Pacific Gas and Electric Company®

James R. Becker
Vice President
Diablo Canyon Operations and Station Director

Diablo Canyon Power Plant
P. O. Box 56
Avila Beach, CA 93424

805.545.3462
Fax: 805.545.4234

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PG&E Letter DCL-07-099
U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Docket No. 50-323, OL-DPR-82
Diablo Canyon Unit 2
ASME Section XI Inservice Inspection Program Relief Request REP-1 U2, Revision 1, and Response to Request for Additional Information.

Reference:

1. PG&E Letter DCL-07-038, "ASME Section XI Inservice Inspection Program Relief Request REP-1 U2," dated March 28, 2007.

Dear Commissioners and Staff:

By letter dated March 28, 2007, PG&E requested NRC approval for Inservice Inspection Program Relief Request REP-1 U2. This request for relief contains alternative requirements for the ASME Section XI Repair/Replacement Program for scheduled preemptive full structural weld overlays (SWOLs) to mitigate the effects of primary water stress corrosion cracking of susceptible material at Diablo Canyon Power Plant (DCPP) Unit 2. This work is planned to be done during the DCPP Unit 2 Fourteenth Refueling Outage (2R14) currently scheduled to begin February 4, 2008.

By email dated July 26, 2007, the NRC requested additional information required to complete their review of Relief Request REP-1 U2. The response to the NRC request for additional information is included in Enclosure 1. A revised relief request, "Use of Weld Overlays as an Alternative Repair Technique," is provided in Enclosure 2. Enclosure 3 includes a discussion of the Performance Demonstration Initiative (PDI) Program alternatives and their bases with respect to ASME Code Section XI, Appendix VIII, Supplement 11 requirements.

PG&E requests approval of this revised relief request no later than February 1, 2008, to support preparations for the SWOLs during 2R14.

This communication contains new commitments to be implemented following NRC approval of this relief request. The commitments are contained in Enclosure 4.

If you have any questions, please contact Mr. Stan Ketelsen at (805) 545-4720.

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NRR

Sincerely,

James R. Becker
Vice President – Diablo Canyon Operations and Station Director

tcg/4231
Enclosures
cc: Diablo Distribution
cc/enc: Gary W. Butner, Acting Branch Chief, California Department of Public Health
Elmo E. Collins, Regional Administrator, NRC Region IV
Michael S. Peck, NRC Senior Resident Inspector
Alan B. Wang, Project Manager, Office of Nuclear Reactor Regulation
State of California, Pressure Vessel Unit

REQUEST FOR ADDITIONAL INFORMATION
RELIEF REQUEST REP-1 U2

By PG&E Letter DCL-07-038, "ASME Section XI Inservice Inspection Program Relief Request REP-1 U2," dated March 28, 2007, Pacific Gas and Electric Company requested NRC approval for Relief Request REP-1 U2, which is related to the preemptive full structural weld overlay of dissimilar and similar metal welds of pressurizer nozzles. To complete its review, the NRC staff requested the following additional information:

Comments on Enclosure 1 to the March 28, 2007, Submittal

NRC Request 1

Relief Request REP-1 U2 uses Code Case N-740-1 as the technical basis for the proposed overlay of the pressurizer nozzle welds. However, the licensee may need to propose the requirements in the code case as a result of staff review. After modifications, the alternative proposed in the submittal would not be the same as the code case approved by the ASME. Therefore, the staff suggests that the licensee revise/replace the title "Code Case N-740-1" in the submittal with an appropriate title.

PG&E Response:

The title of the alternative proposed in the Relief Request REP-1 U2 is changed to "Alternative Requirements for Dissimilar Metal Weld Overlays." Refer to Attachment 1 to the revised relief request (Enclosure 2).

NRC Request 2

In Section 5.3 of Enclosure 1, the licensee proposed to perform UT and surface examination on the temper bead portion of the weld overlay 48 hours after the completion of the third temper bead layer. However in paragraph 3(a)(2) of Enclosure 2, the licensee states that the examination will be performed 48 hours after the completed overlay has returned to ambient temperature. The licensee needs to revise the submittal to reconcile the discrepancy between Enclosure 1 and Enclosure 2 of Relief Request REP-1 U2.

