in accordance with the requirements for Category E overlaid welds as described in Table 3-1 and Section 3.5.1.1 of BWRVIP-75, which states, in part, that "...For weld overlays applied in the future, a preservice examination followed by an inservice examination within three outages is required..." After this initial inservice examination within three outages of the repair, the inspection schedule would then revert to the sample frequency shown in Table 3-1 of BWRVIP-75, i.e., either 25% or 10% every 10 years depending on water chemistry classification. The re-inspection of the welds will be conducted using VT-2 visual inspection and volumetric ultrasonic testing of the PDI process in the re-inspection of the welds.

The staff finds that Entergy's response is acceptable because it will follow the appropriate inspection schedule and criteria of BWRVIP-75.

5. Entergy stated that the proposed alternative applies to the repairs of reactor pressure vessel nozzle safe-end and piping welds for the remaining service life of the welds, meaning to the end of the operating license of the plant. In general, the staff approves relief requests for only one inspection interval within certain fixed calendar dates. The staff requested Entergy to: (a) identify which inspection interval(s) this relief request will be applicable; (b) identify the current inspection interval; and (c) provide the end date of the operating license of the plant and the starting and end dates of the 3rd and 4th inspection intervals.

In the October 12, 2004, letter, Entergy responded that PNPS is in the third 10-year ISI interval, which began on July 1, 1995, and will end on June 30, 2005. The fourth 10-year ISI interval would begin on July 1, 2005 and would end on June 30, 2015. Entergy requested that PRR-39 be granted for the third 10-year ISI interval and the remaining service life of these welds, i.e., fourth 10-year inspection interval. The upcoming refueling outage 15 is the last refueling outage in the third inspection interval. The fourth inspection interval is short by 3 years of a 10-year interval because the operating license for PNPS expires on June 8, 2012. Therefore, the subject welds have a remaining service life of 8 years (2005 to 2012). The staff finds that Entergy's requested relief for the third and fourth 10-year inspection intervals is acceptable because the actual duration of this request is only 8 calendar years.

6. The staff reviewed EPRI Report 1003616 with respect to the request of allowing a weld overlay area of 300 square inches. The staff found that the EPRI report did not include a stress analysis of a weld overlay repair area of 300 square inches. The report does provide a stress analysis of weld overlay areas of 100 and 126 square inches. Although it was not analytically determined whether the stresses derived from the 100 or 126 square-inch model would be applicable to the 300 square-inch weld overlay area, the staff believes that the analyses presented in the EPRI report do provide sufficient understanding of the structural integrity of a weld overlay of 300 square-inch area. Also, the staff has approved a relief request from the Susquehanna nuclear power plant for a weld overlay area of 300 square inches based on the EPRI report. Therefore, the staff finds Entergy's requested weld overlay area of 300 square inches acceptable. The acceptability of any weld overlay area greater than 300 square inches would need to be demonstrated by a stress analysis that considers the exact weld overlay area, to demonstrate that the residual stresses from the weld overlay will not affect the structural integrity of the piping.

The staff has determined that the proposed alternative to use ASME Code Cases N–504-2 and N–638 for the weld overlay repair of recirculation and core spray piping is acceptable because the alternative will provide an acceptable level of quality and safety.

5.0 CONCLUSION

Based on the review of information submitted, the staff has determined that Entergy's proposed PRR-39 will provide an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the NRC staff authorizes Entergy's proposed use of ASME Code Section XI Code Cases N–504-2 and N–638 with modifications as identified in Entergy's submittal to perform structural weld overlay repair of potential crack(s) in the recirculation and core spray piping at PNPS.

All other requirements of Section XI of the ASME Code for which relief has not been specifically requested remain applicable, including third party review by the Authorized Nuclear Inservice Inspector.

Principal Contributor: J. Tsao

Date: April 12, 2005

A.12 Hatch Nozzle N9 (RR and RAI)

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SOUTHERN COMPANY
Energy to Serve Your World℠

February 26, 2008

Docket No.: 50-321

NL-08-0280

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

Edwin I. Hatch Nuclear Plant – Unit 1
Application of a Dissimilar Metal Weld Full-Structural Weld Overlay

Ladies and Gentlemen:

On February 22, 2008 ultrasonic examination indicated that a flaw existed on control rod drive (CRD) return line nozzle dissimilar metal weld 1C11-1CRD-3-R-18A that exceeded ASME Code criteria. This line was cut and capped in 1977 per the requirements of NUREG-0619. Recent technological developments for examination (i.e., phased array examination technique) have facilitated the complete characterization of pre-existing but previously incompletely characterized conditions. On February 23, 2008 the flaw was confirmed and fully characterized using phased array techniques after the weld was conditioned. Based on a review of previous inspection data, coupled with the results of the phased array examination, SNC believes that this flaw has existed for several years. The proposed corrective action is the application of a full-structural weld overlay.

Pursuant to 10 CFR 50.55a(a)(3)(i), Southern Nuclear Operating Company (SNC) hereby requests NRC approval of proposed alternative ISI-GEN-ALT-08-01, Version 1.0 to allow the application of a full-structural weld overlay over weld 1C11-1CRD-3-R-18A.

This proposed alternative is similar to alternative ISI-GEN-ALT-07-01, Revision 2.0, submitted on December 26, 2007 for the Farley Nuclear Plant and the Vogtle Electric Generating Plant. Alternative ISI-GEN-ALT-07-01 was based primarily on NRC approved ISI-GEN-ALT-06-03, Revision 2.0 for the Farley Nuclear Plant. The differences between ISI-GEN-ALT-08-01 and ISI-GEN-ALT-07-01 are as follows:

1. This alternative applies to a single weld,

2. The end cap base material for Hatch is a nickel-based alloy versus the stainless steel safe-end configuration described in the Vogtle and Farley submittals, and

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3. For BWR applications, crediting of the base layer toward weld thickness if there is at least 20% Cr, versus 24% for PWRs.

This alternative is for the Hatch Nuclear Plant (HNP) 4th ISI Interval. The details of the 10 CFR 50.55a request for alternative are contained in Enclosure 1. The list of regulatory commitments is contained in Enclosure 2.

Approval is requested by February 29, 2008 to support application of the weld overlay prior to transitioning to Mode 3, currently scheduled for March 10, 2008.

If you have any questions, please advise.

Sincerely,

David H. Jones
Vice President, Engineering

DHJ/MNW/daj

Enclosures: 1. Request for Alternative - ISI-GEN-ALT-08-01, Version 1.0 Application of a Dissimilar Metal Weld Full-Structural Weld Overlay
2. List of Regulatory Commitments

cc: Southern Nuclear Operating Company
Mr. J. T. Gasser, Executive Vice President
Mr. D. R. Madison, Vice President – Hatch
RTYPE: CHA02.004

U. S. Nuclear Regulatory Commission
Mr. V. M. McCree, Acting Regional Administrator
Mr. R. E. Martin, NRR Project Manager – Hatch
Mr. J. A. Hickey, Senior Resident Inspector – Hatch

Edwin I. Hatch Nuclear Plant

Proposed Alternative in Accordance with 10 CFR 50.55a(a)(3)(i)
Application of a Dissimilar Metal Weld Full-Structural Weld Overlay

Enclosure 1

ISI-GEN-ALT-08-01, Version 1.0

Enclosure 1

SOUTHERN NUCLEAR OPERATING COMPANY
ISI-ALT-08-01, VERSION 1.0
PROPOSED ALTERNATIVE IN ACCORDANCE WITH 10 CFR 50.55a(a)(3)(i)
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This proposed alternative is technically similar to ISI-GEN-ALT-07-01, Version 2.0 previously developed for Farley Nuclear Plant and Vogtle Electric Generating Plant, except that it is specific for one weld. ISI-GEN-ALT-07-01, Version 2.0 is in the final stages of NRC approval.

Plant Site-Unit: Hatch Nuclear Plant - Unit 1 (HNP-1).

Interval Dates: Fourth ISI Interval extending from January 1, 2006 through December 31, 2015.

Requested Date for Approval: Approval is requested by February 29, 2008 to support plant startup.

ASME Code Components Affected: Category B-F, Alloy 82/182 dissimilar metal (DM) butt weld.

Applicable Code Edition and Addenda: The applicable Code edition and addenda is ASME Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," 2001 Edition with Addenda through 2003. The exception is that for ASME Section XI, Appendix VIII, the 2001 Edition of Section XI will be used. This exception is based on 10 CFR 50.55a(b)(2)(xxiv) which states, "The use of Appendix VIII and the supplements to Appendix VIII and Article I-3000 of Section XI of the ASME BPV Code, 2002 Addenda through the latest edition and addenda incorporated by reference in paragraph (b)(2) of this section, is prohibited."

NOTE

Unless identified otherwise, all Code references provided herein are to ASME Section XI.

Applicable Code Requirements: IWA-4110 of ASME Section XI requires that repairs of welds shall be performed in accordance with Article IWA-4000. IWA-4300 requires that defects be removed or reduced to an acceptable size.

Reason for Request: HNP-1 DM weld 1C11-1CRD-3-R-18A has an indication that is approximately 2.3" long at the inside surface and has a maximum depth of 60% through-wall. This indication is attributed to stress corrosion cracking (SCC).

This DM weld joins the N9 reactor pressure vessel Control Rod Drive (CRD) Return nozzle (P No. 3) to a nickel-base alloy cap (P No. 43). The weld material is Alloy 82/182 (F No. 43). The details of this configuration are shown in Appendix 6, Figure 1. (Dimensions in Figure 1 are for ISI use and not for design).

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This cap was installed in 1977 after the CRD return line was re-routed to Feedwater per the requirements of NUREG-0619. The DM weld was subsequently stress improved using a mechanical stress improvement process (MSIP) in 1993. The DM weld was ultrasonically (UT) examined eight times from 1977 through 1994 using progressively improved UT techniques. Five of these examinations were prior to 1993. In 1993 this weld was examined by UT prior to and after the MSIP treatment with an indication being detected. A reexamination in 1994 identified the same indication at the inside surface of the weld in the area of the current flaw, but the indication was characterized as geometry because there was no observable depth. In late 2007, due to SCC occurrences at other sites, the BWRVIP provided requirements to its members requiring each utility to evaluate welds that could have examination issues due to the surface conditions. As a result of the industry requirements, SNC performed surface conditioning on weld 1C11-1CRD-3-R-18A during the current outage (1R23) to improve the examination of the weld. After surface conditioning, the indication length and through-wall dimensions were observed. Final sizing of the indication was performed using a qualified phased-array technique.

Southern Nuclear Operating Company (SNC) proposes to overlay this weld as the method of repair; however, Section XI of the American Society of Mechanical Engineers, Boiler and Pressure Vessel Code (Section XI Code) does not provide rules for the design of weld overlays or for repairs without removal of flaws. Additionally, Code Cases N-504-2 and N-638-1, which have been approved by the NRC for use, do not provide the methodology for overlaying nickel alloy butt welds. Therefore, this proposed alternative is requested.

A comparison to Code Cases N-504-2 and to N-638-1 was provided in ISI-GEN-ALT-07-0; therefore, it is provided in this alternative. (See Appendix 4 and Appendix 5).

Proposed Alternative and Basis for Use:

Proposed Alternative

In lieu of using the IWA-4000 Repair Procedures in the Section XI Code, SNC proposes to use the following alternative requirements for the design, fabrication, pressure testing, and examination of a full-structural weld overlay (FSWOL). This FSWOL will provide an acceptable methodology for reducing a defect in the DM weld to an acceptable size by increasing the wall thickness through deposition of an SCC resistant weld overlay. The methodology is:

1. **General Requirements**:

   (a) An FSWOL will be applied by deposition of weld reinforcement (weld overlay) over the low alloy steel nozzle (P- 3), the DM weld (F-43), and the cap (P-43) as shown in Appendix 6, Figure 2. The weld reinforcement will consist of Alloy 52/152. (Note: As used in this alternative, the use of Alloy 52/152 refers to the family of filler metals which includes filler metals such as 52, 52M, and 52MS.)

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(b) The Alloy 52/152 weld overlay filler metal is an austenitic nickel alloy having a chromium (Cr) content of at least 28%. The weld overlay is applied 360 degrees around the circumference of the item, e.g., safe end to nozzle weld, and will be deposited using a Welding Procedure Specification (WPS) for groove welding, qualified in accordance with the Construction Code and Owner's requirements and identified in the Repair/Replacement Plan. As an alternative to the post-weld heat treatment requirements of the Construction Code and Owner's requirements, the provisions for ambient temperature temperbead welding will be used on the ferritic nozzle. (See "Ambient Temperature Temperbead Welding," which is located in Appendix 1 to this proposed alternative). The maximum area of an individual weld overlay on the finished surface of the <u>ferritic material</u> shall be no greater than 300 square inches.

(c) Prior to deposition of the FSWOL, the surface will be examined by the liquid penetrant method. Indications larger than 1/16-inch shall be removed, reduced in size, or corrected in accordance with the following requirements.

1. One or more layers of weld metal shall be applied to seal unacceptable indications in the area to be repaired, with or without excavation. The thickness of these layers shall not be used in meeting weld reinforcement design thickness requirements. Peening the unacceptable indication prior to welding is permitted.

2. If correction of indications identified in (c)1 is required, the area where the weld overlay is to be deposited, including any local repairs or initial weld overlay layer, shall be examined by the liquid penetrant method. The area shall contain no indications greater than 1/16-inch prior to the application of the structural layers of the weld overlay.

(d) Weld overlay deposits shall meet the following requirements:

The austenitic nickel alloy weld overlay shall consist of at least two weld layers deposited using a filler material such as that identified in 1(b). The first layer of weld metal deposited may not be credited toward the required thickness. Alternatively, for BWR applications, a diluted layer may be credited toward the required thickness, provided the portion of the layer over the austenitic base material, austenitic filler material weld, and the associated dilution zone from an adjacent ferritic base material contain at least 20% Cr, and the Cr content of the deposited weld metal is determined by chemical analysis of the production weld or of a representative coupon taken from a mockup prepared in accordance with the WPS for the production weld.

(e) Welding will only be performed for applications predicted not to have exceeded a thermal neutron fluence of 1×10^{17} (E< 0.5 eV) neutrons per cm^2 prior to welding.

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2. Crack Growth Considerations and Design

(a) Crack Growth Considerations - Crack growth calculations will be performed. Flaw characterization and evaluation requirements shall be based on the as-found flaw. The size of all flaws will be projected to the end of the design life of the overlay. Crack growth, including both stress corrosion and fatigue crack growth, shall be evaluated in the materials in accordance with IWB-3640. If the flaw is at or near the boundary of two different materials, evaluation of flaw growth in both materials is required. This report will be submitted within 90 days after plant startup.

(b) Design of the FSWOL

The following design analysis shall be completed in accordance with IWA-4311.

1. The axial length and end slope of the weld overlay shall cover the weld and the heat affected zones on each side of the weld, and shall provide for load redistribution from the item into the weld overlay and back into the item without violating applicable stress limits of ASME Section III, NB-3200. Any laminar flaws in the weld overlay shall be evaluated in the analysis to ensure that load redistribution complies with these requirements. These requirements will usually be satisfied if the weld overlay full thickness length extends axially beyond the projected flaw by at least $0.75\sqrt{Rt}$, where R is the outer radius of the item and t is the nominal wall thickness of the item.

2. Unless specifically analyzed in accordance with 2(b)1 above, the end transition slope of the overlay shall not exceed 45 degrees. A slope of not more than 1:3 is recommended.

3. The thickness of the FSWOL shall be determined based on the assumption of a through-wall flaw, with a length of 360 degrees in the underlying pipe. The overlay will be applied, so that the criteria of IWB-3640 are met after the overlay is applied. The determination of the thickness shall include the deposit analysis requirements of 1(d).

4. The effects of any changes in applied loads, as a result of weld shrinkage from the entire overlay, on other items in the piping system (e.g., support loads and clearances, nozzle loads, changes in system flexibility and weight due to the weld overlay) shall be evaluated. (There are no pre-existing flaws previously accepted by analytical evaluation to be considered in this evaluation.) Included are:

   i. A stress analysis will be performed that demonstrates that the pressure-retaining components will perform their intended design

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function with the FSWOL installed. The stress analysis report will include results showing that the requirements of Subarticles NB-3200 and NB-3600 of the ASME Code, Section III are satisfied. The stress analysis will also include results showing that the requirements of IWB-3000 of the ASME Code, Section XI, are satisfied. The results will show that the postulated crack including its growth would not adversely affect the integrity of the overlaid welds. This report will be submitted within 90 days after plant startup.

ii. (Leak-before-break does not apply.)

3. Examination and Inspection

In lieu of all other examination requirements, the examination requirements proposed herein shall be met. Nondestructive examination methods shall be in accordance with IWA-2200, except as specified herein. Nondestructive examination personnel shall be qualified in accordance with IWA-2300. Ultrasonic examination procedures and personnel shall be qualified in accordance with Appendix VIII, Section XI, as implemented through the performance demonstration initiative (PDI). (The PDI Program Status for Code Compliance and Applicability developed in June 2005 indicates that the PDI Program is in compliance with Appendix VIII, 2001 Edition of Section XI as amended and mandated by 10 CFR 50.55a, Final Rule dated October 1, 2004.) Ultrasonic examination will be performed to the maximum extent achievable.

Post-Overlay Examinations

There are two examinations to be performed after the overlay is installed, i.e., the Acceptance Examination of the Overlay and the Preservice Examination. The purpose of the Acceptance Examination is to assure a quality overlay was installed. The purpose of the Preservice Examination is to provide a baseline for future examinations and to locate and size any cracks that might have propagated into the upper 25% of the original wall thickness and evaluate accordingly. While listed below as two separate examinations the two examinations may be performed during the same time period. SNC will provide the NRC, within 14 days after the completion of the ultrasonic examination of the weld overlay installations, (1) the examination results of the weld overlays and (2) a discussion of any repairs to the overlay material and/or base metal and the reason for repair.

The NDE requirements listed below cover the area that will be affected by application of the overlay. Any SCC degradation would be in the DM weld or the adjacent heat affected zone (HAZ). Further, the original weld and adjacent base materials have received a radiographic examination (RT) prior to the initial acceptance of the existing butt weld. The proposed surface and volumetric examinations provide adequate assurance that any defects produced by welding of the overlay or by extension of pre-existing defects will be identified.

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(a) Acceptance Examination of the Overlay

1. The weld overlay shall have a roughness average (RA) of 225 micro-inches (250 RMS) or better and a flatness sufficient to allow for adequate examination in accordance with procedures qualified per Appendix VIII. The weld overlay shall be examined to verify acceptable configuration.

2. The weld overlay and the adjacent base material for at least ½ inch from each side of the weld overlay shall be examined using the liquid penetrant method. The weld overlay shall satisfy the surface examination acceptance criteria for welds of the Construction Code or ASME Section III, NB-5300. The adjacent base metal shall satisfy the surface examination acceptance criteria for base material of the Construction Code or ASME Section III, NB-2500. When ambient temperature temperbead welding is used, the liquid penetrant examination shall be conducted at least 48 hours after the third layer of the weld overlay has been completed. See Appendix 7 for 48 hour hold time justification.

3. The examination volume A-B-C-D in Figure 1, which is provided in Appendix 2 to this proposed alternative, shall be ultrasonically examined to assure adequate fusion (i.e., adequate bond) with the base metal and to detect welding flaws, such as interbead lack of fusion, inclusions, or cracks. The interface C-D shown between the overlay and the weld includes the bond and the heat affected zone from the overlay. When ambient temperature temperbead welding is used, the ultrasonic examination shall be conducted at least 48 hours after the third layer of the weld overlay has been completed. See Appendix 7 for 48 hour hold time justification.

4. Planar flaws shall meet the preservice examination standards of Table IWB-3514-2. In applying the acceptance standards, wall thickness "t_w" shall be the thickness of the weld overlay. For weld overlay examination volumes with unacceptable indications, the unacceptable indications will be removed and the volume will be re-welded. Re-examination per IWB-2420 is not required because unacceptable indications will be removed and the volume will be re-welded.

5. Laminar flaws shall meet the acceptance standards of Table IWB-3514-3 with the additional limitation that the total laminar flaw shall not exceed 10% of the weld surface area and that no linear dimension of the laminar flaw area exceeds 3.0 inches. Additional requirements are:

   i. The reduction in coverage of the examination volume in Figure 1 (which is provided in Appendix 2 to this proposed alternative) due to laminar flaws shall be less than 10%. The dimensions of the

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uninspectable volume are dependent on the coverage achieved with the angle beam examination of the overlay.

ii. Any uninspectable volume in the weld overlay beneath a laminar flaw shall be assumed to contain the largest radial planar flaw that could exist within that volume. This assumed flaw shall meet the preservice examination standards of Table IWB-3514-2. In applying the acceptance standards, wall thickness "t_w" shall be the thickness of the weld overlay. Both axial and circumferential planar flaws shall be assumed.

iii. If the preservice acceptance criteria of Table IWB-3514-2 are not met, the assumed flaw shall be evaluated and shall meet the requirements of IWB-3640. The IWB-3640 evaluation shall be submitted to the NRC within 90 calendar days of the completion of the refueling outage. If the assumed flaw is not acceptable for continued service per IWB-3640, the lamination shall be removed or reduced in area such that the assumed flaw is acceptable per IWB-3640.

6. A general requirement after welding is to examine supports to verify design tolerances are still met. There are no supports to be examined.

(b) Preservice Inspection

1. The examination volume A-B-C-D in Figure 2, which is provided in Appendix 3 to this proposed alternative, shall be ultrasonically examined. The angle beam shall be directed perpendicular and parallel to the piping axis, with scanning performed in four directions, to locate and size any cracks that might have propagated into the upper 25% of the original wall thickness or into the weld overlay.

2. The preservice examination acceptance standards of Table IWB-3514-2 shall be applied to planar indications in the weld overlay material. If the indication is found acceptable per Table IWB-3514-2 the weld overlay will be placed in service and the inservice schedule and acceptance criteria of 3(c) will be followed. In applying the acceptance standards, wall thickness, t_w, shall be the thickness of the weld overlay. Planar flaws not meeting the preservice acceptance standards of Table IWB-3514-2 shall be repaired. Re-examination per IWB-2420 is not required because unacceptable indications will be removed and the volume will be re-welded.

3. Cracks in the outer 25% of the original wall thickness shall meet the design analysis requirements as addressed in Section 2, "Crack Growth Considerations and Design," of this proposed alternative.

(c) Inservice Inspection

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Inservice examinations of the FSWOLs will be performed in accordance with Q-4300 and 4310 of Appendix Q to the 2004 Edition of Section XI with Addenda through 2005 with modifications. Appendix 8 shows Q-4300 and 4310 with the SNC modifications shown in italics.

4. Pressure Testing

A system leakage test shall be performed in accordance with IWA-5000.

5. Documentation

Use of this proposed alternative shall be documented on ASME Form NIS-2 or NIS-2A.

Basis for Use:

The use of weld overlay materials resistant to SCC (e.g., Alloy 52/152) that create low tensile or compressive residual stress profiles in the original weld provide increased assurance of structural integrity. The weld overlay is of sufficient thickness and length to meet the applicable stress limits from ASME Section III, NB-3200. Crack growth evaluations for SCC and fatigue of any as-found flaws or any conservatively postulated flaws will ensure that structural integrity will be maintained.

Weld overlay repairs of dissimilar metal welds have been installed and performed successfully for many years in BWRs and recently in PWRs. Weld overlay performance has been excellent. This alternative provides improved structural integrity and reduced likelihood of leakage for the primary system. Accordingly, the use of the alternative provides an acceptable level of quality and safety in accordance with 10 CFR 50.55a(a)(3)(i).

Duration of Proposed Alternative: The proposed alternative is applicable to the 4th ISI Interval.

Precedents: This proposed alternative meets the technical requirements set forth in ISI-GEN-ALT-07-03, Revision 2.0 for Vogtle Electric Generating Plant and Farley Nuclear Plant.

References: None

Status: Awaiting NRC approval.

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APPENDIX 1
AMBIENT TEMPERATURE TEMPERBEAD WELDING

1.0 GENERAL REQUIREMENTS

(a) This appendix applies to dissimilar austenitic filler metal welds between P-Nos. 1, 3, 12A, 12B, and 12C[1] materials and their associated welds and welds joining P-No. 8 or 43 materials to P-No. 1, 3, 12A, 12B, and 12C materials with the following limitation: This Appendix shall not be used to repair SA-302 Grade B material unless the material has been modified to include from 0.4% to 1.0% nickel, quenching and tempering, and application of a fine grain practice. (P-No. 12C designation refers to specific material classifications originally identified in ASME Section III and subsequently reclassified in a later Edition of ASME Section IX).

(b) The maximum area of an individual weld overlay based on the finished surface over the ferritic base material shall be 300 square inches.

(c) Repair/replacement activities on a dissimilar-metal weld in accordance with this Appendix are limited to those along the fusion line of a nonferritic weld to ferritic base material on which 1/8- inch, or less of nonferritic weld deposit exists above the original fusion line.

(d) If a defect penetrates into the ferritic base material, repair of the base material, using a nonferritic weld filler material, may be performed in accordance with this Appendix, provided the depth of repair in the base material does not exceed 3/8-inch.

(e) Prior to welding the area to be welded and a band around the area of at least 1-1/2 times the component thickness or 5 inches, whichever is less, shall be at least 50 degrees Fahrenheit.

(f) Welding materials shall meet the Owner's Requirements and the Construction Code and Cases specified in the Repair/Replacement Plan. Welding materials shall be controlled so that they are identified as acceptable until consumed.

(g) Peening may be used, except on the initial and final layers.

2.0 WELDING QUALIFICATIONS

The welding procedures and the welding operators shall be qualified in accordance with ASME Section IX and the requirements of 2.1 and 2.2 provided below.

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APPLICATION OF A DISSIMILAR METAL WELD FULL-STRUCTURAL WELD OVERLAY
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APPENDIX 1 (Continued)
AMBIENT TEMPERATURE TEMPERBEAD WELDING

2.1 Procedure Qualification

(a) The base materials for the welding procedure qualification shall be of the same P-Number and Group Number, as the materials to be welded. The materials shall be postweld heat treated to at least the time and temperature that was applied to the materials being welded.

(b) The root width and included angle of the cavity in the test assembly shall be no greater than the minimum specified for the repair.

(c) The maximum interpass temperature for the first three layers of the test assembly shall be 150 degrees Fahrenheit.

(d) The test assembly cavity depth shall be at least 1 inch. The test assembly thickness shall be at least twice the test assembly cavity depth. The test assembly shall be large enough to permit removal of the required test specimens. The test assembly dimensions surrounding the cavity shall be at least the test assembly thickness and at least 6 inches. The qualification test plate shall be prepared in accordance with Figure 1-1.

(e) Ferritic base material for the procedure qualification test shall meet the impact test requirements of the Construction Code and Owner's Requirements. If such requirements are not in the Construction Code and Owner's Requirements, the impact properties shall be determined by Charpy V-notch impact tests of the procedure qualification base material at or below the lowest service temperature of the item to be repaired. The location and orientation of the test specimens shall be similar to those required in (f) below, but shall be in the base metal.

(f) Charpy V-notch tests of the ferritic heat-affected zone (HAZ) shall be performed at the same temperature as the base metal test of (e) above. Number, location, and orientation of test specimens shall be as follows:

(i) The specimens shall be removed from a location as near as practical to a depth of one-half the thickness of the deposited weld metal. The coupons for HAZ impact specimens shall be taken transverse to the axis of the weld and etched to define the HAZ. The notch of the Charpy V-notch specimen shall be cut approximately normal to the material surface in such a manner as to include as much HAZ as possible in the resulting fracture. When the material thickness permits, the axis of a specimen shall be inclined to allow the root of the notch to be aligned parallel to the fusion line.

(ii) If the test material is in the form of a plate or a forging, the axis of the weld shall be oriented parallel to the principal direction of rolling or forging.

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APPENDIX 1 (Continued)
AMBIENT TEMPERATURE TEMPERBEAD WELDING

(iii) The Charpy V-notch test shall be performed in accordance with ASME Section II, Part A, SA-370. Specimens shall be in accordance with SA-370, Figure 11, Type A. The test shall consist of a set of three full-size 10 mm X 10 mm specimens. The lateral expansion, percent shear, absorbed energy, test temperature, orientation and location of all test specimens shall be reported in the Procedure Qualification Record.

(g) The average lateral expansion value of the three HAZ Charpy V-notch specimens shall be equal to or greater than the average lateral expansion value of the three unaffected base metal specimens. However, if the average lateral expansion value of the HAZ Charpy V-notch specimens is less than the average value for the unaffected base metal specimens and the procedure qualification meets all other requirements of this appendix, either of the following shall be performed:

(1) The welding procedure shall be requalified.

(2) An Adjustment Temperature for the procedure qualification shall be determined in accordance with the applicable provisions of NB-4335.2 of Section III, 2001 Edition with 2002 Addenda. The RT_{NDT} or lowest service temperature of the materials for which the welding procedure will be used shall be increased by a temperature equivalent to that of the Adjustment Temperature.

2.2 Performance Qualification

Welding operators shall be qualified in accordance with ASME Section IX.

3.0 WELDING PROCEDURE REQUIREMENTS

The welding procedure shall include the following requirements.

(a) The weld metal shall be deposited by the automatic or machine GTAW process.

(b) Dissimilar metal welds shall be made using A-No. 8 weld metal (ASME Section IX, QW-442) for P-No. 8 to P-No. 1, 3, or 12 (A, B, or C) weld joints or F-No. 43 weld metal (ASME Section IX QW-432) for P-No. 8 or 43 to P-No. 1, 3, or 12 (A, B, or C) weld joints.

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APPENDIX 1 (Continued)
AMBIENT TEMPERATURE TEMPERBEAD WELDING

(c) The area to be welded shall be buttered with a deposit of at least three layers to achieve at least 1/8-inch overlay thickness, with the heat input for each layer controlled to within ±10% of that used in the procedure qualification test. The heat input of the first three layers shall not exceed 45,000 J/inch under any conditions. Particular care shall be taken in the placement of the weld layers of the austenitic overlay filler material at the toe of the overlay to ensure that the HAZ and ferritic base metal are tempered. Subsequent layers shall be deposited with a heat input not exceeding that used for layers beyond the third layer in the procedure qualification.

(d) The maximum interpass temperature for field applications shall be 350^0F for all weld layers regardless of the interpass temperature used during qualification. The interpass temperature limitation of QW-406.3 need not be applied.

(e) The interpass temperature shall be determined by (e)(1). If it is not possible to use (e)(1) then (e)(2) and (e)(3) may be used in combination.

(1) Temperature measurement (e.g., pyrometers, temperature indicating crayons, thermocouples) during welding. Trending of the interpass temperatures during installation of overlays using contact pyrometers has shown that the difference between the observed temperatures and the maximum allowable interpass temperature of 350^0F is large and considerable margin exists. Based on this trending, there is reasonable assurance that the temperature of any bead will not approach the maximum allowable temperature. SNC will monitor the interpass temperature every weld pass for the first three layers. For additional layers, the frequency of measuring interpass temperature may be reduced when the temperature is at least 100^0 F below the 350^0 F limit and trend data supports a reduced monitoring frequency.

(2) Heat flow calculations using the variables listed below as a minimum.
(i) welding heat input
(ii) initial base material temperature
(iii) configuration, thickness, and mass of the item being welded
(iv) thermal conductivity and diffusivity of the materials being welded
(v) arc time per weld pass and delay time between each pass
(vi) arc time to complete the weld

(3) Measurement of the maximum interpass temperature on a test coupon that is equal to or less than the thickness of the item to be welded. The maximum heat input of the welding procedure shall be used in the welding of the test coupon.

(f) Particular care shall be given to ensure that the weld region is free of all potential sources of hydrogen. The surfaces to be welded, filler metal, and shielding gas shall be suitably controlled.

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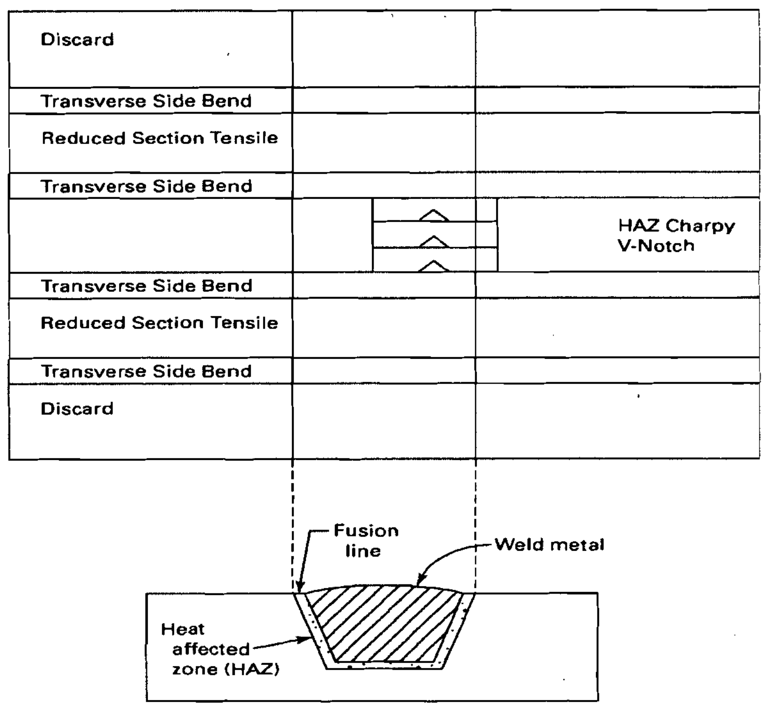
APPENDIX 1 (Continued)
AMBIENT TEMPERATURE TEMPERBEAD WELDING



Base metal Charpy impact specimens are not shown. This figure illustrates a similar-metal weld.

Figure 1-1: QUALIFICATION TEST PLATE

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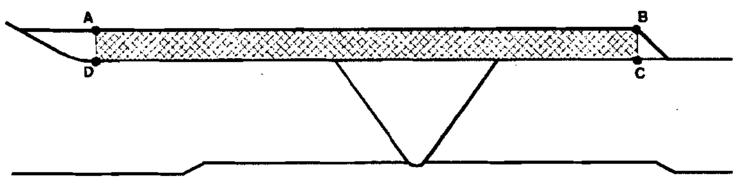
APPENDIX 2
ACCEPTANCE EXAMINATION VOLUME



Examination Volume A-B-C-D

FIGURE 1: ACCEPTANCE EXAMINATION VOLUME

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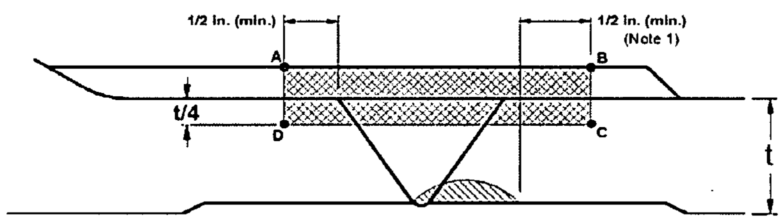
APPENDIX 3
PRESERVICE EXAMINATION VOLUME



Examination Volume A-B-C-D

FIGURE 2: PRESERVICE EXAMINATION VOLUME

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APPENDIX 4
COMPARISON OF PROPOSED ALTERNATIVE WITH N-504-2

CODE CASE N-504-2	PROPOSED ALTERNATIVE
N-504-2 for weld overlay repair of SS piping	Proposed alternative is for dissimilar metal weld overlay repairs.
Reply-reduce a flaw to acceptable size by weld overlay on austenitic SS piping	*Reply*- reduce a flaw to acceptable size by weld overlay on austenitic stainless steel or austenitic nickel alloy piping, components and associated welds
Material covered is P-8	Per Section 1.0(a) of Appendix 1 materials covered are P-8 or P-43 and P-1, 12A, 2B or 12c or between P-1, 3, 12A, 12B or 12C. Also includes P-8 to P-43, P-8 to P-8 or P-43 to P-43 joined with austenitic filler materials
(b) Filler Material – low C (0.035% max) SS	(b) Filler Materials – Low C (0.035% max) SS or austenitic nickel alloy (28% Cr min.)
(c) (d) Repair of indications prior to overlay	(c) Repair of indications prior to overlay (Same as N-504-2)
(e) Weld Reinforcement Min. 2 layers with-7.5 FN. In first austenitic SS layer 5 FN acceptable by evaluation.	(d) Weld Reinforcement (1) Min. 2 layers with-7.5 FN. In first layer 5FN acceptable if deposited weld metal less than 0.02% C. (2) Provides requirements for austenitic nickel alloy weld overlay.
(f) (g) Design – Requires flaw evaluation of the existing flaw based on IWB-3640 for design life. Requires postulated 100 % through wall for design of the weld overlay (full-structural) except for four or fewer axial flaws. Meet ASME Section III for primary local and bending stresses and secondary peak stresses. Requires end transition slope less than 45 degrees. Axial length requirement usually met if overlay 0.75 $(Rt)^{1/2}$ beyond flaws. Shrinkage and other applied loads evaluated on other items and other flawed welds in system.	2.0 Design Requires flaw evaluation of the existing flaw based on IWB-3640. Flaw evaluation of both materials required if flaw is at or near the boundary. Requires postulated 100 % through wall for design (full-structural) of the weld overlay. Axial length and end slope shall cover the weld and heat affected zones and shall provide for load redistribution into the item and back into the overlay either out violating stress limits. There is no exception for four or fewer axial flaws. Design analysis per IWA-4311. Meet ASME Section III, NB-3200 applicable stress limits. Any laminar flaws in the weld overlay evaluated to ensure load distribution meets NB-3200. Same as N-504-2 for shrinkage and evaluation of other existing flaws.