PG&E Response:

The alternative requirements in paragraphs 3(a)(2) and 3(a)(3) have been modified to be consistent with Section 5.3. Refer to the revised relief request.

Comments on Enclosure 2 to the March 28, 2007, submittal

NRC Request 3

Paragraphs 1(c)(1), 1(c)(1)(a), and 1(c)(1)(b) provide the alternative to the post weld heat treatment (PWHT) of the Construction Code and Owner's requirements. The alternative eliminates PWHT for weld overlays when the overlay is applied to P-No.1 base material. As of July 2007, the staff has not decided the acceptability of the elimination of post weld heat treatment in paragraphs 1(c)(1)(a) and 1(c)(1)(b). In addition, the nozzle material at Diablo Canyon is P-No.3 and is not applicable to the specifications of these paragraphs. Therefore, the staff suggests eliminating these paragraphs or provide justification for the proposed alternative in these paragraphs.

PG&E Response:

Paragraphs 1(c)(1), 1(c)(1)(a), and 1(c)(1)(b) are not applicable to Diablo Canyon Power Plant (DCPP) Unit 2 and therefore are removed from the revised relief request. Refer to Attachment 1 to revised relief request.

NRC Request 4

Please revise paragraphs 2(a), 2(a)(1), and 2(a)(2) to clarify whether the flaw(s) in the crack growth calculation is located in the original weld/base metal or in the weld overlay.

PG&E Response:

The flaws are assumed to be in the underlying weld and base metal. Enclosure 2, Attachment 1, Section 2(a) provides clarification on location of the postulated flaws.

NRC Request 5

Paragraph 2(a) of the original Code Case N-740 requires that "...If the flaw is at or near the boundary of two different materials, evaluation of flaw growth in both materials is required...." The staff suggests this statement be included as part of paragraph 2(a) in Enclosure 2 or discuss why this requirement is not included.

PG&E Response:

Flaws detected near the boundary of the Alloy 82/182 dissimilar metal welds (DMWs) with the stainless steel or low alloy steel base materials are not controlling for primary water stress corrosion cracking (PWSCC) flaw growth evaluations. The growth rates for stress corrosion in Alloy 82 and Alloy 182 used in the evaluation are much greater than either stress corrosion or fatigue for the adjacent materials. Enclosure 2, Attachment 1, paragraph 2(a) is modified to require evaluation of growth rates in both materials.

NRC Request 6

Paragraph 2(a) states that the size of all flaws detected or postulated in the original weldment shall be projected to the end of the expected life of the overlay. Provide/describe the expected life of the overlay.

PG&E Response:

The expected life of the overlay is 20 years beyond the current license expiration date of August 26, 2025.

NRC Request 7

Revise Paragraph 2(a)(2)(b) to clarify from where the subject flaw is initiated (i.e., inside or outside surface of the pipe). The flaws initiated from the outside surface of the pipe may have a different stress distribution than the flaws initiated from the inside surface of the pipe.

PG&E Response:

Paragraph 2(a)(2)(a) is revised to state that the postulated 75 percent through wall flaws are inside surface connected. Refer to the revised relief request.

NRC Request 8

For Paragraph 2(a)(2)(c), the staff's position is that the initial flaw size in the crack growth calculation should consider the as-found flaw size from the UT-qualified region plus a postulated worst-case flaw from the UT unqualified region of the base metal. The postulated worst-case flaw size should be the depth of the base metal for which the UT is not qualified. The staff suggests paragraph 2(a)(2)(c) be revised accordingly or justify the acceptability of paragraph 2(a)(2)(c).

PG&E Response:

The ultrasonic examination procedure is qualified for the outer 25 percent of the underlying weld and base material wall thickness. Therefore 75 percent through wall inner surface connected circumferential and axial flaws are assumed for the flaw growth evaluations as stated in paragraph 2(a)(2)(a) of Attachment 1 to the revised relief request. The original paragraph 2(a)(2)(c) has been deleted.

NRC Request 9

Paragraph 2(a)(2)(d) states that "...Any inside surface connected planar flaw found by the overlay preservice inspection of paragraph 3(b), which exceed the depth of (a), (b), or (c) above, shall be used as the initial flaw depth in determining the expected life of the overlay. Overlays meeting this condition shall be considered a repair..." The staff suggests that Paragraph 2(a)(2)(d) be revised because of the following concerns.