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APPENDIX 4
COMPARISON OF PROPOSED ALTERNATIVE WITH N-504-2

N-504-2	PROPOSED ALTERNATIVE
(i) No specific reference given for acceptance examination of the weld overlay. Acceptance criteria of the Construction Code and Section III would be applicable. (Causes problems with volumetric acceptance criteria since construction criteria based on RT examination rather than UT examination. Also presents difficulty in determining applicable criteria for laminar flaws in the overlay) Preservice Exams to the methods of IWB-2200. Exam procedures shall be specified in the Repair Program. Acceptance standard-IWB-3514-2 (planar flaws). UT exams to verify integrity of new applied weld reinforcement. Include upper 25% of pipe wall in the examination.	3.0 Examination and Inspection Examinations in the proposed alternative shall be met in lieu of all other exams. NDE methods to IWA-2200 except as specified in the case. NDE personnel qualified to IWA-2300. UT procedures and personnel qualified to Section XI, Appendix VIII. (a) Acceptance Examinations-Surface finish 250 micro-inch (or 225 RA) and flatness sufficient to allow adequate examination in accordance with Appendix VIII procedures. PT the overlay and ½-inch on either side of the overlay. Acceptance standards for the PT of the weld overlay, meet weld Construction Code criteria or NB-5300. Base material, meet base material criteria or NB-2500. A 48-hour hold time after the third layer is completed is imposed when ambient temperature temperbead welding is used. UT examination for acceptance Figure 1 shows the examination volume. IWB-3514-2 for planar flaw acceptance. IWB-3514-3 for laminar flaw acceptance with additional limitation not to exceed 10% of the surface area and no linear dimension in excess of 3 inches. Reduction in coverage limited to 10%. Criteria for radial planar flaw size in the uninspected volume for IWB-3640 evaluation. (b) Preservice Examinations Figure 2 defines the examination volume. Angle beam exam parallel and perpendicular to piping axis. Scan in four directions to locate and size flaws. Acceptance criteria IWB-3514-2 for the overlay. Wall thickness t_w is the thickness of the overlay. Flaws in outer 25% of base material meet design requirements of 2.0.

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APPENDIX 4
COMPARISON OF PROPOSED ALTERNATIVE WITH N-504-2

N-504-2	PROPOSED ALTERNATIVE
	(c) Inservice Examinations Use Q-4300 of Appendix Q to the 2004 Edition of Section XI with Addenda through 2005. (d) Additional Examinations Use Q-4300 of Appendix Q to the 2004 Edition of Section XI with Addenda through 2005.
(h) System Hydrostatic Test if pressure boundary penetrated (leak). System Leakage Test if pressure boundary not penetrated (no leak).	4.0 Pressure Testing System Leakage Test per IWA-5000
(k) VT-3 of snubbers, supports and restraints after welding	There are no snubbers, supports, or whip restraints.
(l) Reference to other applicable requirements of IWA-4000	IWA-4000 requirements would be met unless an alternative provided
(m) Use of case to be documented on an NIS-2 form	5.0 Documentation Use of case to be documented on an ASME Form NIS-2 (or ASME Form NIS-2A).

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APPENDIX 5
COMPARISON OF APPENDIX 1 OF PROPOSED ALTERNATIVE WITH N-638-1

N-638-1	**APPENDIX 1 OF THE PROPOSED ALTERNATIVE**
Code Case N-638-1 provides rules for automatic or machine GTAW temperbead welding without pre-heat or post weld heat treatment. The case covers similar and dissimilar welding for cavity and overlay repairs. The code case permits the use of NDE examinations in accordance with the case in lieu of those in the Construction Code. This case has a broader scope of use then Appendix 1.	Appendix 1 is invoked in by 1.(b) of the alternative for use of ambient temperature temperbead welding as an alternative to the post weld heat treatment requirements of the Construction Code and Owner's requirements. The appendix provides the ambient temperature temperbead requirements applicable to dissimilar metal weld overlay repairs. NDE requirements are in lieu of the Construction Code and were covered in Section 3.0 of the alternative.
1.0 General Requirements	1.0 General Requirements
Scope of welds in the Reply	(a) Scope of welds. Same as N-638-1
(a) Max area of finished surface of the weld limited to 100 square inches and half of the ferritic base metal thickness. (Note: the depth requirement is for the ferritic material. There is no need to limit either surface area or depth for welding on austenitic SS or nickel alloys since no post weld heat treatment is required.)	(b) Surface area limitation 300 square inches over the ferritic material. (Note: Code Case N-638-3 which has been approved by ASME but has not been issued in Supplement 9. Residual stress analyses results show that stresses for 100 square inches through 500 square inches surface area overlays very similar.)
(b) (c) (d) (e) (f)	(c) (d) (e) (f) (g) same as requirements listed for N-638-1
1.0 Welding Qualifications The welding procedures and welding operators shall be qualified in accordance with Section IX and the requirements of 2.1 and 2.2	2.0 Welding Qualifications The welding procedures and welding operators shall be qualified in accordance with Section IX and the requirements of 2.1 and 2.2
2.1 Procedure Qualification Sections (a) (d) (e) (f) (g) Section (h) Section (i) Section (j)	2.1 Procedure Qualification Sections (a) (b) (c) (d) (e) same as in N-638-1 for equivalent paragraphs. Equivalent paragraph not in Appendix 1. Section (f) same as (i) from N-638-1. Section (g) changed the first sentence adding "lateral expansion" in front of "value" both at the beginning and end of the sentence. Additional provisions as follow

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APPENDIX 5
COMPARISON OF APPENDIX 1 OF PROPOSED ALTERNATIVE WITH N-638-1

N-638-1	APPENDIX 1 OF THE PROPOSED ALTERNATIVE
Section (b) Provisions for welding in a pressurized environment Section (c) Provisions to address radiation effects	were added: However if the average lateral expansion value of the HAZ Charpy V-notch specimens is less than the average value of the unaffected base metal specimen and the procedure qualification meets all other requirements of this appendix, either of the following shall be performed: (1) The welding procedure shall be requalified. (2) An Adjustment Temperature for the procedure qualification shall be determined in accordance with the applicable provisions of NB-4335.3 of Section III, 2001 Edition with 2002 Addenda. RT_{ndt} or lowest service temperature of the materials for which the welding procedure will be used shall be increased by a temperature equivalent to that of the Adjustment Temperature. This is identical wording to N-638-2, which has been approved by ASME. Not included for overlays in Appendix 1. Not included in Appendix 1. Thermal neutron limitation imposed in the proposed alternative.
1.1 Performance Qualification Welding operators shall be qualified in accordance with Section IX.	2.2 Performance Qualification Welding operators shall be qualified in accordance with Section IX.
3.0 Welding Procedure Requirements	3.0 Welding Procedure Requirements
(no corresponding section)	(e) Section added to clarify temperature measurement requirements. This is identical wording to N-638-2, which has been approved by ASME.
(a) (b) (c)	(a) (b) (c) same as N-638-1 except last two

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APPENDIX 5 COMPARISON OF APPENDIX 1 OF PROPOSED ALTERNATIVE WITH N-638-1	
N-638-1	**APPENDIX 1 OF THE PROPOSED ALTERNATIVE**
(d)	sentences deleted in (c) from N-638-1 since not applicable to this proposed alternative. (d) same as N-638-1 but the following added: The interpass temperature of QW-406.3 need not be applied. This is identical wording to N-638-2, which has been approved by ASME.
(no corresponding section)	(e) Section added to clarify temperature measurement requirements. This is identical wording to N-638-2, which has been approved by ASME.
(e)	(f) same as (e) from N-638-1
4.0 Examination The final weld surface and the band around the area defined in paragraph 1.0(d) of N-638-1 shall be examined using surface and ultrasonic methods when the completed weld has been at ambient temperature for at least 48 hours.	Examination and Inspection is shown in Section 3 of the proposed alternative.
5.0 Documentation	Documentation is shown in Section 5 of the proposed alternative.
(no corresponding section)	Pressure Testing is shown in Section 4 of the proposed alternative.

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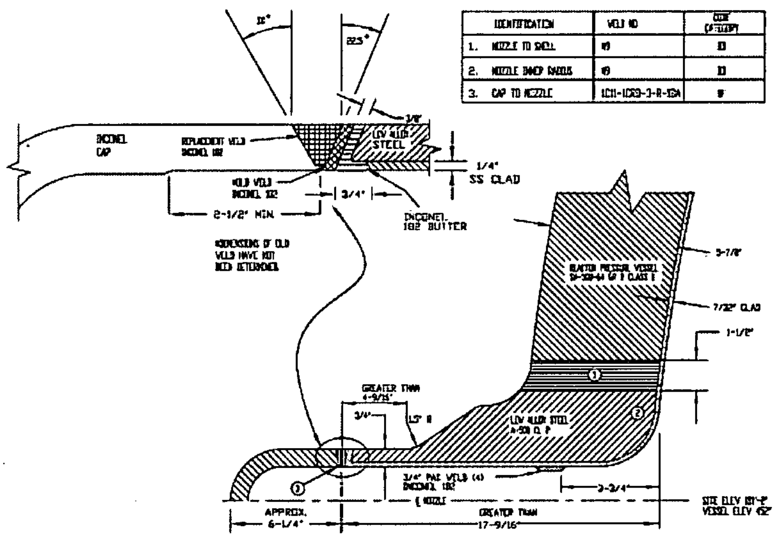
APPENDIX 6

FIGURE 1
EXISTING WELD CONFIGURATION



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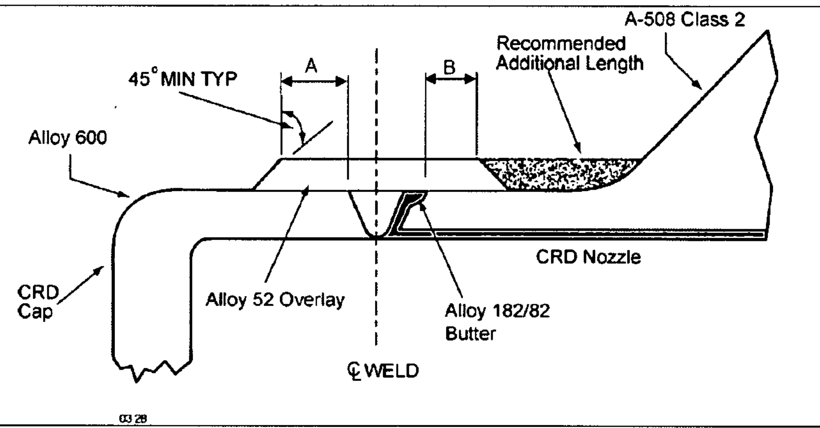
APPENDIX 6 (Continued)

FIGURE 2
OVERLAY CONFIGURATION



WELD NUMBER	FLAW CHARACTERIZATION	Design Dimensions t	A	B	COMMENTS
Nozzle N9 CRD Hydraulic Return Cap Weld	Assumed 360° Circ. 100% throughwall flaw	0.25" see Note 4	1.0" MIN	1.0" MIN	A is measured from the weld-cap interface; B is measured from the butter-nozzle interface

1. Component surface is to be examined by dye penetrant method and accepted as clean prior to overlay application.
2. In the event that the original component surface does not pass the note 1 requirements, the final deposited temper bead weld layer is to be examined by dye penetrant method and accepted as clean before proceeding with subsequent layers.
3. Weld overlay wire shall be ERNiCrFe-7 (Alloy 52), or equivalent.
4. The design thickness (0.25 inch) is the minimum thickness beyond the first PT clean surface or layer.
5. Apply as many layers as required to achieve the design overlay thickness "t".
6. Design thickness includes no allowance for surface conditioning operations to facilitate UT inspection.
7. Design length is that required for structural reinforcement; greater length may be required for effective UT inspection. This is to be determined in the field.

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APPENDIX 7

JUSTIFICATION FOR PERFORMING EXAMINATIONS 48 HOURS AFTER THE COMPLETION OF THE THIRD WELD LAYER

American Society of Mechanical Engineers (ASME) Code, Section XI, Code Case N-638-1 requires (when ambient temperbead welding is used over ferritic materials) that surface and ultrasonic examinations be performed when the completed weld has been at ambient temperature for least 48 hours. This delay was provided to allow sufficient time for hydrogen cracking to occur (if it is to occur) in the heat affected zone (HAZ) of ferritic materials prior to performing examinations, to ensure detection by non-destructive examinations (NDE). However, based on research and industry experience, EPRI has provided a technical basis for starting the 48-hour hold after completion of the third temperbead weld layer rather than waiting for the weld overlay to cool to ambient temperature. Weld layers beyond the third layer are not designed to provide tempering to the ferritic HAZ during ambient temperature temperbead welding. EPRI has documented their technical basis in Technical Update report 1013558, "Repair and Replacement Applications Center: Temperbead Welding Applications 48-Hour Hold Requirements for Ambient Temperature Temperbead Welding" (ADAMS Accession No. ML070670060). The technical data provided by EPRI in their report is based on testing performed on SA-508, Class 2 low-alloy steels, which is the nozzle material. After evaluating all of the issues relevant to hydrogen cracking such as microstructure of susceptible materials, availability of hydrogen, applied stresses, temperature, and diffusivity and solubility of hydrogen in steels, EPRI concluded that: "...[t]here appears to be no technical basis for waiting the 48 hours after cooling to ambient temperature before beginning the NDE of the completed weld. There should be no hydrogen present, and even if it were present, the temperbead welded component should be very tolerant of the moisture..." EPRI also notes that over 20 weld overlays and 100 repairs have been performed using temperbead techniques on low alloy steel components over the last 20 years. During this time, there has never been an indication of hydrogen cracking by the non-destructive examinations performed after the 48-hour hold or by subsequent ISI examinations.

In addition, the ASME database, C&S Connect, for Code Case N-638-4 contains background material consisting of a Technical Basis Paper to support the 48-hour hold time alternative. The Technical Basis Paper (ADAMS Accession No. ML070790679) points out that the introduction of hydrogen to the [ferritic] HAZ is limited to the first weld layer since this is the only weld layer that makes contact with the [ferritic] base material. While the potential for the introduction of hydrogen to the [ferritic] HAZ is negligible during subsequent weld layers, these layers provide a heat source that accelerates the dissipation of hydrogen from the [ferritic] HAZ in non-water backed applications. The Technical Basis Paper concludes that there is sufficient delay time to facilitate the detection of potential hydrogen cracking when NDE is performed 48 hours after completion of the third weld layer.

Furthermore, the solubility of hydrogen in austenitic materials such as Alloy 52M is much higher than that of ferritic materials while the diffusivity of hydrogen in austenitic materials is lower than that of ferritic materials. As a result, hydrogen in the ferritic HAZ tends to diffuse into the austenitic weld metal, which has a much higher solubility for hydrogen. This diffusion process is enhanced by heat supplied in subsequent weld layers.

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APPENDIX 7

JUSTIFICATION FOR PERFORMING EXAMINATIONS 48 HOURS AFTER THE COMPLETION OF THE THIRD WELD LAYER (Continued)

Based on this information, SNC concludes that performing NDE 48 hours after the third weld layer is installed will provide an acceptable level of quality and safety. As a precedent see the April 6, 2007, safety evaluation for Arkansas Nuclear One, Unit 1 (TAC NO. MD4019) and the December 19, 2007 safety evaluation for Farley Nuclear Plant Units 1 and 2 (TAC NOS. MD6304 and MD6305).

Enclosure 1

SOUTHERN NUCLEAR OPERATING COMPANY
ISI-ALT-08-01, VERSION 1.0
PROPOSED ALTERNATIVE IN ACCORDANCE WITH 10 CFR 50.55a(a)(3)(i)
APPLICATION OF A DISSIMILAR METAL WELD FULL-STRUCTURAL WELD OVERLAY
HATCH NUCLEAR PLANT UNIT 1

APPENDIX 8

Q-4300 EXAMINATION REQUIREMENTS

Q-4300 Inservice Examination Requirements

(a) The weld overlay examination volume in Fig. Q-4300-1 shall be added to the inspection plan and shall be ultrasonically examined during the first or second refueling outage following application.

(b) The weld overlay examination volume in Fig. Q-4300-1 shall be ultrasonically examined to determine if any new or existing cracks have propagated into the upper 25% of the pipe base material or into the overlay. The angle beam shall be directed perpendicular and parallel to the pipe axis, with scanning performed in four directions.

Modified Q-4300 Inservice Flaw Evaluation Requirements

(a) Flaws characterized as SCC in the Alloy 52/152 weld overlay are unacceptable and the use of IWB-3514-2 and IWB-3640 for SCC evaluation in the Class 1 overlay material is prohibited.

(b) For non-SCC flaws in the Alloy 52/152 overlay, Table IWB-3514-2 must be used to evaluate recordable indications prior to the use of the acceptance criteria of IWB-3600. If the requirements of Table IWB-3514-2 cannot be satisfied, the acceptance criteria of IWB-3600 shall be satisfied. For unacceptable indications, the weld overlay (or the portion of the weld overlay containing the unacceptable indication) shall be removed and corrected by a repair/replacement activity in accordance with IWA-4000.

(c) If examinations reveal crack growth or new cracking in the upper 25% of the original weld or base materials, the as-found flaw (postulated 75% through wall, plus the portion of the flaw in the upper 25%) will be used to re-evaluate the crack growth analysis. The size of all flaws will be projected to the end of the design life of the overlay. Crack growth, including both stress corrosion and fatigue crack growth, shall be evaluated in the materials in accordance with IWB-3640. If the flaw is at or near the boundary of two different materials, evaluation of flaw growth in both materials is required. For unacceptable indications, the weld overlay shall be removed, including the original defective piping weldment, and corrected by a repair/replacement activity in accordance with IWA-4000.

Modified Q-4300 Re-examination Requirements

(a) Weld overlay examination volumes that show no indication of crack growth or new cracking shall be placed into a population to be examined on a sampling basis. Twenty-five percent of this population shall be examined once every ten years.