(a) The first sentence of paragraph 2(a)(2)(d) is incorrect because current UT examination is not qualified to detect inside surface connected planar flaws after the overlay is installed on the pipe. Therefore, it is not possible to detect an inside surface connected planar flaw. Also, Paragraph 3(b) of the Code Case (preservice examination) requires examination of only the weld overlay thickness and outer 25% of the base metal. The inner 75% of the base metal is not part of preservice examination.

(b) The initial flaw assumed in Paragraph 2(a)(2)(d) is not conservative for the original weld that was not ultrasonically examined prior to installing the overlay. For the original weld that was not inspected prior to overlay installation, if a flaw is detected in the base metal after the overlay installation, the staff recommends that the crack growth calculation include an initial flaw size of the actual detected flaw size plus the assumed 75% through wall (originated from the inside surface of the base metal). The 75% through wall flaw size should be added because UT is not yet Appendix VIII qualified to examine the inner 75% of the overlaid pipe wall thickness. The region should be assumed to contain a 75% throughwall flaw.

(c) It is not clear how the initial flaw size used in the crack growth calculation determines the expected life of the weld overlay. It seems that the crack growth calculation would determine how many years (i.e., expected life) before the initial flaw size would grow 100% through wall. However, when designing the weld overlay thickness, the weld overlay is designed for certain loadings in certain number of years (e.g., 40 years). Explain how the initial flaw size determines the expected life of the weld overlay.

PG&E Response:

Paragraph 2(a)(2)(b) is revised to clarify that flaw(s) detected during preservice ultrasonic examination will be evaluated in combination with the postulated inside surface connected 75 percent through wall flaws.

The original paragraph 2(a)(2)(d) has been deleted.

Seventy-five percent through wall inside connected planar flaws in both the axial and circumferential directions are postulated for the flaw growth evaluations. Planar flaws detected during preservice ultrasonic examinations will be addressed in the flaw growth evaluations in combination with the initial postulated flaws as stated in paragraph 2(a)(2)(b) of Attachment 1 to the revised relief request.

If the initial 75 percent through-original wall thickness flaw grows through the remaining original wall thickness, flaw growth into the overlay is assumed to occur. The required thickness of the overlay is based on extending its life until 20 years beyond the current license expiration date of August 26, 2025. Therefore, the initial overlay design thickness is sufficient to accommodate the maximum potential hypothetical flaw growth into the weld overlay for the life of the component.

NRC Request 10

Paragraph 2(b)(7) states that ". . .any planar flaws in the weld overlay. . . shall be evaluated and shall meet the requirements of IWB-3640, IWC-3640, or IWD-3640 as applicable. . ." The staff does not agree that planar flaws in the weld overlay should be evaluated for acceptability by IWB-3640 as part of the preservice examination. The staff's position is that any planar flaws found in the weld overlay during preservice examination that do not satisfy Table IWB-3514-2 needs to be removed. These planar flaws cannot be accepted by IWX-3640. The licensee needs to either delete the words "any planar flaws" from the above statement or provide additional technical justification.

PG&E Response:

Planar flaws detected in the overlay during the preservice inspection that exceed Table IWB-3514-2 limits will be removed. The reference in 2(b)(7) to "any planar flaws" is removed.

NRC Request 11

The first sentence under Section 3 reads: "...In lieu of all other examination requirements, the examination requirements of this Case shall be met . . . " This requirement implies that if a dissimilar metal weld was examined under the risk-informed inservice inspection program or some other ISI program prior to the installation of the weld overlay, after the overlay is installed on the subject weld, the weld will be examined in the future in accordance with the requirements of Relief Request REP-1 U2. However, the above requirement does not specify a period of time during which the Code Case would be effective. Clarify the above requirement by adding an effective period of time.

PG&E Response:

The inservice inspection (ISI) requirements of ASME Section XI, Appendix Q, Subarticle Q-4300, will be implemented for the life of the overlay with the exception that flaws detected in the overlay that are due to stress corrosion cracking that exceed the standards of Table IWB-3514-2 are not allowed to remain in service. ISI requirements and acceptance criteria are addressed in paragraphs 3(c)(1) and 3(c)(2) of Attachment 1 to the revised request.

NRC Request 12

Paragraph 3(c)(2) reads: "... Alternatively, for mitigative weld overlays, in which examinations are performed in accordance with 2(a)(2)(a), 3(a), and 3(b), and no inside surface connected planar flaws are discovered, the overlay may be placed directly into the population to be examined in accordance with (c)(5) below..." The staff's position is that all planar flaws, not only inside surface connected planar flaws, should not be present for the weld to be placed in the population of paragraph 3(c)(5). Also, the above requirement should also specify where the planar flaws are prohibited (i.e., in the weld overlay and base metal). The licensee needs to revise paragraph 3(c)(2) accordingly or justify why paragraph 3(c)(2) is acceptable.

PG&E Response:

The original 3(c)(2) does not apply to DCPP Unit 2 since no pre-overlay examinations will be performed. Seventy-five percent through wall inside surface connected planar flaws are assumed for the flaw growth evaluations. Other flaws detected in the ISI examination volume will be evaluated in combination with these original postulated flaw(s). ISI will be performed as described in the response to NRC Request 11. Paragraph (3)(c)(2) of is revised accordingly. Refer to Attachment 1 to the revised relief request.

NRC Request 13

Paragraph 3(c)(4). The staff considers that a flaw detected in the weld overlay that is attributed to PWSCC should not remain in service if the flaw exceeds the standards of Table IWB-3514-2 because the high PWSCC crack growth rate. Therefore, the staff recommends that Paragraph 3(c)(4) be revised to prohibit the use of IWB-3600, IWC-3600, or IWD-3600 to accept flaws in the weld overlay that are attributed to PWSCC.

PG&E Response:

Acceptance of flaws in the weld overlay that are PWSCC-related and exceed the standards for inservice examination of Table IWB-3514-2 is prohibited as stated in revised paragraph 3(c)(2) of Attachment 1 to the revised relief request.

Comments on Mandatory Appendix I

NRC Request 14

Paragraph 1(a) shows superscript "1" on "12C", representing footnote 1. However, footnote 1 is not identified in Appendix I.

PG&E Response:

The revised submittal is corrected to delete reference to P-No. 1 and P-No. 12A, 12B, and 12C since they do not apply to DCPP Unit 2.

NRC Request 15

There are two "f" paragraphs under Section 2.1.

PG&E Response:

The revised submittal is corrected.

General Comments

NRC Request 16

By letter dated April 28, 2006, Exelon submitted a relief request for the preemptive weld overlays of the pressurizers lines at Byron and Braidwood. By letter dated September 14, 2006, Exelon committed to provided 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, (2) a discussion of any repairs to the overlay material and/or base metal and the reason for the

repair, and (3) commitment to perform the subsequent inservice examination in accordance with Subarticle Q-4300 of Appendix Q to the ASME Code, Section XI. The staff has accepted the submittal of ultrasonic examination results within 60 day of the examination in the review of relief requests from other licensees. Please provide a commitment to submit the above information regarding the results of the ultrasonic examination of the weld overlay installation.

PG&E Response:

PG&E will provide details of the examination results of the structural weld overlays on the DCPP Unit 2 pressurizer spray, relief, safety and surge nozzle safe-ends to the NRC within 60 days after completion of the final installation ultrasonic examination. The results will include description(s) of any weld repairs to the weld overlay material and/or base material and the reason(s) for the weld repair(s).

The inservice inspection requirements of ASME Section XI, Appendix Q, Subarticle Q-4300 will be implemented as described in the response to NRC question 11.

NRC Request 17:

If the pressurizer surge line in Diablo Canyon Unit 2 has been approved for leak-before-break, please confirm that the results of the original leak-before-break analyses are still valid and associated acceptance criteria (e.g., the safety margin on crack size and leak rates as specified in Standard Review Plan 3.6.3) are still acceptable after the weld overlay is applied to the surge line.

PG&E Response:

The pressurizer surge line has not been approved for leak-before-break.