Enclosure 1

SOUTHERN NUCLEAR OPERATING COMPANY
ISI-ALT-08-01, VERSION 1.0
PROPOSED ALTERNATIVE IN ACCORDANCE WITH 10 CFR 50.55a(a)(3)(i)
APPLICATION OF A DISSIMILAR METAL WELD FULL-STRUCTURAL WELD OVERLAY
HATCH NUCLEAR PLANT UNIT 1

APPENDIX 8
Q-4300 EXAMINATION REQUIREMENTS (Continued)

(b) If inservice examinations reveal *acceptable* crack growth or new cracking *in the upper 25% of the original weld or base materials*, the weld overlay examination volume shall be reexamined during the first or second refueling outage following discovery of the growth or new cracking. Weld overlay examination volumes that show no additional indication of crack growth or new cracking shall be placed into a population to be examined on a sample basis. Twenty-five percent of this population shall be examined once every ten years.

(c) *If inservice examinations reveal acceptable non-SCC flaws in the overlay material, the weld overlay examination volume shall be reexamined during the first or second refueling outage following discovery of the growth or new cracking. Weld overlay examination volumes that show no additional indication of crack growth or new cracking shall be placed into a population to be examined on a sample basis. Twenty-five percent of this population shall be examined once every ten years.*

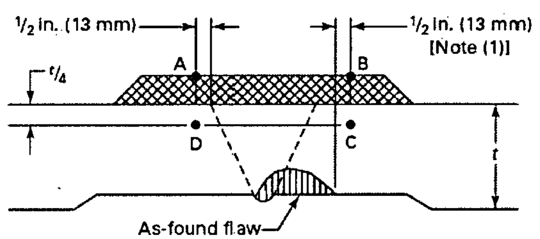
Q-4310 Additional Examinations

If inservice examinations reveal an unacceptable indication, crack growth into the weld overlay design thickness, or axial crack growth beyond the specified examination volumes, additional weld overlays, equal to the number scheduled for the current inspection period, shall be examined prior to return to service. If additional unacceptable indications are found in the second sample, a total of 50% of the total population of weld overlays shall be examined prior to operation. If additional unacceptable indications are found, the entire remaining population of weld overlays shall be examined prior to return to service.

Enclosure 1

SOUTHERN NUCLEAR OPERATING COMPANY
ISI-ALT-08-01, VERSION 1.0
PROPOSED ALTERNATIVE IN ACCORDANCE WITH 10 CFR 50.55a(a)(3)(i)
APPLICATION OF A DISSIMILAR METAL WELD FULL-STRUCTURAL WELD OVERLAY
HATCH NUCLEAR PLANT UNIT 1

APPENDIX 8
Q-4300 EXAMINATION REQUIREMENTS (Continued)



Examination Volume A-B-C-D

NOTE:
(1) For axial or circumferential flaws, the axial extent of the examination volume shall extend at least ½ in. (13 mm) beyond the as-found flaw and at least ½ in. (13 mm) beyond the toes of the original piping weldment, including weld end butter, where applied.

FIG. Q-4300-1 PRESERVICE AND INSERVICE EXAMINATION VOLUME

Edwin I. Hatch Nuclear Plant

Proposed Alternative in Accordance with 10 CFR 50.55a(a)(3)(i)
Application of a Dissimilar Metal Weld Full-Structural Weld Overlay

Enclosure 2

ISI-GEN-ALT-08-01, Version 1.0
List of Regulatory Commitments

Enclosure 2

ISI-GEN-ALT-08-01, Version 1.0
List of Regulatory Commitments

The following table identifies those actions committed by Southern Nuclear Operating Company in this document for Edwin I. Hatch Nuclear Plant. Any other statements in this submittal are provided for information purposes and are not considered to be regulatory commitments.

Commitment	Type		Scheduled Completion Date (If Required)
	One-Time Action	Continuing Compliance	
SNC will report to the NRC (1) the examination results of the weld overlay and (2) a discussion of any repairs to the overlay material and/or base metal and the reason for repair.	X		Within 14 days after ultrasonic examination of weld overlay installations
SNC will report to the NRC the results of the stress analysis report, which will include results showing that the requirements of Subarticles NB-3200 and NB-3600 of the ASME Code, Section III are satisfied. The stress analysis will also include results showing that the requirements of IWB-3000 of the ASME Code, Section XI, are satisfied. The results will show that the postulated crack including its growth in the nozzles would not adversely affect the integrity of the overlaid welds.	X		Within 90 calendar days of the completion of the refueling outage

David H. Jones
Vice President
Engineering

Southern Nuclear
Operating Company, Inc.
40 Inverness Center Parkway
Birmingham, Alabama 35242

Tel 205.992.5984
Fax 205.992.0341

SOUTHERN COMPANY
Energy to Serve Your World℠

February 28, 2008

Docket No.: 50-321

NL-08-0311

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

Edwin I. Hatch Nuclear Plant – Unit 1
Response to NRC Request for Additional Information Regarding
Application of a Dissimilar Metal Weld Full-Structural Weld Overlay

Ladies and Gentlemen:

By letter dated February 26, 2008 Southern Nuclear Operating Company (SNC) requested NRC approval of proposed alternative ISI-ALT-08-01, Version 1.0 to allow the application of a full-structural weld overlay over weld 1C11-1CRD-3-R-18A, pursuant to 10 CFR 50.55a(a)(3)(i). On February 27, 2008 the NRC provided an e-mail Request for Additional Information (RAI) to SNC. Additionally, these RAIs were discussed in a telephone conversation between SNC and the NRC on February 28, 2008.

The SNC response to the NRC RAIs is provided in Enclosure 1. If you have any questions, please contact Ray Baker at 205-992-7367.

Sincerely,

D. H. Jones
Vice President – Engineering

DHJ/MNW/daj

Enclosure: 1. SNC Responses to NRC Request for Additional Information Regarding Proposed Alternative ISI-ALT-08-01, Version 1.0

U. S. Nuclear Regulatory Commission
NL-08-0311
Page 2

cc: Southern Nuclear Operating Company
Mr. J. T. Gasser, Executive Vice President
Mr. D. R. Madison, Vice President – Hatch
RTYPE: CHA02.004

U. S. Nuclear Regulatory Commission
Mr. V. M. McCree, Acting Regional Administrator
Mr. R. E. Martin, NRR Project Manager – Hatch
Mr. J. A. Hickey, Senior Resident Inspector – Hatch

Edwin I. Hatch Nuclear Plant
Proposed Alternative in Accordance with 10 CFR 50.55a(a)(3)(i)
Application of a Dissimilar Metal Weld Full-Structural Weld Overlay

Enclosure 1

SNC Response to Request for Additional Information

Enclosure 1

SNC Response to Request for Additional Information

OFFICE OF NUCLEAR REACTOR REGULATION
REQUEST FOR ADDITIONAL INFORMATION
EDWIN I. HATCH PLANT UNIT 1
SOUTHERN COMPANY
REQUEST FOR STRUCTURAL OVERLAY
DOCKET NO. 50-321

The Nuclear Regulatory Commission (NRC) staff has reviewed the Southern Company (the licensee) request dated February, 26, 2008, for application of a dissimilar metal weld full structural overlay at the Edwin I. Hatch Plant, Unit 1, and has determined that additional information is necessary to complete the review of their request for relief. Based on the staff's review, please provide a response which addresses the following request for additional information (RAI) questions.

NRC Question 1

Since the ASME Code, Section XI, Code Case N-504-3 became effective as of December 19, 2007, the staff recommends that it should use Code Case N-504-3 in lieu of Code Case N-504-2.

SNC Response

For the preparation of this alternative, Southern Nuclear Operating Company (SNC) initiated discussions with the NRC staff on February 25, 2008 regarding the development of an alternative for a full-structural weld overlay on the CRD return nozzle N9. It was agreed that SNC would develop the alternative based on the technical information previously submitted in ISI-GEN-ALT-07-01, Version 2.0, which was submitted on December 26, 2007 for Farley Nuclear Plant and the Vogtle Electric Generating Plant. ISI-GEN-ALT-07-01, Version 2 references Code Case N-504-2 and provides a comparison of Code Case N-504-2 to the technical content in ISI-GEN-ALT-07-01, Version 2. Therefore, since ISI-GEN-ALT-07-01, Version 2 referenced Case N-504-2, this alternative for Hatch Nuclear Plant Unit 1 (HNP-1) also referenced Case N-504-2.

NRC Question 2

The licensee has stated that the weld overlay of the dissimilar metal welds may require welding no more than 300 square inches of surface on the steel base material. What is the specific maximum area of the carbon or low alloy steel material for that will be welded on? This should be stated in Relief Request for each component to be overlayed.

SNC Response

CRD return nozzle N9 is a small diameter nozzle with a design circumference of approximately 17." If it is determined that the overlay will be extended out to the nozzle radius as shown in Appendix 6, Figure 2, the overlay length from the edge of the weld to the nozzle would not exceed 5.5 inches; therefore, the maximum area of the overlay in this region is less than 94 square inches.

Enclosure 1

SNC Response to Request for Additional Information

__NRC Question 3__

Provide the American Society of Mechanical Engineers (ASME) SA or American Society for Testing and Materials (ASTM) material and grade or class of materials for each component to be overlayed.

__SNC Response__

GE document titled, "Hydraulic System Return Nozzle," is a controlled document within SNC's Appendix B program. Per this document, the nozzle material is SA-508, Class II (P No. 3) and the Cap material is SB-166 (P No. 43). The weld material is Alloy 82/182 (F No. 43).

__NRC Question 4__

Since full ultrasonic examination of the final weld surface and band area (1.5T width) as required by Code Case N-638-1 will not be performed, provide a detailed explanation for the basis for these alternative examinations. Figure 1 in Appendix 2 indicates that no UT examination will be performed beyond AD into the nozzle. Since this area is not volumetrically inspected, any cracks in the nozzle underneath the overlay will not be detected. Provide an explanation for not performing UT in this area.

__SNC Response__

Figure 1 in Appendix 2 defines the examination volume for the acceptance examination of the overlay and, as discussed, it does not require examination of volume below the overlay. However, a preservice examination will be performed in conjunction with the acceptance examination. The preservice examination volume shown in Figure 2 of Appendix 2 shows that the overlay and the upper 25% of the base material will be examined out to ½" from the edge of the weld. SNC considers Figure 2 to be a minimum coverage requirement and will examine the entire length of overlay and the upper 25% of the base metal, to the extent practical.

__NRC Question 5__

Item (g)(2) of the ASME Code, Section XI, Code Case N-504-2 requires that for repair welds the evaluation shall consider residual stresses produced by the structural overlay with other loads applied on the system. The effects of water backing on the repair weld shall be considered. The evaluation shall demonstrate that the requirements of IWB-3640 of the ASME Code, Section XI, 2001 Edition with Addenda through 2003 are satisfied. Consistent with this requirement, the licensee should make a statement in its Relief Request that it will consider the effect of water backing in the evaluation for the structural overlay on the CRD return nozzle N9.

__SNC Response__

SNC will consider the effect of water backing in the evaluation for the structural overlay on the CRD return nozzle N9. An evaluation will be submitted to the NRC within 90 days after plant startup.

A.13 James A. FitzPatrick N-2C (RR)

Entergy

Entergy Nuclear Northeast
Entergy Nuclear Operations, Inc.
James A. Fitzpatrick NPP
P.O. Box 110
Lycoming, NY 13093
Tel 315-342-3840

JAFP-08-0102
October 1, 2008

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

SUBJECT: James A. FitzPatrick Nuclear Power Plant
Docket No. 50-333
License No. DPR-59

James A. FitzPatrick Request for Relief (RR-7 Revision 1) - Proposed Alternative to ASME Code Requirements for Weld Overlay Repairs

REFERENCES:
1) Entergy Letter to NRC, JAFP-08-0099, "James A. FitzPatrick Request for Relief (RR-7) - Proposed Alternative to ASME Code Requirements for Weld Overlay Repairs", dated September 26, 2008
2) Teleconference between Entergy Nuclear, James A. FitzPatrick Nuclear Power Plant, and NRC, Request Clarification Regarding "James A. FitzPatrick Request for Relief (RR-7) - Proposed Alternative to ASME Code Requirements for Weld Overlay Repairs", October 1, 2008

Dear Sir or Madam:

Pursuant to 10 CFR 50.55a(a)(3), Entergy submitted "James A. FitzPatrick Request for Relief (RR-7) - Proposed Alternative to ASME Code Requirements for Weld Overlay Repairs", JAFP-08-0099, dated September 26, 2008 (Reference 1). On October 1, 2008 staff from Entergy Nuclear and the James A. FitzPatrick Nuclear Power Plant (JAF) participated in a teleconference with the NRC Staff to discuss clarification on two items:

1) The Licensee has eliminated the statement "Welding procedures and welding operators shall be qualified in accordance with ASME Section IX and the requirements of Sections 2.1 and 2.2 below," from paragraph 2.0 on page 1 of Attachment 3 to Enclosure 1;

2) The term, "AMTB" on the bottom of page 1 of Attachment 4 to Enclosure 1 is not defined.

JAF has added the statement regarding the qualification of welding procedures and welding operators and defined AMTB (Ambient Temperature Temperbead) in Attachments 3 and 4 respectively to Relief Request RR-7 Revision 1.

This letter transmits "James A. FitzPatrick Request for Relief (RR-7 Revision 1) - Proposed Alternative to ASME Code Requirements for Weld Overlay Repairs".

JAF requests approval of the relief request by October 3, 2008 in support of the current refueling outage.

A047
NRR

JAFP-08-0102
Page 2 of 2

If you have any questions or require additional information, please contact Mr. Eugene Dorman, Acting Licensing Manager, at 315-349-6810.

Enclosure 1 contains Request for Relief RR-7 Revision 1, Alternative Repair plan for Reactor Pressure Vessel Nozzle-to-Safe End Welds and Enclosure 2 contains the four regulatory commitments associated with the proposed Relief Request RR-7 Rev. 1.

Sincerely,

Eugene Dorman
Acting Licensing Manager

ED/ed

cc:

Mr. Samuel J. Collins, Regional Administrator
U.S. Nuclear Regulatory Commission, Region
475 Allendale Road
King of Prussia, PA 19406-1415

Office of NRC Resident Inspector
James A. Fitzpatrick Nuclear Power Plant
P.O. Box 136
Lycoming, New York 13093

Mr. Paul Tonko, President
New York State Energy Research and Development Authority
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Albany, New York 12203-6399

Mr. Bhalchandra Vaidya, Project Manager
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3. Empire State Plaza
Albany, New York 12223-1350

Enclosure 1 to JAF-08-0102

James A. Fitzpatrick Nuclear Power Station
Docket No. 50-333

RELIEF REQUEST RR-7 Revision 1,
ALTERNATIVE REPAIR PLAN FOR REACTOR PRESSURE VESSEL
NOZZLE-TO-SAFE END WELD

Enclosure 1 JAFP-08-0102
Relief Request RR-7 Rev. 1

Enclosure 1 Table of Contents

Enclosure 1 JAFP-08-0102
Relief Request RR-7 Rev. 1

ENTERGY NUCLEAR OPERATIONS, INC.
James A. FitzPatrick Nuclear Power Plant

REQUEST FOR RELIEF
JAF RR-7 Rev. 1

I. ASME CODE COMPONENTS AFFECTED

Components:	ISI Weld N-2C-SE	Reactor Pressure Vessel "N-2C" Nozzle Dissimilar Metal Weld to Recirculation Inlet Piping
Code Class:	1	

References:

1. ASME Section XI - 2001 Edition / 2003 Addenda except as listed in Reference 2
2. ASME Section XI - 2001 Edition to be used for Appendix VIII, "Performance Demonstration for Ultrasonic Examination Systems"
3. ASME Section III, – 1965 Edition/1966 Addenda
4. ASME Section III, Subsection NB – 2001 Edition/2003 Addenda
5. JAF-RPT-06-001, *ASME B&PV Code Section XI, Fourth Ten Year Inspection Interval Inservice (ISI) Program Plan*
6. EPRI Report 1011898, *Justification for the Removal of the 100 Square Inch Temperbead Weld Repair Limitation*
7. EPRI Report GC-111050, *Ambient Temperature Preheat for Machine GTAW Temperbead Applications*
8. EPRI Report 1013558, *Temperbead Welding Applications – 48 hour Hold for Ambient Temperature Temperbead Welding*
9. EPRI Report BWRVIP-75-A, *Technical Basis for Revisions to Generic Letter 88-01 Inspection Schedules (1012621)*
10. ASME Code Case N-740
11. ASME Code Case N-504-3
12. ASME Code Case N-638-1
13. Relief Request RR-5, *Relief from ASME Section XI Appendix VII, Supplement 11 Requirements for Structural Weld Overlays (PDI)*

Unit / Inspection Interval Applicability: James A. Fitz Patrick Nuclear Power Plant (JAF) / Fourth (4th) 10-Year Interval and the period of extended operation.

Enclosure 1 JAFP-08-0102
Relief Request RR-7 Rev. 1

II. APPLICABLE CODE REQUIREMENT

The ASME Code (Code), Section XI, Subsections IWA-4411 and IWA-4520(a) require that repair/replacement activities be performed and examined in accordance with the Owner's Requirements and the original Construction Code of the component or system. Alternatively, Subsections IWA-4411(a) and (b) allow use of later Editions/Addenda of the Construction Code (or a later different Construction Code such as ASME Section III) and revised Owner Requirements. Subsections IWA-4411(e) and IWA-4600(b) provide alternative welding methods when the requirements of Subsection IWA-4411 cannot be met. Subsection IWA-4530(a) requires the performance of pre-service examinations based on Subsection IWB-2200 for Class 1 components. Table IWB-2500, Category B-F, prescribes inservice inspection requirements for Class 1 butt welds in piping.

III. REASON FOR PROPOSED ALTERNATIVE

Intergranular stress corrosion cracking (IGSCC) in boiling water reactor (BWR) piping was identified as a problem in the United States in the early 1970s. Initially, cracking was only observed in small-bore piping. However, in 1982 cracking caused by IGSCC was also identified in large-bore piping. JAF manages this condition by performing routine inservice inspections in accordance with ASME Section XI and the inspection requirements of BWRVIP-75A.

JAF is presently in Refueling Outage R-18. During this outage, twelve (12) Category "D"[1] dissimilar metal welds (DMW) have been scheduled for ultrasonic (UT) examination to comply with BWRVIP-75A. Eight (8) of these DMWs are on Reactor Pressure Vessel (RPV) N-2 nozzle-safe-ends. During UT examination of the N-2C nozzle to safe-end DMW, an axial indication approximately 0.8" long with a 0.5" (approximately 40%) through-wall depth was detected. Due to the high IGSCC crack growth rate, the DMW with the axial indication cannot be accepted by an ASME Section XI, IWB-3600 analytical evaluation. As a result, Entergy proposes to repair the subject DMW by installing a structural weld overlay.

JAF performs repair/replacement activities in accordance with the 2001 Edition / 2003 Addenda of ASME Section XI, except as described in Reference 2. This Edition of ASME Section XI does not include requirements for application of a full structural weld overlay. Moreover, requirements for installing full structural weld overlay on DMWs are not presently included in any Edition/Addenda of ASME Section XI (including Code Cases) approved by the NRC.