INSERVICE INSPECTION (ISI) RELIEF REQUEST REP-1 U2, Revision 1
In Accordance with 10 CFR 50.55a(a)(3)(i)

USE OF WELD OVERLAYS AS AN ALTERNATIVE REPAIR TECHNIQUE

--Alternative Provides Acceptable Level of Quality and Safety--

1. ASME Code Component Affected

Code components associated with this request are high safety significant (HSS) Class 1 dissimilar metal welds (DMWs) with Alloy 82/182 weld metal in the pressurizer nozzle-to-safe end connection that are believed to be susceptible to primary water stress corrosion cracking (PWSCC). There are six dissimilar metal welds that are scheduled to have preemptive full structural weld overlays (SWOLs) applied. In addition, the SWOLs will extend across the six adjacent stainless steel pipe-to-safe end similar metal welds. These welds are scheduled to have SWOLs applied during the upcoming Diablo Canyon Power Plant (DCPP) Unit 2 Fourteenth Refueling Outage (2R14).

1.1 Category and System Details:

Code Class: ASME Class 1
System Welds: Reactor Coolant System
Examination Categories: B-F (Risk-informed Category R-A)

Note: Following weld overlay installation, inservice inspections (ISI) will be performed in accordance with the requirements of this relief request.

1.2 Component Descriptions:

The application of this alternative is to apply SWOLs on one potentially PWSCC-susceptible safe end-to-pressurizer surge nozzle DMW, three safe end-to-safety nozzle DMWs, one safe end-to-relief nozzle DMW, and one safe end-to-spray nozzle DMW. The SWOLs will extend outward across the adjacent stainless steel pipe-to-safe end welds. The applicable weld identification is as follows:

a) Weld No. WIB-439SE Safe End -To-Surge Nozzle Weld and adjacent Pipe-to-Safe End Weld No. WIB-438 (Line Identifier 2-*-16-14SPL)

b) Weld No. WIB-369SE Safe End-to-8010A Safety Nozzle Weld and adjacent Pipe-to-Safe End Weld No. WIB-369 (Line Identifier 2-S6-729-6)
c) Weld No. WIB-423SE Safe End-to-8010B Safety Nozzle Weld and adjacent Pipe-to-Safe End Weld No. WIB-423 (Line Identifier 2-S6-728-6)
d) Weld No. WIB-359SE Safe End-to-8010C Safety Nozzle Weld and adjacent Pipe-to-Safe End Weld No. WIB-359 (Line Identifier 2-S6-727-6)
e) Weld No. WIB-380SE Safe End-to-Relief Nozzle Weld and adjacent Pipe-to-Safe End Weld No. WIB-380 (Line Identifier 2-S6-730-6)
f) Weld No. WIB-345SE Safe End-to-Spray Nozzle Weld and adjacent Pipe-to-Safe End Weld No. WIB-345 (Line Identifier 2-S6-15-4SPL)

1.3 Component Materials:

a) Nozzles are Low Alloy Steel SA-508 CL2 (P-No. 3 Group No. 3)
b) Safe End-to-Nozzle Welds and Buttering are Alloy 82/182 (F-No. 43)
c) Safe Ends are Wrought Stainless Steel SA-182 GR F316L (P-No. 8)
d) Attached Pipe is Wrought Seamless Stainless Steel SA-376 Type 316 (P-No. 8) and Welds are Stainless Steel (A-No. 8)

The materials listed above apply to all pressurizer nozzles.

2. Applicable Code Edition and Addenda

DCPP Unit 2 is currently in the third 10-year ISI interval. The ASME Boiler and Pressure Vessel Code (Code) of record is Section XI, 2001 Edition, including Addenda through 2003 (Reference 8.1) for the current 10-year ISI interval and the Repair/Replacement and ISI Program. ASME Code Section XI, 2001 Edition, no Addenda, Appendix VIII, Supplement 11, (Reference 8.2) as implemented by the Performance Demonstration Initiative (PDI) Program, is used for ultrasonic examination qualification for SWOLs.

3. Applicable Code Requirement

The applicable Code requirement for which relief is requested is ASME Code Section XI, 2001 Edition, including Addenda through 2003, IWA-4410 and IWA-4611, and ASME Code Section XI, 2001 Edition, no Addenda, Appendix VIII, Supplement 11. (Reference 8.2)

IWA-4410 states, in part, the following:

"Welding, brazing, defect removal, ...and installation shall be performed in accordance with this Subarticle."