Structural weld overlays have been used for years on piping of both BWRs and pressurized water reactors (PWRs) to arrest the growth of existing flaws while establishing a new structural pressure boundary. Until recently, these weld overlays were applied in accordance with various revisions of ASME Code Cases N-504 and N-638. (At present, code case revisions N-504-3 and N-638-1 are "conditionally accepted" by the NRC in Regulatory Guide 1.147). Application of these code cases to nozzle DMWs requires a series of relief requests since Code Case N-504-3 was written specifically for stainless steel pipe-to-pipe welds and Code Case N-638-1 contains some restrictions and requirements that are not applicable to weld overlays. In October 2006, Code Case N-740 was approved by the ASME Code Committee to specifically address weld overlays on DMWs. Code Case N-740 also incorporates ambient temperature

[1] As defined in BWRVIP-75A, Category "D" welds "are those not made with resistant materials and not given an SI (Stress Improvement) treatment, but that have been examined by personnel using procedures in conformance with Section 5.2.1 of NUREG-0313, Revision 2, and found to be free of cracks."

Enclosure 1 JAFP-08-0102
Relief Request RR-7 Rev. 1

temperbead rules that are based on Code Case N-638-3. However, Code Case N-740 has not yet been accepted by the NRC in Regulatory Guide 1.147.

This request for alternative is specific to the N-2C nozzle to safe-end DMW. The subject DMW joins a P-No. 3, Group 3 low alloy steel nozzle to a P-No. 8 austenitic stainless steel safe-end. The DMW was welded with 82/182 weld metal. The full structural weld overlay will be applied by deposition of Alloy 52M (ERNiCrFe-7A) weld metal on the outside surface of the DMW and adjacent base material. See Attachment 1 for additional details.

IV. PROPOSED ALTERNATIVE

Pursuant to 10 CFR 50.55a(a)(3), Entergy proposes the following as an alternative to the Code requirements specified in Section II above. The proposed alternative is applicable to the DMW of the RPV N-2C nozzle.

A. Install a full structural weld overlay in accordance with the proposed alternatives specified in Attachments 2 and 3. These alternatives are based on the methodology of ASME Section XI Code Case N-740.

- Attachment 2 specifies an alternative applicable to the design, fabrication, examination, pressure testing, and inservice inspection of full structural weld overlays.
- Attachment 3 specifies an alternative applicable to ambient temperature temper bead welding. Attachment 3 will be applied as an alternative to the post-weld heat treatment requirements of ASME Section III.

V. BASIS FOR PROPOSED ALTERNATIVE

A. Proposed Alternative for Structural Weld Overlays

Entergy intends to install a full structural weld overlay to the subject DMW in accordance with the proposed alternative of Attachment 2. A tabular comparison of the Attachment 2 proposed alternative with Code Case N-504-3 and Appendix Q of ASME Section XI has been performed and is provided in Attachment 4. Note that ASME Code Case N-504-3 has been conditionally approved by the NRC in Regulatory Guide 1.147 with the condition that the provisions of ASME Section XI, Appendix Q be met when using the Case.

This proposed alternative provides an acceptable methodology for preventing potential failures due to IGSCC based on the use of filler metals that are resistant to this damage mechanism (e.g., Alloy 52M). Procedures that create compressive residual stress profiles along the inside diameter of the original weld, and post-overlay preservice and inservice inspection requirements ensure structural integrity for the life of the plant. The proposed weld overlays will also meet the applicable stress limits from ASME Section III. Crack growth evaluations for IGSCC and fatigue of any conservatively postulated flaws will demonstrate that structural integrity will be maintained. It should also be noted that JAF is on HWC/NMCA chemistry which has been shown to retard crack growth and prevent crack initiation. A basis discussion is provided in BWRVIP-75A.

Enclosure 1 JAFP-08-0102
Relief Request RR-7 Rev. 1

As stated above, weld overlays will be installed using Alloy 52M filler metal in accordance with Attachment 2. However, Alloy 52M weld metal has a demonstrated sensitivity to certain impurities, such as sulfur, when deposited onto austenitic stainless steel base materials. Therefore, if the impurity level is sufficiently high, it may become necessary to deposit an austenitic buffer layer prior to installation of the weld overlay. While this condition has been limited to PWR applications, Entergy has developed a contingency to install a buffer layer should this unexpected condition occur. If required, a buffer layer of ER308L austenitic stainless steel filler metal will be deposited across the austenitic stainless steel safe-end. While the balance of this layer would be deposited with Alloy 52M weld metal, an Alloy 82 bridge bead (or transitional bead) would be deposited over the fusion line between the existing Alloy 82 weld and stainless steel safe-end. The bridge bead will be deposited with ERNiCrFe-3 filler metal. The ER308L filler metal will have a delta ferrite content of 5 – 15 FN as reported on the CMTR. It will be deposited with a welding procedure and welders that have been qualified in accordance with ASME Section IX. Liquid penetrant (PT) examinations will be performed prior to and after deposition of the buffer layer. The second PT examination is performed to ensure that the completed buffer layer is free from cracks and other unacceptable indications prior to deposition of the Alloy 52M weld overlay. The austenitic stainless steel buffer layer, if required, will not be included in the structural weld overlay thickness as defined in Attachment 2.

1. Weld Overlay Design and Verification

   The fundamental design basis for full structural weld overlays is to maintain the original design margins with no credit taken for the underlying IGSCC-susceptible weldments. The assumed design basis flaw for the purpose of structural sizing of the weld overlay is a flaw completely around the circumference (360°) and 100% through the original wall thickness of the DMWs. The specific analyses and verifications to be performed are summarized as follows:

   - Nozzle-specific stress analyses have been performed to establish a residual stress profile in the nozzle to safe end weld. A severe internal diameter weld repair was assumed in this analysis that effectively bound any actual weld repairs that may have occurred in the nozzle. The analyses simulates application of the weld overlay to determine the final residual stress profile. Post-weld overlay residual stresses at normal operating conditions will be shown to result in beneficial compressive stresses on the inside surface of the components, assuring that further crack initiation due to IGSCC is highly unlikely.

   - Fracture mechanics analyses will also be performed to predict crack growth of detected flaws. Crack growth due to IGSCC and fatigue will be analyzed for the original DMW. The crack growth analyses will consider all design loads and transients, plus the post-weld overlay and through-wall residual stress distributions. The analyses will demonstrate that the postulated cracks will not degrade the design basis for the weld overlays.

   - The analyses will demonstrate that applying the weld overlays does not impact the conclusions of the existing nozzle stress reports. The ASME Code, Section III primary stress criteria will continue to be met.

Enclosure 1 JAFP-08-0102
Relief Request RR-7 Rev. 1

- Shrinkage will be measured during the overlay application. Shrinkage stresses at other locations in the piping systems arising from the weld overlays will be demonstrated not to have an adverse effect on the systems. Clearances of affected supports and restraints will be checked after the overlay repair and will be reset within the design ranges if required.

- The total added weight on the piping systems due to the overlays will be evaluated for potential impact on piping system stresses and dynamic characteristics.

- The as-built dimensions of the weld overlays will be measured and evaluated to demonstrate that they meet or exceed the minimum design dimensions of the overlays.

2. Suitability of Proposed Ambient Temperature Temperbead Technique

An ambient temperature temperbead welding technique will be used when welding on the ferritic base materials of the nozzles in lieu of the post-weld heat treatment requirements of ASME Section III. Research by the Electric Power Research Institute (EPRI) and other organizations on the use of an ambient temperature temperbead process using the machine gas tungsten arc welding (GTAW) process is documented in EPRI Report GC-111050 (Reference 7). According to the EPRI report, repair welds performed with an ambient temperature temperbead procedure utilizing the machine GTAW process exhibit mechanical properties equivalent to or better than those of the surrounding base material. Laboratory testing, analysis, successful procedure qualifications, and successful repairs have all demonstrated the effectiveness of this process.

a. Suitability of Ambient Temperature Temperbead Welding

The effects of the ambient temperature temperbead welding process of Attachment 3 on mechanical properties of welds, hydrogen cracking, and cold restraint cracking are addressed in the following paragraphs:

- Mechanical Properties

  The principal reasons to preheat a component prior to repair welding is to minimize the potential for cold cracking. The two cold cracking mechanisms are hydrogen cracking and restraint cracking. Both of these mechanisms occur at ambient temperature. Preheating slows down the cooling rate resulting in a ductile, less brittle microstructure thereby lowering susceptibility to cold cracking. Preheat also increases the diffusion rate of monatomic hydrogen that may have been trapped in the weld during solidification.

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As an alternative to preheat, the ambient temperature temperbead welding process utilizes the tempering action of the welding procedure to produce tough and ductile microstructures. Because precision bead placement and heat input control are utilized in the machine GTAW process, effective tempering of weld heat affected zones (HAZ) is possible without applying preheat. According to Section 2-1 of EPRI Report GC-111050, "the temperbead process is carefully designed and controlled such that successive weld beads supply the appropriate quantity of heat to the untempered HAZ such that the desired degree of carbide precipitation (tempering) is achieved. The resulting microstructure is very tough and ductile."

The IWA-4630 temperbead process includes a post-weld soak requirement. Performed at 450°F - 550°F for 4 hours (P-No. 3 base materials), this post-weld soak assists diffusion of any remaining hydrogen from the repair weld. As such, the post-weld soak is a hydrogen bake-out and not a post-weld heat treatment as defined by the ASME Code. At 450°F - 550°F, the post-weld soak does not stress relieve, temper, or alter the mechanical properties of the weldment in any manner.

The alternative described in Attachment 3 establishes detailed welding procedure qualification requirements for base materials, filler metals, restraint, impact properties, and other procedure variables. The qualification requirements contained in Attachment 3 provide assurance that the mechanical properties of repair welds will be equivalent to or superior to those of the surrounding base material.

- Hydrogen Cracking

Hydrogen cracking is a form of cold cracking. It is produced by the action of internal tensile stresses acting on low toughness HAZs. The internal stresses are produced from localized build-ups of monatomic hydrogen. Monatomic hydrogen forms when moisture or hydrocarbons interact with the welding arc and molten weld pool. The monatomic hydrogen can be entrapped during weld solidification and tends to migrate to transformation boundaries or other microstructure defect locations. As concentrations build, the monatomic hydrogen will recombine to form molecular hydrogen, thus generating localized internal stresses at these internal defect locations. If these stresses exceed the fracture toughness of the material, hydrogen-induced cracking will occur. This form of cracking requires the presence of hydrogen and low toughness materials. It is manifested by intergranular cracking of susceptible materials and normally occurs within 48 hours of welding.

Subsection IWA-4600 establishes elevated preheat and post-weld soak requirements. The elevated preheat temperature of 300°F increases the diffusion rate of hydrogen from the weld. The post-weld soak at 450°F - 550°F was also established to bake-out or facilitate diffusion of any remaining hydrogen from the weldment. However, while hydrogen cracking is a concern for shielded metal arc welding (SMAW), which uses flux covered electrodes, the potential for hydrogen cracking is significantly reduced when using the machine GTAW process.

The machine GTAW process is inherently free of hydrogen. Unlike the filler metal used in the SMAW process, GTAW filler metals do not rely on flux coverings, which may be susceptible to moisture absorption from the environment. Conversely, the GTAW process utilizes dry inert shielding gases that cover the molten weld pool from oxidizing atmospheres. Any moisture on the surface of the component being welded will be vaporized ahead of the welding torch. The vapor is prevented from being mixed with the molten weld pool by the inert shielding gas that blows the vapor away before it can be mixed. Furthermore, modern filler metal manufacturers produce wires having very low residual hydrogen. This is important because filler metals and base materials are the most realistic sources of hydrogen for automatic or machine GTAW temperbead welding. Therefore, the potential for hydrogen-induced cracking is greatly reduced by using the machine GTAW process.

In the unlikely event that hydrogen cracking occurs, nondestructive examination (NDE) of the weldment will be not be performed until at least 48 hours after completing the third layer of the weld overlay, thereby providing assurance that the cracking would be identified. See paragraphs 3.e and 3.f below for additional information.

- Cold Restraint Cracking

  Cold cracking generally occurs during cooling at temperatures approaching ambient temperature. As stresses build under a high degree of restraint, cracking may occur at defect locations. Brittle microstructures with low ductility are subject to cold restraint cracking. However, the ambient temperature temperbead process is designed to provide a sufficient heat inventory so as to produce the desired tempering for high toughness. Because the machine GTAW temperbead process provides precision bead placement and control of heat, the toughness and ductility of the HAZ will typically be superior to the base material. Therefore, the resulting structure will be appropriately tempered to exhibit toughness sufficient to resist cold cracking.

b. Exceptions to ASME Code Case N-638-1 Conditions

The ambient temperature temperbead technique of Code Case N-638-1 was conditionally approved by the NRC in Regulatory Guide 1.147. The proposed ambient temperature temperbead welding technique of Attachment 3 is identical to Code Case N-638-1 with the following exceptions:

- Code Case N-638-1, paragraph 1.0(a) limits the maximum area of an individual weld to 100 square inches. The proposed alternative limits the surface area to 500 square inches. The technical basis for this change is provided in Attachment 5.

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- Code Case N-638-1, paragraph 1.0(a) states that "the depth of the weld shall not be greater than one-half of the ferritic base metal thickness." Because the proposed alternative applies to deposition of weld overlays for which there are no weld or base material excavations, this limitation does not apply and is not included in Attachment 3.

- When welding is to be performed in a pressurized environment (e.g., an enclosed environment that is pressurized to prevent leakage so that welding can be performed), Code Case N-638-1, paragraph 2.1(b) requires that the pressurized environment be duplicated in the procedure qualification test assembly. Because this condition does not exist when applying weld overlays, this requirement is not included in Attachment 3.

- Code Case N-638-1, paragraph 2.1(h) requires the performance of Charpy V-notch testing of the ferritic weld metal of the procedure qualification test coupon. Because austenitic weld metal (i.e., Inconel Alloy 52M) will be used to fabricate the proposed weld overlays, this requirement does not apply and is not included in Attachment 3.

- Code Case N-638-1, paragraph 2.1(j) specifies acceptance criteria for Charpy V-notch tests of the HAZ. According to paragraph 2.1(j), the "average values of the three HAZ impact tests shall be equal to or greater than the average values of the three unaffected base metal tests." Although not explicitly stated, the average values referred to in paragraph 2.1(j) are the *average lateral expansion values* of the HAZ and base material specimens. Because this is the case, the acceptance criteria for Charpy V-notch testing of the HAZ is also based on *average lateral expansion values* in the proposed alternative. The technical basis for this change is provided in Attachment 5.

- Code Case N-638-1, paragraph 3.0(c) requires the deposition and removal of at least one weld reinforcement layer for "similar materials" (i.e., ferritic materials). This requirement is only applicable when welding is performed using ferritic filler weld metal. When temperbead welding is performed with ferritic filler metal, each ferritic weld layer must be tempered by the heat supplied from a subsequent weld layer. Because the final layer of a completed weld or weld repair would be untempered, paragraph 3.0(c) requires the deposition and removal of an additional layer (weld reinforcement) to ensure that the final layer of the completed weld is tempered. Since only austenitic filler metal (i.e., Alloy 52M) will be used to fabricate the proposed weld overlays, depositing and removing a weld reinforcement layer is not required. Therefore, this requirement is not included into Attachment 3.

- Because Code Case N-638-1, paragraph 3.0 does not specifically address monitoring or verification of welding interpass temperatures, interpass temperature controls have been specified in Attachment 3. The proposed interpass temperature controls are based on field experience with depositing weld overlays. Interpass temperature beyond the third layer has no impact on the metallurgical properties of the low alloy steel HAZ.

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- As an alternative to the examination requirements of Section 4.0 of Code Case N-638-1, the weld overlay will be examined in accordance with the examination requirements of Attachment 2, Section 3.0. The suitability of the proposed examinations is described in paragraph 3, below.

3. Suitability of Proposed NDE

The length, surface finish, and flatness requirements will be specified in the weld overlay design to provide for inspection of the examination volumes shown in Attachment 2, Figures 1 and 2. Furthermore, the examinations and inspections specified in this proposed alternative will provide adequate assurance of structural integrity for the following reasons:

a. Weld overlays have been used for repair and mitigation of cracking in BWRs since the early 1980s. In Generic Letter (GL) 88-01, *NRC Position on Intergranular Stress Corrosion Cracking (IGSCC) in BWR Austenitic Stainless Steel Piping*, the NRC approved the use of ASME Section XI acceptance standards for determining the acceptability of installed weld overlays.

b. The ultrasonic examinations performed in accordance with the proposed alternative are in accordance with ASME Section XI, Appendix VIII, Supplement 11 as implemented through the PDI. These examinations are considered more sensitive for detecting fabrication and service-induced flaws than the ASME Section III radiographic or ultrasonic examination methods. Furthermore, construction-type flaws have been included in the PDI qualification sample sets for evaluating procedures and personnel.

c. Per Section 3.0(a)(3) of Attachment 2, any planar flaws found during either the acceptance or preservice examination are required to meet the requirements of Table IWB-3514-2. This approach was previously determined to be acceptable in the NRC Safety Evaluation Report (SER) dated July 21, 2004 for Three Mile Island, Unit 1. However, within the same SER, the NRC had issues regarding the application of Table IWB-3514-3 to laminar flaws in a weld overlay. The SER stated, "Applying Table IWB-3514-3 to a weld overlay exposes several inherent oversights. For instance, the acceptance of a laminar flaw size is independent of the weld overlay size, and the acceptance criteria are silent on the inaccessible volume beneath the lamination which may hide other flaws beneath the lamination." These issues are addressed, as follows:

   - Per Section 3.0(a)(3)(i) of Attachment 2, Table IWB-3514-3 has been restricted so that the total laminar flaw shall not exceed 10% of the weld surface area and no linear dimension of the laminar flaw shall exceed 3 inches.

   - Per Section 3.0(a)(3)(ii) of Attachment 2, the reduction in coverage due to laminar flaws shall be less than 10%. The dimensions of the un-inspectable volume are based on the coverage obtained by angle beam examinations of the weld overlay.