IWA-4611.1(a) states, in part, the following:

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

IWA-4611.2(a) states, in part, the following:

"After final processing, the affected surfaces, including surfaces of cavities prepared for welding, shall be examined by the magnetic particle or liquid penetrant method to ensure that the indication has been reduced to an acceptable size in accordance with IWB-3500."

Appendix VIII provides requirements for performance demonstration for ultrasonic examination systems. Supplement 11 provides qualification requirements for full structural overlaid wrought austenitic piping welds.

4. Reason for Request

DMWs, primarily consisting of Alloy 82/182 weld metal, are frequently used in pressurized water reactor (PWR) construction to connect stainless steel safe ends to vessel nozzles, which are constructed of carbon or low alloy ferritic steel. These welds have shown a potential for PWSCC degradation, especially in components subjected to high operating temperatures such as the pressurizer. See EPRI MRP-169 "Technical Basis for Preemptive Weld Overlays for Alloy 82/182 Butt Welds in PWRs," October 2005 (Reference 8.3).

For the upcoming 2R14 refueling outage, 6 DMWs located on the pressurizer are currently scheduled to have SWOLs applied. Repair/replacement activities associated with SWOL repairs are required to address the materials, welding parameters, ALARA concerns, operational constraints, examination techniques and procedure requirements for repairs.

ASME Code Section XI, 2001 Edition, including Addenda through 2003 (Reference 8.1), IWA-4410 and IWA-4611, do not address all the needed requirements for this type of repair since potential existing defects will not be removed or reduced in size and weld overlay of potential existing flaws in DMWs will be performed. Also, comprehensive and generic NRC

approved criteria for mitigation of potential PWSCC are not currently available for application of SWOL repairs to DMWs constructed of Alloy 82/182 weld material.

In addition, ASME Code Section XI, 2001 Edition, no Addenda, Appendix VIII, Supplement 11 (Reference 8.2), cannot be implemented as written for ultrasonic examination of a SWOL repair. Enclosure 3 includes a discussion of the PDI Program alternatives and their bases with respect to Appendix VIII, Supplement 11 requirements.

Section 5.0 is proposed to permit the implementation of SWOLs at DCPP Unit 2, and provides alternatives to the repair/replacement requirements of the ASME Code Section XI, 2001 Edition, including Addenda through 2003 (Reference 8.1), IWA-4410 and IWA-4611 and ASME Code Section XI, 2001 Edition, no Addenda, Appendix VIII, Supplement 11. (Reference 8.2)

5. Proposed Alternative and Basis for Use

This request proposes the use of the alternative requirements included in Attachment 1, for implementing the 6 scheduled SWOLs for PWSCC-susceptible safe end-to-nozzle welds of the pressurizer. These SWOLs will include the six adjacent stainless steel pipe-to-safe end welds. This request applies to each of the welds listed in Section 1.2, which are generically depicted in Figure 1. The proposed alternative is scheduled to be performed during the upcoming 2R14 refueling outage in February 2008.

This proposed alternative is the result of industry experience with weld overlay modifications for potential or known flaws caused by PWSCC, and directly applies to the Alloy 52 or 52M weld material that is primarily being used for these SWOLs.

The ultrasonic examination of the completed SWOLs will be accomplished with personnel and procedures qualified in accordance with ASME Code Section XI, 2001 Edition, no Addenda, Appendix VIII, Supplement 11 (Reference 8.2), as implemented by the PDI program.

5.1 SWOL Design

The SWOLs satisfy all the structural design requirements of the pipe, as specified in the alternative requirements in Attachment 1. As shown in Figure 1, the SWOLs will completely cover the existing Alloy 82/182 weld and will extend onto the ferritic nozzle and austenitic stainless steel material on each end of the weld, including the adjacent pipe-to-safe end

weld. The SWOLs extend around the entire circumference of the nozzle. Alloy 52M and 52 filler metals are compatible with all the wrought base materials and the DMWs and similar metal welds that will be covered by the SWOL.

The SWOLs will be designed as full structural overlays to repair the assumed worst case flaw in accordance with the alternative requirements in Attachment 1. Note that the details surrounding the design analysis for the SWOLs are being developed to support the 2R14 refueling outage and our vendor has committed to supplying this analysis to PG&E. The design analyses for the preemptive structural weld overlays will be available at the plant for NRC review at the beginning of 2R14.

5.2 Welding

The welding will be performed in accordance with the alternative requirements in Attachment 1 using a remote machine gas tungsten-arc welding (GTAW) process and the ambient temperature temper bead method with ERNiCrFe-7A (Alloy 52M) weld metal. Manual GTAW, using ERNiCrFe-7 (Alloy 52) or Alloy 52M, will be used if local repairs of weld defects are necessary or additional weld metal is required locally to form the final SWOL contour in locations at least 3/16 inch away from the low alloy steel nozzles.

Recent industry experience from weld overlay activities using ERNiCrFe-7A (Alloy 52M) and ERNiCrFe-7 (Alloy 52) reveals a potential for flaws in the first layer deposited on the austenitic stainless steel portions (safe ends, pipe etc.) of the assemblies.

The flaw characteristics observed in the first layer are indicative of hot cracking. This phenomenon has not been observed on the ferritic steel or ENiCrFe-3 (Alloy 182) DMW portions of the assemblies when Alloy 52M is used for the first layer.

Further studies have determined that this problem may occur when using Alloy 52M filler metal on austenitic stainless steel materials with high sulfur content.

Limited tests and evaluations recently performed have concluded that welding with Alloy 52M on stainless steel base material with 0.020 wt% sulfur results in cracking. Conversely, welding on stainless steel base materials with less than 0.010 wt% has resulted in no cracking.

Diablo Canyon Unit 2 material composition records indicate that the possibility of hot cracking due to the influence of sulfur in existing base

materials can not be ruled out. In order to minimize the occurrence of hot cracking, one or more barrier layers will be applied to all stainless steel items prior to Alloy 52M overlay. The barrier layer(s) will be ER309L for the stainless steel base and weld metal, and Alloy 82 for the DMW fusion zone and adjacent stainless steel heat affected zone.

The barrier layer will not be credited in the structural analysis or in the crack growth analysis. See Attachment 2 for additional barrier layer information.

5.3 Examination

The current configuration of the existing DMWs does not permit an ASME Code Section XI, Appendix VIII Supplement 10 ultrasonic examination to obtain greater than 90 percent coverage of the required examination volume. Therefore, none of the welds will receive a pre-weld overlay ultrasonic examination.

All overlay examinations will meet the requirements of the alternative requirements in Attachment 1. The ultrasonic examination qualification will be in accordance with ASME Code Section XI, 2001 Edition, no Addenda, Appendix VIII, Supplement 11 (Reference 8.2), as implemented by the PDI Program. See Enclosure 3 for a comparison of differences between Appendix VIII and the PDI program.

Ultrasonic and surface examinations of the completed overlay will be performed on the temper bead portion of the SWOLs no sooner than 48 hours after completion of the third temper bead layer as specified in Paragraphs 3(a)(2) and 3(a)(3), Attachment 1.

The 48-hour delay provides time for delayed hydrogen cracking occurrence. Attachment 1, Appendix 1 requires the machine or automatic GTAW process to be used for temper bead welding thereby eliminating the use of welding processes requiring flux for arc shielding.

The machine GTAW temper bead process is inherently free of hydrogen. The GTAW process relies on a bare welding electrode and bare wire filler metal with no flux to absorb moisture. An inert gas blanket provides shielding for the weld and surrounding metal, which protects the region during welding from the atmosphere and the moisture it may contain and typically produces porosity-free welds. In accordance with the weld procedure qualification, welding grade argon is used for the inert gas blanket. To further reduce the likelihood of any hydrogen effects, specific controls will be used to ensure the base metal, shielding gas, welding electrodes, filler metal and weld region are free of all sources of hydrogen.

In addition, the use of the machine GTAW temper bead process provides precise control of heat input, bead placement, bead size and contour. The very precise control over these factors afforded by the machine GTAW process provides effective tempering of the nozzle ferritic steel heat affected zone resulting in achievement of lower hardness and tempered martensite. This further reduces susceptibility to hydrogen-induced cracking.