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- Per Section 3.0(a)(3)(iii) of Attachment 2, any un-inspectable volume in the weld overlay shall be assumed to contain the largest radial planar flaw that could exist within that volume. This assumed flaw shall meet the inservice examination standards of Table IWB-3514-2. Alternately, the assumed flaw shall be evaluated and meet the requirements of Subsection IWB-3640. Both axial and circumferential planar flaws shall be assumed.

d. Weld overlays for repair of cracks in piping are not addressed by ASME Section III. ASME Section III utilizes NDE procedures and techniques with flaw detection capabilities that are well within the practical limits of workmanship standards for welds. These standards are most applicable to volumetric examinations conducted by radiographic examination. Radiography (RT) of weld overlays is not appropriate because of the potential for radioactive material in the RCS and water in piping and components. Section III acceptance standards are written for a range of fabrication flaws including lack of fusion, incomplete penetration, cracking, slag inclusions, porosity, and concavity. However, experience and fracture mechanics have demonstrated that many of the flaws that are rejected using Section III acceptance standards do not have a significant effect on the structural integrity of the component. Furthermore, utilizing ASME Section III acceptance standards on weld overlays would be inconsistent with years of NRC precedence and is without justification given the evidence of past NRC approvals and operating experience.

e. Regarding hydrogen cracking concerns, NDE required by paragraphs 3.0(a)(2) and 3.0(a)(3) of Attachment 2 is more than capable of detecting hydrogen cracking in ferritic materials. First of all, if hydrogen cracking were to occur, it would occur in the HAZ of the ferritic base material either below or immediately adjacent to the weld overlay. Therefore, it is unnecessary to examine the entire 1.5T band defined in paragraph 1.0(e) of Attachment 3. Hydrogen cracking is not a concern in austenitic materials. If it occurs in the ferritic base material below the weld overlay, it will be detected by the ultrasonic examination which will interrogate the entire weld overlay including the interface and HAZ beneath the weld overlay. If it occurs in the ferritic base material immediately adjacent to the weld overlay, it will be detected by the liquid penetrant examination which is performed at least ½ inch on each side of the weld overlay. Finally, when ambient temperature temperbead welding is performed over ferritic materials, the liquid penetrant and ultrasonic examinations will not be performed until at least 48 hours after completion of the third layer of the weld overlay. Technical justification for initiating the 48 hour hold after completion the third layer is provided in paragraph 3.f below.

f. Based on Code Case N-740, the 48-hour hold for performing NDE starts after the weld overlay cools to ambient temperature when performing ambient temperature temperbead welding. This 48-hour hold is specified to allow sufficient time for hydrogen cracking to occur (if it is to occur) in the HAZ of ferritic materials prior to performing final NDE. However, based on extensive research and industry experience, EPRI has provided a technical basis for starting the 48-hour hold after completing the third temperbead weld layer rather than waiting for the weld overlay to cool to ambient temperature (weld

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layers beyond the third layer are not designed to provide tempering to the ferritic HAZ when performing ambient temperature temperbead welding). EPRI has documented their technical basis in technical report 1013558, *Temperbead Welding Applications – 48 Hour Hold Requirements for Ambient Temperature Temperbead Welding* (Reference 8). The technical data provided by EPRI in their report is based on testing performed on SA-508, Class 2 low alloy steels and other P-Number 3, Group 3 materials. This point is important because the JAF RPV N-2C nozzle was manufactured from SA-508, Class 2 steel. After evaluating the issues relevant to hydrogen cracking such as microstructure of susceptible materials, availability of hydrogen, applied stresses, temperature, and diffusivity and solubility of hydrogen in steels, EPRI concluded the following on page 5-2 of the report: "There appears to be no technical basis for waiting 48 hours after cooling to ambient temperature before beginning the NDE of the completed weld. There should be no hydrogen present, and even if it were present, the temperbead welded component should be very tolerant of the moisture." Page 5-2 of the report also notes that over 20 weld overlays and 100 repairs have been performed using temperbead techniques on low alloy steel components over the last 20 years. During this time, there has never been an indication of hydrogen cracking by the nondestructive examination performed after the 48 hour hold or by subsequent inservice inspection.

In addition, the ASME Section XI Committee approved Revision 4 to Code Case N-638 (i.e., N-638-4) in October 2006 to allow the 48-hour hold to begin after completing the third weld layer when using austenitic filler metals. Paragraph 4(a)(2) of the code case states in part: "When austenitic materials are used, the weld shall be nondestructively examined after the three tempering layers (i.e., layers 1, 2, and 3) have been in place for at least 48 hours." The ASME Section XI technical basis for this change is documented in the white paper contained in ASME C&S Connect for Code Case N-638-4. The ASME white paper points out that introducing hydrogen to the ferritic HAZ is limited to the first weld layer since this is the only weld layer that makes contact with the ferritic base material. While the potential for introducing hydrogen to the ferritic HAZ is negligible during subsequent weld layers, these layers provide a heat source that accelerates the dissipation of hydrogen from the ferritic HAZ in non-water backed applications. Furthermore, the solubility of hydrogen in austenitic materials such as Alloy 52M is much higher than that of ferritic materials, while the diffusivity of hydrogen in austenitic materials is lower than that of ferritic materials. As a result, hydrogen in the ferritic HAZ tends to diffuse into the austenitic weld metal which has a much higher solubility for hydrogen. This diffusion process is enhanced by heat supplied in subsequent weld layers. Like the EPRI report, the ASME white paper concludes that there is sufficient delay time to facilitate detecting potential hydrogen cracking when NDE is performed 48 hours after completing the third weld layer.

g. The successive examination requirements of Attachment 2, paragraph 3.0(c) ensure that cracks identified by inservice inspections are appropriately monitored. According to paragraph 3.0(c) of Attachment 2, the weld overlay "shall be reexamined during the first or second refueling outage following discovery of the growth or new cracking." If additional crack growth or a new crack is discovered during a successive examination, then the successive examination of the weld overlay would be re-performed within the next two refueling outages. However, if the successive examination of the weld overlay reveals no additional indication of crack growth or new cracking, the weld overlay shall be placed into a population to be examined on a sample basis. Twenty-five percent (25%) of this population shall be examined once every ten (10) years. This successive examination schedule is identical to that specified in paragraph Q-4300 of ASME Section XI, Appendix Q which has been imposed as a condition to using Code Case N-504-3 by the NRC in RG 1.147.

h. The examination and inspection requirements in Attachment 2, Section 3.0 are equivalent to or more conservative than the examination and inspection requirements of Appendix Q of ASME Section XI as demonstrated in the comparison provided in Attachment 4 of this request.

i. The EPRI Performance Demonstration Initiative (PDI) qualification program for full structural weld overlays does not comply with all provisions of Appendix VIII, Supplement 11 (of ASME Section XI) as endorsed by the NRC in 10CFR50.55. However, JAF addressed this issued under Relief Request RR-5 which was approved by the NRC in an SER dated March 13, 2008.

4. NRC Submittals

As listed in Enclosure 2, Entergy will submit the following information to the NRC within fourteen (14) days from completing the final ultrasonic examinations of the completed weld overlays:

- Weld overlay examination results including a listing of indications detected[2]
- Disposition of indications using the standards of ASME Section XI, Subsection IWB-3514-2 and/or IWB-3514-3 criteria and, if possible, the type and nature of the indications[3]
- A discussion of any repairs to the weld overlay material and/or base metal and the reason for the repairs.

Entergy will also submit to the NRC a stress analysis summary demonstrating that the N-2C nozzle to safe-end DMW will perform its intended design function after weld overlay installation. The stress analysis report will include results showing that the requirements of NB-3200 and NB-3600 of the ASME Code, Section III are satisfied. The stress analysis will also include results showing that the requirements of Subsection IWB-3000 of the ASME Code, Section XI, are

[2] The recording criteria of the ultrasonic examination procedure to be used for the weld overlay examination requires that all indications, regardless of amplitude, be investigated to the extent necessary to provide accurate characterization, identity, and location. Additionally, the procedure requires that all indications, regardless of amplitude, that cannot be clearly attributed to the geometry of the overlay configuration be considered flaw indications.

[3] The ultrasonic examination procedure requires that all suspected flaw indications are to be plotted on a cross-sectional drawing of the weld and that the plots should accurately identify the specific origin of the reflector.

satisfied. The results will show that the postulated crack including its growth in the nozzles will not adversely affect the integrity of the overlaid welds. This information will be submitted to the NRC within 60 days of completing JAF's refueling outage R-18.

5. Precedents

The proposed repair activity is consistent with repair activities that have been approved by the NRC for other plants. By letter dated April 6, 2007 NRC approved "Arkansas Nuclear One, Unit-1 Request for Alternative ANO1-R&R-010 to Use Proposed Alternative to the American Society of Mechanical Engineers Boiler and Pressure Vessel Code Requirements for Pressurizer Nozzle Weld Overlay Repairs (TAC No. MD4019)", by letter dated March 17, 2008 NRC approved "Arkansas Nuclear One, Unit No. 2 (ANO-2) – Approval of relief Request for Alternative ANO2-R&R-005 to Install Weld Overlays on Hot Leg Dissimilar Metal Welds (TAC No. MD4907)", and by letter dated June 16, 2008 NRC approved "Arkansas Nuclear One, Unit No. 1 - Approval Of Relief Request ANO-1 R&R-011 To Use A Proposed Alternative To The American Society Of Mechanical Engineers Boiler And Pressure Vessel Code Requirements For Weld Overlay Repairs (TAC NO. MD6958)"

VI. CONCLUSION

10 CFR 50.55a(a)(3) states:

"Proposed alternatives to the requirements of (c), (d), (e), (f), (g), and (h) of this section or portions thereof may be used when authorized by the Director of the Office of Nuclear Reactor Regulation. The applicant shall demonstrate that:

(i) The proposed alternatives would provide an acceptable level of quality and safety, or

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

Entergy believes that the proposed alternatives of this request provide an acceptable level of quality and safety. The proposed weld overlay will be installed using Nickel Alloy 52M filler metal that is resistant to IGSCC. While this is the case, the weld overlay will also create compressive residual stresses along the inside diameter of the original weld, which prevents the initiation of new IGSCC. Finally, preservice and inservice inspection of the weld overlay will be performed to ensure structural integrity is maintained. Therefore, Entergy requests that the NRC staff authorize the proposed alternative in accordance with 10 CFR 50.55a(a)(3).

VII DURATION OF PROPOSED ALTERNATIVE

The proposed alternative is applicable to the fourth (4th) 10-Year ISI interval for JAF (March 1, 2007 to December 31, 2016) and for the period of extended operation which expires October 17, 2034.

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Dissimilar Metal Weld Details and Figures

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DISSIMILAR METAL WELD DETAILS

Nozzle Description	Nozzle Material	Weld Mat'l. ISI No.	Safe End Material	Pipe Size	Nozzle Size	Figure No.
RPV Recirculation Inlet Nozzle N-2C	SA-508, Class 2[1] w/SST Clad	82/182[2] N-2C-SE	SA-182, F304[3]	12" NPS	14 3/8" OD	1

Notes:

1. Nozzle material is P-Number 3, Group 3 low alloy steel.
2. DMW includes butter and weld.
3. Safe-end material is P-Number 8 stainless steel.

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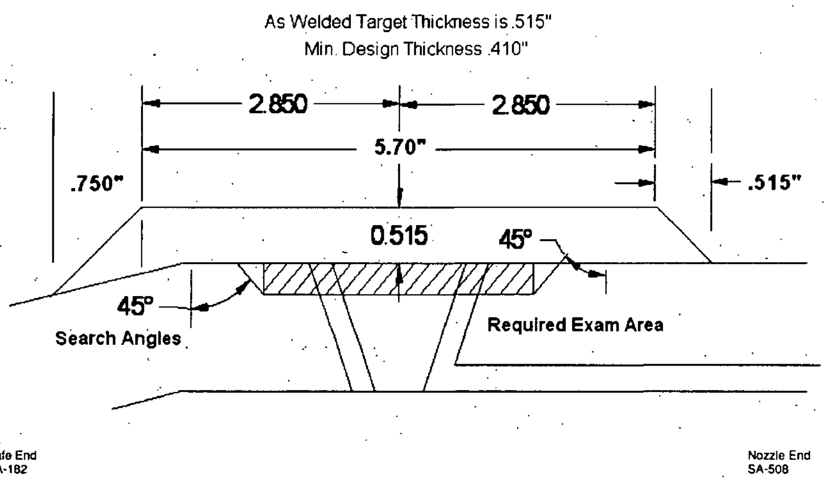
FIGURE 1



This figure encompasses the design requirements, thickness and length of the overlay have been increased to accommodate surface finishing and NDE requirement.

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Attachment 2 to Enclosure 1

Proposed Alternative for Full Structural Weld Overlays

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PROPOSED ALTERNATIVE FOR FULL STRUCTURAL WELD OVERLAYS

1.0 GENERAL REQUIREMENTS

(a) Weld overlays may be applied to the 82/182 dissimilar metal welds joining the materials listed below.

- P-No. 3, Group 3 low alloy steel to P-No. 8 stainless steel

(b) Weld overlay filler metal shall be austenitic Nickel Alloy 52M (ERNiCrFe-7A) filler metal having a chromium content of at least 28%. The weld overlay is applied 360° around the circumference of the item, and shall be deposited using a Welding Procedure Specification (WPS) for groove welding, qualified in accordance with the Construction Code and Owner's Requirements, and identified in the Repair/Replacement Plan. As an alternative to the post-weld heat treatment requirements of the Construction Code and Owner's requirements, the provisions for "Ambient Temperature Temperbead Welding" may be used on the ferritic nozzle as described in Attachment 3.

(c) Prior to deposition of the weld overlay, the surface to be repaired shall be examined by the liquid penetrant method. Indications larger than 1/16 inch shall be removed, reduced in size, or corrected in accordance with the following requirements.

(1) One or more layers of weld metal (GTAW or SMAW) shall be applied to seal unacceptable indications in the area to be repaired with or without excavation. The thickness of these layers shall not be used in meeting weld reinforcement design thickness requirements. Peening the unacceptable indication prior to welding is permitted.

(2) If correcting indications identified in 1.0(c) is required, the area where the weld overlay is to be deposited, including any local repairs or initial weld overlay layer, shall be examined by the liquid penetrant method. The area shall contain no indications greater than 1/16 inch prior to applying the structural layers of the weld overlay.

(d) Weld overlay deposits shall meet the following requirements:

The austenitic nickel alloy weld overlay shall consist of at least two weld layers deposited with a filler material such as identified in 1.0(b) above. The first layer of weld metal deposited may not be credited toward the required thickness. Alternatively, a diluted layer may be credited toward the required thickness, provided the portion of the layer over the austenitic base material, austenitic weld, and the associated dilution zone from an adjacent ferritic base material contains at least 20% chromium. The chromium content of the deposited weld metal may be determined by chemical analysis of the production weld or from a representative coupon taken from a mockup prepared in accordance with the WPS (or a representative WPS) for the production weld.

(e) A new weld overlay shall not be installed on top of an existing weld overlay that has been in service.

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2.0 CRACK GROWTH CONSIDERATIONS AND DESIGN

(a) Crack Growth

(1) Flaw characterization and evaluation requirements shall be based on the as-found flaw. However, the size of all flaws shall be projected to the end of the design life of the overlay. Crack growth, including both stress corrosion and fatigue crack growth, shall be evaluated in the materials in accordance with IWB-3640. If the flaw is at or near the boundary of two different materials, evaluation of flaw growth in both materials is required.

(2) The size of all flaws detected shall be used to define the life of the weld overlay. In no case shall the inspection interval be longer than the life of the weld overlay.

(b) Structural Design

The design of the weld overlay shall be analyzed and shown to satisfy the following, using the assumptions and flaw characterization restrictions in 2.0(a). The following design analysis shall be completed in accordance with IWA-4311.

(1) The axial length and end slope of the weld overlay shall cover the weld and the heat affected zones (HAZs) on each side of the weld, and shall provide for load redistribution from the item into the weld overlay and back into the item without violating applicable stress limits of NB-3200. Any laminar flaws in the weld overlay shall be evaluated in the analysis to ensure that load redistribution complies with the above. These requirements will usually be satisfied if the weld overlay full thickness length extends axially beyond the projected flaw by at least $0.75\sqrt{Rt}$, where "R" is the outer radius of the item and "t" is the nominal wall thickness of the item.

(2) Unless specifically analyzed in accordance with 2.0(b)(1) above, the end transition slope of the overlay shall not exceed 45°. A slope of not more than 1:3 is recommended.

(3) For determining the combined length of circumferentially oriented flaws in the underlying base material or weld, multiple flaws shall be treated as one flaw of length equal to the sum of the lengths of the individual flaws characterized in accordance with IWA-3300.

(4) For circumferentially oriented flaws, if the combined length is greater than 10% of the items circumference, the flaws shall be assumed to be 100% through the original wall thickness of the item for the entire circumference of the item. If the combined length of circumferentially oriented flaws does not exceed 10% of the item's circumference, the flaws shall be assumed to be 100% through the original wall thickness of the item for a circumferential length equal to the combined lengths of the flaws.

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(5) For axial flaws 1.5" or longer, or for five or more flaws of any length, the flaws shall be assumed to be 100% through the original wall thickness of the item for the entire axial length of the flaw or combined flaws, as applicable.

(6) The overlay design thickness of items meeting 2.0(b)(4) or (5) above shall be based on the measured diameter using only the weld overlay thickness conforming to the deposit analysis requirements of 1.0(d) above. The combined wall thickness at the weld overlay, any planar flaws in the weld overlay, and the effects of any discontinuity (e.g., another weld overlay or reinforcement for a branch connection) within a distance of 2.5√Rt from the toes of the weld overlay, shall be evaluated and shall meet the requirements of IWB-3640.

Note: Although planar flaws are considered in the IWB-3640 evaluation of the combined wall thickness in paragraph 2.0(b)(4), these planar flaws must meet the acceptance standards of IWB-3500 as required by paragraphs 3.0(a) and (b) of this attachment.

(7) The effects of any changes in applied loads, as a result of weld shrinkage from the entire overlay, on other items in the piping system (e.g., support loads and clearances, nozzle loads, changes in system flexibility and weight due to the weld overlay) shall be evaluated. Existing flaws previously accepted by analytical evaluation shall be evaluated in accordance with IWB-3640.

3.0 <u>EXAMINATION AND INSPECTION</u>

In lieu of all other examination requirements, the examination requirements proposed herein shall be met. Nondestructive examination (NDE) methods shall be in accordance with IWA-2200, except as specified herein. NDE personnel shall be qualified in accordance with IWA-2300. Ultrasonic examination procedures and personnel shall be qualified in accordance with Appendix VIII of ASME Section XI.

(a) <u>Acceptance Examination</u>

(1) The weld overlay shall have a surface finish of 250 micro-inch (6.3 micrometers) RMS or better and a flatness that is sufficient to allow for adequate examination in accordance with procedures qualified per Appendix VIII. The weld overlay shall be examined to verify acceptable configuration.

(2) The weld overlay and the adjacent base material for at least ½ inch from each side of the weld shall be examined using the liquid penetrant method. The weld overlay shall satisfy the surface examination acceptance criteria for welds of the Construction Code or ASME Section III, NB-5300. The adjacent base metal shall satisfy the surface examination acceptance criteria for base material of the Construction Code or ASME Section III, NB-2500. If ambient temperature temperbead welding is used, liquid penetrant examination shall be conducted at least 48 hours after completing the third layer of the weld overlay.

(3) The examination volume A-B-C-D in Figure 1 (below) shall be ultrasonically examined to assure adequate fusion (i.e., adequate bond) with the base metal and to detect welding flaws, such as inter-bead lack of fusion, inclusions, or

cracks. The interface C-D shown between the overlay and the weld includes the bond and the HAZ from the overlay. If ambient temperature temperbead welding is used, the ultrasonic examination shall be conducted at least 48 hours after completing the third layer of the weld overlay. Planar flaws shall meet the preservice examination standards of Table IWB-3514-2. In applying the acceptance standards, wall thickness "t_w" shall be the thickness of the weld overlay. Laminar flaws shall meet the following:

(i) Laminar flaws shall meet the acceptance standards of Table IWB-3514-3 with the additional limitation that the total laminar flaw shall not exceed 10% of the weld surface area and that no linear dimension of the laminar flaw area exceeds 3.0 inches.

(ii) The reduction in coverage of the examination volume in Figure 2 due to laminar flaws shall be less than 10%. The dimensions of the un-inspectable volume are dependent on the coverage achieved with the angle beam examination of the overlay.

(iii) Any un-inspectable volume in the weld overlay shall be assumed to contain the largest radial planar flaw that could exist within that volume. This assumed flaw shall meet the inservice examination standards of Table IWB-3514-2. Alternately, the assumed flaw shall be evaluated and shall meet the requirements of IWB-3640. Both axial and circumferential planar flaws shall be assumed.

(4) If a weld overlay does not meet the acceptance standards specified in 3.0(a)(2) and (3) above, the weld overlay shall be corrected by a repair/replacement activity in accordance with IWA-4000.

(5) After completing welding activities, affected restraints, supports, and snubbers shall be VT-3 visually examined to verify that design tolerances are met.

(b) Preservice Inspection

(1) The examination volume A-B-C-D in Figure 2 (below) shall be ultrasonically examined. The angle beam shall be directed perpendicular and parallel to the piping axis, with scanning performed in four directions to locate and size any cracks that might have propagated into the upper 25% of the base material or into the weld overlay. If ambient temperature temperbead welding is used, the ultrasonic examination shall be conducted at least 48 hours after completing the third layer of the weld overlay.

(2) The preservice examination acceptance standards of Table IWB-3514-2 shall be met for the weld overlay. In applying the acceptance standards, wall thickness, t_w, shall be the thickness of the weld overlay. Cracks in the outer 25% of the base metal shall meet the design analysis requirements of 2.0 above.

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(c) Inservice Inspection

(1) The weld overlay examination volume A-B-C-D in Figure 2 shall be added to the inspection plan and shall be ultrasonically examined during the first or second refueling outage following application.

(2) The weld overlay examination volume in Figure 2 shall be ultrasonically examined to determine if any new or existing cracks have propagated into the upper 25% of the base material or into the overlay. The angle beam shall be directed perpendicular and parallel to the piping axis, with scanning performed in four directions.

(3) The acceptance standards for the ultrasonic examination of the weld overlay are specified in Table IWB-3514-2. However, if the weld overlay fails to meet the acceptance standards of Table IWB-3514-2, it can be accepted based on an analytical evaluation meeting the requirements and acceptance criteria of IWB-3600. However, flaws identified as intergranular stress corrosion cracking (IGSCC) cannot be accepted by an IWB-3600 analytical evaluation. Cracks in the outer 25% of the base metal shall meet the design analysis requirements of 2.0 above.

(4) Weld overlay examination volumes that show no indication of crack growth or new cracking shall be placed into a population to be examined on a sample basis. Twenty-five percent of this population shall be examined once every ten years, except as required in paragraph 2.0(a)(2) of this attachment.

(5) If inservice examinations reveal crack growth, or new cracking, meeting the acceptance standards, the weld overlay examination volume shall be reexamined during the first or second refueling outage following discovery of the growth or new cracking. Weld overlay examination volumes that show no additional indication of crack growth or new cracking shall be examined in accordance with paragraph 3.0(c)(4).

(6) For weld overlay examination volumes that fail to meet the acceptance criteria as described in 3.0(c)(3) above, the weld overlay shall be removed, including the original defective weld, and the item shall be corrected by a repair/replacement activity in accordance with IWA-4000.

(d) Additional Examinations

If inservice examinations reveal an unacceptable indication, crack growth into the weld overlay design thickness, or axial crack growth beyond the specified examination volume, additional weld overlay examination volumes, equal to the number scheduled for the current inspection period, shall be examined prior to return to service. If additional unacceptable indications are found in the second sample, 50% of the total population of weld overlay examination volumes shall be examined prior to operation. If additional unacceptable indications are found, the entire remaining population of weld overlay examination volumes shall be examined prior to return to service.

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4.0 PRESSURE TESTING

A system leakage test and VT-2 shall be performed in accordance with IWA-5000.

5.0 DOCUMENTATION

Use of this alternative shall be documented on Form NIS-2. Alternatively, it may be documented on Form NIS-2A based on appropriate NRC approval.

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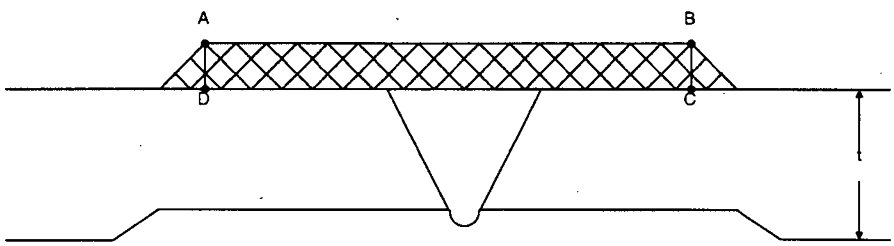
FIGURE 1

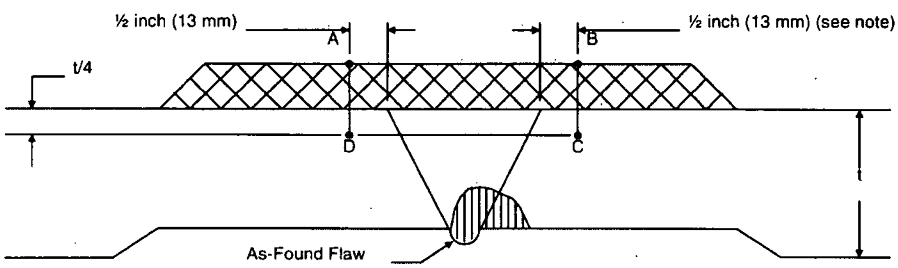
ACCEPTANCE EXAMINATION VOLUME



Examination Volume A-B-C-D

FIGURE 2

PRESERVICE AND INSERVICE EXAMINATION VOLUME



Examination Volume A-B-C-D

NOTE

For axial or circumferential flaws, the axial extent of the examination volume shall extend at least ½ inch (13 mm) beyond the as-found flaw and at least ½ inch beyond the toes of the original weld, including weld end butter, where applied.

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Attachment 3 to Enclosure 1

Proposed Ambient Temperature Temperbead Technique

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PROPOSED AMBIENT TEMPERATURE TEMPERBEAD TECHNIQUE

1.0 GENERAL REQUIREMENTS

(a) This appendix applies to dissimilar austenitic filler metal welds joining P-No. 8 material to P-No. 3 material.

(b) The maximum area of an individual weld overlay based on the finished surface over the ferritic base material shall be 500 square inches.

(c) Repair/replacement activities on a dissimilar-metal weld in accordance with this attachment are limited to those along the fusion line of a nonferritic weld to ferritic base material on which 1/8 inch, or less of nonferritic weld deposit exists above the original fusion line.

(d) If a defect penetrates into the ferritic base material, repair of the base material, using a nonferritic weld filler material, may be performed in accordance with this attachment, provided the depth of repair in the base material does not exceed 3/8 inch.

(e) Prior to welding the area to be welded and a band around the area of at least 1½ times the component thickness or 5 inches, whichever is less, shall be at least 50°F (10°C).

(f) Welding materials shall meet the Owner's Requirements and the Construction Code and Cases specified in the Repair/Replacement Plan. Welding materials shall be controlled so that they are identified as acceptable until consumed.

(g) Peening may be used, except on the initial and final layers.

2.0 WELDING QUALIFICATIONS

Welding procedures and welding operators shall be qualified in accordance with ASME Section IX and the requirements of Sections 2.1 and 2.2 below.

2.1 Procedure Qualification

(a) The base materials for the welding procedure qualification shall be of the same P-Number and Group Number, as the materials to be welded. The materials shall be post-weld heat treated to at least the time and temperature that was applied to the materials being welded.

(b) Consideration shall be given to the effects of irradiation on the properties of material, including weld material for applications in the core beltline region of the reactor vessel. Special material requirements in the Design Specification shall also apply to the test assembly materials for these applications.

(c) The root width and included angle of the cavity in the test assembly shall be no greater than the minimum specified for the repair.

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(d) The maximum interpass temperature for the first three layers of the test assembly shall be 150°F.

(e) The test assembly cavity depth shall be at least 1 inch. The test assembly thickness shall be at least twice the test assembly cavity depth. The test assembly shall be large enough to permit removing the required test specimens. The test assembly dimensions surrounding the cavity shall be at least the test assembly thickness and at least 6 inches. The qualification test plate shall be prepared in accordance with Figure 1-1.

(f) Ferritic base material for the procedure qualification test shall meet the impact test requirements of the Construction Code and Owner's Requirements. If such requirements are not in the Construction Code and Owner's Requirements, the impact properties shall be determined by Charpy V-notch impact tests of the procedure qualification base material at or below the lowest service temperature of the item to be repaired. The location and orientation of the test specimens shall be similar to those required in (g) below, but shall be in the base metal.

(g) Charpy V-notch tests of the ferritic heat-affected zone (HAZ) shall be performed at the same temperature as the base metal test of (f) above. Number, location, and orientation of test specimens shall be as follows:

  (1) The specimens shall be removed from a location as near as practical to a depth of one-half the thickness of the deposited weld metal. The coupons for HAZ impact specimens shall be taken transverse to the axis of the weld and etched to define the HAZ. The notch of the Charpy V-notch specimen shall be cut approximately normal to the material surface in such a manner as to include as much HAZ as possible in the resulting fracture. Where the material thickness permits, the axis of a specimen shall be inclined to allow the root of the notch to be aligned parallel to the fusion line.

  (2) If the test material is in the form of a plate or a forging, the axis of the weld shall be oriented parallel to the principal direction of rolling or forging.

  (3) The Charpy V-notch test shall be performed in accordance with SA-370. Specimens shall be in accordance with SA-370, Figure 11, Type A. The test shall consist of a set of three full-size 10 mm X 10 mm specimens. The lateral expansion, percent shear, absorbed energy, test temperature, orientation and location of all test specimens shall be reported in the Procedure Qualification Record.

(h) The average lateral expansion value of the three HAZ Charpy V-notch specimens shall be equal to or greater than the average lateral expansion value of the three unaffected base metal specimens.

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2.2 Performance Qualification

Welding operators shall be qualified in accordance with ASME Section IX.

3.0 WELDING PROCEDURE REQUIREMENTS

The welding procedure shall include the following requirements.

(a) The weld metal shall be deposited by the automatic or machine gas tungsten arc welding (GTAW) process.

(b) Dissimilar metal welds shall be made using F-No. 43 weld metal (QW-432) for P-No. 8 to P-No. 3 weld joints.

(c) The area to be welded shall be buttered with a deposit of at least three layers to achieve at least 1/8 inch overlay thickness with the heat input for each layer controlled to within ±10% of that used in the procedure qualification test. Particular care shall be taken in the placement of the weld layers of the austenitic overlay filler material at the toe of the overlay to ensure that the HAZ and ferritic base metal are tempered. Subsequent layers shall be deposited with a heat input not exceeding that used for layers beyond the third layer in the procedure qualification.

(d) The maximum interpass temperature for field applications shall be 350°F (180°C) for all weld layers regardless of the interpass temperature used during qualification.

(e) The preheat and interpass temperatures will be measured using a contact pyrometer. In the first three layers, the interpass temperature will be measured every three to five passes. After the first three layers, interpass temperature measurements will be taken every six to ten passes for the subsequent layers. Contact pyrometers will be calibrated in accordance with approved calibration and control program documents.

(f) Particular care shall be given to ensure that the weld region is free of all potential sources of hydrogen. The surfaces to be welded, filler metal, and shielding gas shall be suitably controlled.

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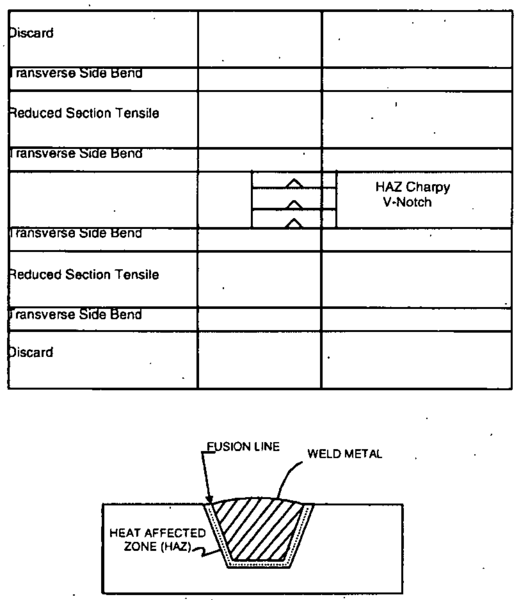
FIGURE 1-1

QUALIFICATION TEST PLATE



NOTE

Base metal Charpy impact specimens are not shown.

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Comparison of ASME Code Case N-504-3 and Appendix Q of ASME Section XI with the Proposed Alternative of Attachment 2 for Full Structural Weld Overlays

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COMPARISON OF ASME CODE CASE N-504-3 AND APPENDIX Q OF ASME SECTION XI WITH THE PROPOSED ALTERNATIVE OF ATTACHMENT 2 FOR FULL STRUCTURAL WELD OVERLAYS

Code Case N-504-3 and Appendix Q of ASME Section XI	Proposed Alternative of Attachment 2
Code Case N-504-3 provides requirements for reducing a defect to a flaw of acceptable size by deposition of weld reinforcement (weld overlay) on the outside surface of the pipe using austenitic stainless steel filler metal as an alternative to defect removal. Code Case N-504-3 is applicable to austenitic stainless steel piping only. According to Regulatory Guide 1.147, the provisions of Non-mandatory Appendix Q of ASME Section XI must also be met when using this Case. Therefore, the Code Case N-504-3 requirements presented below have been supplemented by Appendix Q of ASME Section XI.	The proposed alternative of Attachment 2 provides requirements for installing a full structural weld overlay by deposition of weld reinforcement (weld overlay) on the outside surface of the item using Nickel Alloy 52M filler metal. Attachment 2 is applicable to dissimilar metal welds associated with ferritic, stainless steel, and nickel alloy materials. It is also applicable to similar metal welds in austenitic stainless steels. The proposed alternative of Attachment 2 is based on Code Case N-740.
General Requirements	**1.0 General Requirements**
Code Case N-504-3 and Appendix Q are only applicable to P-No. 8 austenitic stainless steels.	As specified in paragraph 1.0(a) of Attachment 2, the proposed alternative is applicable to dissimilar metal 82/182 welds joining P-No. 3 to P-No. 8 materials. **Basis**: Code Case N-504-3 and Appendix Q are applicable to austenitic weld overlays of P-No. 8 austenitic stainless steel materials. Based on Code Case N-740, the proposed alternative of Attachment 2 was specifically written to address the application of weld overlays over dissimilar metal welds.
According to paragraph (b) of Code Case N-504-3 as supplemented by Appendix Q, weld overlay filler metal shall be low carbon (0.035% max.) austenitic stainless steel applied 360 degrees around the circumference of the pipe, and shall be deposited using a Welding Procedure Specification for groove welding, qualified in accordance with the Construction Code and Owner's Requirements and identified in the Repair/Replacement Plan. The SAW process is not allowed for weld overlays.	The weld filler metal and procedure requirements of Attachment 2, paragraph 1.0(b) are equivalent to Code Case N-504-3 and Appendix Q except as noted below: • Weld overlay filler metal shall be austenitic Nickel Alloy 52M (ERNiCrFe-7A) filler metal which has a chromium content of at least 28%. • Only the GTAW process is allowed based on reference to ERNiCrFe-7 filler metal. If Ambient Temperature Temperbead (AMTB) welding is performed, GTAW must also be used.

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Code Case N-504-3 and Appendix Q of ASME Section XI	Proposed Alternative of Attachment 2
	As an alternative to post-weld heat treatment, the provisions for "Ambient Temperature Temperbead Welding" may be used on the ferritic nozzle as described in Attachment 3. **Basis**: The weld overlay will be deposited with ERNiCrFe-7 (Alloy 52M) filler metal. It has been included into ASME Section IX as F-No. 43 filler metals. Containing 28.0 – 31.5% chromium (roughly twice the chromium content of 82/182 filler metal), this filler metal has excellent resistance to IGSCC. This point has been clearly documented in EPRI Technical Report MRP-115, Section 2.2. Regarding the WPS, paragraph 1.0(b) of Attachment 2 provides clarification that the WPS used for depositing weld overlays must be qualified as a groove welding procedure to ensure that mechanical properties of the WPS are appropriately established. Where welding is performed on ferritic nozzles, an ambient temperature temperbead WPS will be used. Suitability of an ambient temperature temperbead WPS is addressed in Section V.A.2 of this Request. While paragraph 1.0(b) does not specifically prohibit use of the SAW, this process will not be used because it invokes the GTAW process for both temperbead and non-temperbead welding application.
According to paragraph (e) of Code Case N-504-3 as supplemented by Appendix Q, the weld reinforcement shall consist of at least two weld layers having as-deposited delta ferrite content of at least 7.5 FN. The first layer of weld metal with delta ferrite content of at least 7.5 FN shall constitute the first layer of the weld reinforcement that may be credited toward the required thickness. Alternatively, first layers of at least 5 FN provided the carbon content is determined by chemical analysis to be less than 0.02%.	The weld overlay Attachment 2 is deposited using Nickel Alloy 52M filler metal instead of austenitic stainless steel filler metals. Therefore, the basis for crediting the first layer towards the required design thickness will be based on the chromium content of the nickel alloy filler metal. According to paragraph 1.0(d) of Attachment 2, the first layer of Nickel Alloy 52M deposited weld metal may be credited toward the required thickness provided the portion of the layer over the austenitic base material, austenitic weld, and the associated dilution zone from an adjacent ferritic base material contains at least 20% chromium. The chromium content of the deposited weld metal may be determined by chemical analysis of the production weld or from a representative coupon taken from a mockup prepared in accordance with the WPS for the production weld. **Basis**: The weld overlay will be deposited with ERNiCrFe-7 (Alloy 52M) filler metal. Credit for the first weld layer may not be taken toward the required thickness unless it has been shown to contain at least 20% chromium. This is a sufficient amount of chromium to prevent IGSCC.

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Code Case N-504-3 and Appendix Q of ASME Section XI	**Proposed Alternative of Attachment 2**
	Section 2.2 of EPRI Technical Report MRP-115 states the following: "The only well explored effect of the compositional differences among the weld alloys on IGSCC is the influence of chromium. Buisine, et al. evaluated the IGSCC resistance of nickel-based weld metals with various chromium contents ranging from about 15% to 30% chromium. Testing was performed in doped steam and primary water. Alloy 182, with about 14.5% chromium, was the most susceptible. Alloy 82 with 18-20% chromium took three or four times longer to crack. For chromium contents between 21 and 22%, no stress corrosion crack initiation was observed..."
Design and Crack Growth Considerations	**2.0 Design and Crack Growth Considerations**
The design and flaw characterization provisions of Code Case N-504-3, paragraphs (f) and (g) as supplemented by Appendix Q. The supplemental Appendix Q requirements are summarized below: (i) Flaw characterization and evaluation are based on the as-found flaw and as described below. Flaw evaluation of the existing flaws is based on IWB-3640 for the design life. [Ref: Q-3000(a)] • Multiple circumferential flaws shall be treated as one flaw of length equal to the sum of the lengths of the individual flaws characterized in accordance with IWA-3300. • When the combined length of circumferential flaws exceeds 10% of the pipe circumference, the circumferential flaws shall be assumed to be 100% through-wall for the entire circumference of the pipe. • When the combined length of circumferential flaws does not exceed 10% of the circumference, the flaws are only assumed to be 100% through-wall for a circumferential length equal to the combined length of the flaws. • For axial flaws 1.5 inches or longer, or for five or more axial flaws of any length, the flaws shall be assumed to be 100% through-wall for the entire axial length of the flaw and entire	The design and flaw evaluation provisions in the proposed alternative of Attachment 2, Section 2.0 are similar to those in Code Case N-504-3 as supplemented in Appendix Q as briefly noted below: (i) Flaw characterization and evaluation are based on the as-found flaw. However, the size of all flaws shall be projected to the end of the design life of the overlay. Crack growth, including both stress corrosion and fatigue crack growth, shall be evaluated in the materials in accordance with IWB-3640. The size of all flaws detected shall be used to define the life of the weld overlay. In no case shall the inspection interval be longer than the life of the weld overlay. (ii) Design will comply with the following: • The axial length and end slope of the weld overlay shall cover the weld and the HAZs on each side of the weld, and provide for load redistribution from the item into the weld overlay and back into the item without violating applicable stress limits. Any laminar flaws in the weld overlay shall be evaluated in the analysis to ensure that load redistribution complies with the above. • Unless specifically analyzed, the end transition slope of the overlay shall not exceed 45°. A 1:3 is recommended. • The methods and assumptions for combining axial and circumferential flaws are very similar to that specified in Code Case

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Code Case N-504-3 and Appendix Q of ASME Section XI	Proposed Alternative of Attachment 2
circumference of the pipe.. • For four or fewer axial flaws less than 1.5 inches in length and no circumferential flaws, the weld overlay thickness need only consist of two or more layers of weld metal meeting the deposit analysis requirements. No additional structural reinforcement is required. The axial length of the weld overlay shall cover the weld and HAZs on each side of the weld, and shall extend ½" beyond the ends of observed flaws. provide for load redistribution from the item into the weld overlay and back into the item without violating applicable stress limits of the Construction Code. (ii) The design of the weld overlay shall satisfy the requirements of the Construction Code and Owner's Requirements in accordance with IWA-4221 and the following using the assumptions and flaw characterization restrictions of Q-3000(a). The design analysis shall comply with IWA-4311. [Ref: Q-3000(b)] • The axial length and end slope of the weld overlay shall cover the weld and HAZs on each side of the weld, and provide for load redistribution from the item into the weld overlay and back into the item without violating applicable stress limits of the Construction Code. Any laminar flaws in the weld overlay shall be evaluated in the analysis to ensure that load redistribution complies with the above. These requirements are usually met if the weld overlay extends beyond the projected flaw by at least 0.75 $(Rt)^{1/2}$. • Unless specifically analyzed, the end transition slope of the overlay shall not exceed 45°. A slope of not more than 1:3 is recommended. • The overlay design thickness of items shall be based on the measured diameter, using only the weld overlay thickness as restricted in Q-2000(d). The wall thickness of the weld overlay, any planar flaws in the weld overlay, and	N-504-3 as supplemented by Appendix Q. • The effects of any changes in applied loads, as a result of weld shrinkage from the entire overlay, on other items in the piping system (e.g., support loads and clearances, nozzle loads, changes in system flexibility and weight due to the weld overlay) shall be evaluated. Existing flaws previously accepted by analytical evaluation shall be evaluated in accordance with IWB-3640. **Basis:** Weld overlays are being installed in accordance with Attachment 2 as a repair and to mitigate any future IGSCC issues with the subject welds. As shown above, the design and crack evaluations of Attachment 2, Section 2.0 are very similar and/or equivalent to those of Code Case N-504-3 as supplemented by Appendix Q .

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Code Case N-504-3 and Appendix Q of ASME Section XI	Proposed Alternative of Attachment 2
the effects of any discontinuity (e.g., another weld overlay or reinforcement for a branch connection) within a distance of 2.5 $(Rt)^{1/2}$ from the toes of the weld overlay, shall be evaluated and meet the requirements of IWB-, IWC-, or IWD-3640. • The effects of any changes in applied loads, as a result of weld shrinkage or existing flaws previously accepted by analytical evaluation shall be evaluated in accordance with IWB-3640, IWC-3640, or IWD-3640, as applicable.	
Examination and Inspection	**3.0 Examination and Inspection**
Code Case N-504-3 does not include requirements for acceptance examination or inservice examination of weld overlays. Preservice examination is addressed. However, Appendix Q, Article Q-4000 does specify requirements applicable to weld acceptance examinations, preservice examinations, and inservice examinations.	Attachment 2, Section 3.0 of the proposed alternative specifies requirements applicable to weld acceptance examinations, preservice examinations, and inservice examinations.

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Code Case N-504-3 and Appendix Q of ASME Section XI	Proposed Alternative of Attachment 2
Acceptance Examination	**3.0(a) Acceptance Examination**
Acceptance Examination Q-4100(c) states that the examination volume in Figure Q-4100-1 shall be ultrasonically examined to assure adequate fusion (i.e., adequate bond) with the base metal and to detect welding flaws, such as inter-bead lack of fusion, inclusions, or cracks. Planar flaws shall meet the preservice examination standards of Table IWB-3514-2. Laminar flaws shall meet the following:	The acceptance standards in paragraph 3.0(a)(3) of Attachment 2 are identical to those of paragraph Q-4100(c) except that paragraph 3.0(a)(3) includes requirements and clarifications that are not included in Appendix Q. First, it specifies that the ultrasonic examination shall be conducted at least 48 hours after completing the third layer of the weld overlay when ambient temperature temperbead welding is used. Secondly, it provides the following clarifications: • The interface C-D between the weld overlay and the weld includes the bond and the HAZ from the weld overlay. • In applying the acceptance standards, wall thickness "t_w" shall be the thickness of the weld overlay. **Basis:** Appendix Q is applicable to austenitic stainless steel materials only; therefore, ambient temperature temperbead welding would not be applicable. It is applicable to welding performed in the proposed alternative. When ambient temperature temperbead welding is performed, nondestructive examinations must be performed at least 48 hours after completing the third layer of the weld overlay to allow sufficient time for hydrogen cracking to occur (if it is to occur). Technical justification for starting the 48 hours after completion of the third layer of the weld overlay is provided in paragraph V.A.3.f of the Request. The other two changes are simply clarifications that were added to ensure that the examination requirements were appropriately performed.
Q-4100(c)(1) states that laminar flaws shall meet the acceptance standards of Table IWB-3514-3.	The acceptance standards in paragraph 3.0(a)(3)(i) of Attachment 2 are identical to paragraph Q-4100(c)(1) except that paragraph 3.0(a)(3)(i) includes the additional limitation that the total laminar flaw shall not exceed 10% of the weld surface area and that no linear dimension of the laminar flaw area exceeds 3 inches. **Basis:** These changes were made to provide additional conservatism to the weld overlay examination and to reduce the size of the un-inspectable volume beneath a laminar flaw. See paragraph V.A.3.c of the Request for

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Code Case N-504-3 and Appendix Q of ASME Section XI	Proposed Alternative of Attachment 2
	additional information.
Q-4100(c)(4) allows the performance of radiography in accordance with the Construction Code as an alternative to Q-4100(c) (3).	The acceptance standards in paragraph 3.0(a)(3) of Attachment 2 do not include the radiographic alternative of paragraph Q-4100(c)(4). **Basis**: The UT examinations performed in accordance with the proposed alternative are in accordance with ASME Section XI, Appendix VIII, Supplement 11 as implemented through the PDI. These examinations are considered more sensitive for detection of defects, either from fabrication or service-induced, than either ASME Section III radiographic or ultrasonic methods. Furthermore, construction type flaws have been included in the PDI qualification sample sets for evaluating procedures and personnel. See Section V.A.3 of this Request for additional justification.
Preservice Inspection	**3.0(b) Preservice Inspection**
Q-4200(b) states that the preservice examination acceptance standards of Table IWB-3514-2 shall be met for the weld overlay. Cracks in the outer 25% of the base metal shall meet the design analysis requirements of Q-3000.	The acceptance standards in paragraph 3.0(b)(2) of Attachment 2 are identical to paragraph Q-4200(b) except paragraph 3.0(b)(2) includes the following statement: "In applying the acceptance standards, wall thickness, t_w, shall be the thickness of the weld overlay." **Basis**: This provision is actually a clarification that the nominal wall thickness of Table IWB-3514-2 shall be considered the thickness of the weld overlay. It must be remembered that the acceptance standards were originally written for the welds identified in IWB-2500. Because IWB-2500 does not address weld overlays, this clarification was provided to avoid any potential confusion. However, defining the weld overlay thickness as the nominal wall thickness of Table IWB-3514-2 has always been the practice since it literally becomes the new design wall of the piping or component nozzle.

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Code Case N-504-3 and Appendix Q of ASME Section XI	Proposed Alternative of Attachment 2
Pressure Testing	**4.0 Pressure Testing**
(h) The completed repair shall be pressure tested in accordance with IWA-5000. A system hydrostatic test is required if the flaw penetrated the pressure boundary. A system leakage test may be performed if pressure boundary is not penetrated.	The pressure testing requirements of Section 4.0 of Attachment 1 are similar to paragraph (h) of Code Case N-504-3 except that only a system leakage test per IWA-5000 is required.

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Attachment 5 to Enclosure 1

Technical Basis for Alternatives to ASME Code Case N-638-1,
Ambient Temperature Temperbead Welding

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TECHNICAL BASIS FOR PROPOSED ALTERNATIVES TO ASME CODE CASE N-638-1, *AMBIENT TEMPERATURE TEMPERBEAD WELDING*

1. Basis for Area Limitation Change to 500 Square Inches

IWA-4600 and versions of ASME Code Case N-638 prior to Revision 3 contained a limit of 100 square inches for the surface area of a temperbead weld over ferritic base metal. The area limitation in Attachment 3 is 500 square inches. The proposed weld overlay will be greater than 100 square inches but less than 500 square inches.

Technical justification for allowing weld overlays on ferritic materials with surface areas up to 500 square inches is provided in the white paper supporting the changes in ASME Code Case N-638-3 and EPRI Report 1011898 (Ref. 6). The ASME white paper notes that the original limit of 100 square inches in Code Case N-638-1 was arbitrary. It cites evaluations of a 12-inch diameter nozzle weld overlay to demonstrate adequate tempering of the weld heat affected zone (HAZ) (Section 2a of the white paper), residual stress evaluations demonstrating acceptable residual stresses in weld overlays ranging from 100 to 500 square inches (Section 2b of the white paper), and service history in which weld repairs exceeding 100 square inches were NRC approved and applied to DMW nozzles in several BWR and PWR (Section 3c of the white paper) applications. Some of the cited repairs are greater than 15 years old, and have been inspected several times with no evidence of any continued degradation.

It is important to note that the above theoretical arguments and empirical data have been verified in practice by extensive field experience with temperbead weld overlays, with ferritic material coverage ranging from less than 10 square inches up to and including 325 square inches. The table below provides a partial list of such applications.

Date	Plant	Component	Nozzle Diameter (in)	Approx. LAS Coverage (in²)
November 2006	SONGS Unit 3	PZR spray nozzle Safety/relief nozzles PZR surge nozzle	5.1875 8 12.75	40 60 110
November 2006	Catawba Unit 1	PZR spray nozzle Safety/relief nozzles PZR surge nozzle	4 6 14	30 50 120
November 2006	Oconee Unit 1	PZR spray nozzle Safety/relief nozzles PZR surge nozzle HL Surge Nozzle	4.5 4.5 10.875 10.75	30 30 105 70
October 2006	McGuire Unit 2	PZR spray nozzle Safety/relief nozzles PZR surge nozzle	4 6 14	30 50 120
April 2006	Davis-Besse	Hot leg drain nozzle	4	16
February 2006	SONGS Unit 2	PZR spray nozzle Safety/relief nozzles	8 6	50 28

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Date	Plant	Component	Nozzle Diameter (in)	Approx. LAS Coverage (in²)
November 2005	Kuosheng Unit 2	Recirc. outlet nozzle	22	250
April 2004	Susquehanna Unit 1	Recirc. inlet nozzle Recirc. outlet nozzle	12 28	100 325
November 2003	TMI Unit 1	Surge line nozzle	11.5	75
October 2003	Pilgrim	Core spray nozzle CRD return nozzle	10 5	50 20
October 2002	Peach Bottom Units 2 & 3	Core spray nozzle Recirc. outlet nozzle CRD return nozzle	10 28 5	50 325 20
October 2002	Oyster Creek	Recirc. outlet nozzle	26	285
December 1999	Duane Arnold	Recirc. inlet nozzle	12	100
June 1999	Perry	Feedwater nozzle	12	100
June 1998	Nine Mile Point Unit 2	Feedwater nozzle	12	100
March 1996	Brunswick Units 1 & 2	Feedwater nozzle	12	100
February 1996	Hatch Unit 1	Recirc. inlet nozzle	12	100
January 1991	River Bend	Feedwater nozzle	12	100
March 1986	Vermont Yankee	Core spray nozzle	10	50

It can be seen from the information above that the original DMW weld overlay was applied over 20 years ago, and weld overlays with low alloy steel coverage in the 100-square inch range have been in service for 5 to 15 years. Several overlays have been applied with low alloy steel coverage significantly greater than the 100 square inches. These overlays have been examined with PDI qualified techniques, in some cases multiple times, and none have shown any signs of new cracking or growth of existing cracks.

2. <u>Clarification of Charpy V-Notch Acceptance Criteria</u>

Paragraph 2.1(j) of Code Case N-638-1 states, "The average of the three HAZ impact tests shall be equal to or greater than the average values of the three unaffected base metal tests." However, the Charpy V-notch test acceptance criteria in Code Case N-638-1 is misleading and inconsistent with the specified acceptance criteria in Section XI applicable to other Class 1 components, since it implies that all three parameters - lateral expansion, absorbed energy, and percent shear fracture – must be equal to or exceed the base material values.

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Code Case N-638-2 corrected paragraph 2.1(j) to state that Charpy V-notch acceptance criteria is based on the *average lateral expansion values* rather than the average of all three values. This change clarified the intent of the code case and aligned its Charpy V-notch acceptance criteria with that of Sections III and XI as demonstrated in the Code references provided below.

- ASME Section III – NB-4330, *Impact Test Requirements*
- ASME Section XI - IWA-4620, *Temperbead Welding of Similar Materials*
- ASME Section XI - IWA-4630, *Temperbead Welding of Dissimilar Materials*

The Attachment 3 acceptance criteria for Charpy V-notch testing of the weld HAZ is as specified in Code Case N-638-2. The ASME Section XI basis for this change is documented in the White Paper in ASME C&S Connect for Code Case N-638-2.

Enclosure 2

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List of Regulatory Commitments

List of Regulatory Commitments

The following table identifies those actions committed to by Entergy in this document. Any other statements in this submittal are provided for information purposes and are not considered to be regulatory commitments.

COMMITMENT	TYPE (Check one)		SCHEDULED COMPLETION DATE (If Required)
	ONE-TIME ACTION	CONTINUING COMPLIANCE	
Weld overlay examination results including a listing of indications detected.	X		14 days after completing the final ultrasonic examinations of the completed weld overlays
Disposition of indications using the standards of ASME Section XI, Subsection IWB-3514-2 and/or IWB-3514-3 criteria and, if possible, the type and nature of the indications	X		14 days after completing the final ultrasonic examinations of the completed weld overlays
A discussion of any repairs to the weld overlay material and/or base metal and the reason for the repairs.	X		14 days after completing the final ultrasonic examinations of the completed weld overlays
Submit to the NRC a stress analysis summary demonstrating that the N-2C nozzle to safe-end DMW will perform its intended design function after weld overlay installation	X		Within 60 days of completing JAF's refueling outage R-18

The NRC staff evaluated the differences between the PDI program and the ASME Code, Section XI, Appendix VIII, Supplement 11 as shown in Attachment VII of the June 1, 2007, submittal. The NRC staff concludes that the justifications for the differences are acceptable and the PDI program provides an acceptable level of quality and safety. Therefore, the proposed PDI program is acceptable for use to meet requirements of Supplement 11 of Appendix VIII to the ASME Code, Section XI.

The NRC staff finds that the requirements of Relief Request RR-III-05 are consistent with the provisions of Code Cases N-504-3 and N-638-1 and Appendix Q of the ASME Code, Section XI. Therefore, the proposed Relief Request RR-III-05 is acceptable.

5.0 CONCLUSION

The NRC staff has reviewed the licensee's submittal and determined that Relief Request RR-III-05 will provide an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the NRC staff authorizes the use of Relief Request RR-III-05 for weld overlay of the dissimilar and similar metal welds of the pressurizer safety valve, relief valve, spray line, and surge line nozzles for the third 10-year ISI interval at VCSNS.

All other ASME Code, Section XI requirements for which relief was not specifically requested and approved in this relief request remain applicable, including third-party review by the Authorized Nuclear Inservice Inspector.

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Date: March 25, 2008