EPRI Report 1013558, "Temperbead Welding Applications, 48-Hour Hold Requirements for Ambient Temperature Temperbead Welding," Technical Update, December 2006 (Reference 8.4), provides justification for allowing the 48-hour hold time on P-No. 3 Group No. 3 ferritic steel base material to start after completion of the third temper bead layer. EPRI Report 1013558 addresses microstructural issues, hydrogen sources, tensile stress and temperature, and diffusivity and solubility of hydrogen in steels.

Furthermore, past industry experience with the use of the machine or automatic GTAW process has resulted in no detection of hydrogen-induced cracking after the 48-hour hold nondestructive examination (NDE) or subsequent ISI.

Code Case N-638-4, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique Section XI, Division 1," specifies NDE to be performed on the final weld no sooner than 48 hours after completion of the third temper bead layer.

5.4 Conclusion

Similar NRC approved requests have been used to produce acceptable weld overlays when applied to Alloy 82/182 DMWs at other facilities (see Section 6). The proposed alternative in Attachment 1 has been developed to cover the most recent operating experience and NRC-approved criteria that are associated with similar SWOL applications. Therefore, PG&E considers that Attachment 1, and the previously NRC-approved PDI Program ultrasonic examination qualification alternative to ASME Section XI, 2001 Edition, no Addenda, Appendix VIII, Supplement 11, provide an acceptable level of quality and safety, consistent with provisions of 10 CFR 50.55a(a)(3)(i).

6. Precedents

Similar relief requests have been submitted by other utilities to address the issues that are contained in this request. The following relief requests have been approved by the NRC:

6.1 AmerGen Energy Company, Three Mile Island Nuclear Station, Unit 1, on July 21, 2004, in NRC letter, "Safety Evaluation of Request for Relief from Flaw Removal, Heat Treatment and Nondestructive Examination (NDE) Requirements for the Third 10-year Inservice Inspection Interval, Three Mile Island Nuclear Station, Unit 1 (TMI-1)," Docket No. 50-289, (TAC No. MC1201), dated July 21, 2004 (ADAMS Accession No. ML041670510).

6.2 Constellation Energy's Calvert Cliffs Nuclear Power Plant, Unit 2, on July 20, 2005, in NRC letter, "Safety Evaluation for Calvert Cliffs Nuclear Power Plant, Unit No. 2, Docket No. 550-318, Relief Request for Use Weld Overlay and Associated Alternative Inspection Techniques," (TAC Nos. MC6219 and MC6220), dated July 20, 2005 (ADAMS Accession No. ML051930316).

6.3 Millstone Unit 3, on January 20, 2006, in NRC letter, "Safety Evaluation of Relief Request IR-2-39 Pertaining to the Repair and Inspection of Nozzle to Safe End Weld, Weld No. 03-X-5641-E-T at Millstone Power Station Unit No. 3 (MPS3)," Docket No. 50-423, (TAC No. MC8609), dated January 20, 2006 (ADAMS Accession No. ML053260012).

6.4 Indiana Michigan Power Company, Donald C. Cook Unit 1, on February 10, 2006, in NRC letter, "Safety Evaluation of Alternative Regarding Repair of Safe-End-To-Elbow Weld 1-RC-9-01F at the Donald C. Cook Nuclear Plant Unit 1," Docket No. 50-315, (TAC No. MC8807), dated February 10, 2006 (ADAMS Accession No. ML060240355).

6.5 Indiana Michigan Power Company, Donald C. Cook Unit 2, on March 1, 2007, in NRC letter, "Safety Evaluation of Inservice Inspection Program Relief Request ISIR-20," Docket No. 50-316, (TAC No. MC9305), dated March 1, 2007 (ADAMS Accession No. ML070460121).

7. Duration of Proposed Alternative

The alternative requirements of this request will be applied to installation of weld overlays for the duration of the current third 10-year ISI interval. Overlay inservice inspection requirements are applicable for the expected life of the overlay, which is 20 years beyond the current license expiration date of August 26, 2025.

8. References

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

8.2 ASME Code, Section XI, 2001 Edition, no Addenda, Appendix VIII, Supplement 11.

8.3 EPRI MRP-169 "Technical Basis for Preemptive Weld Overlays for Alloy 82/182 Butt Welds in PWRs," October 2005.

8.4 EPRI Report 1013558, "Temperbead Welding Applications, 48 Hour Hold Requirements for Ambient Temperature Temperbead Welding," Technical Update, December 2006.

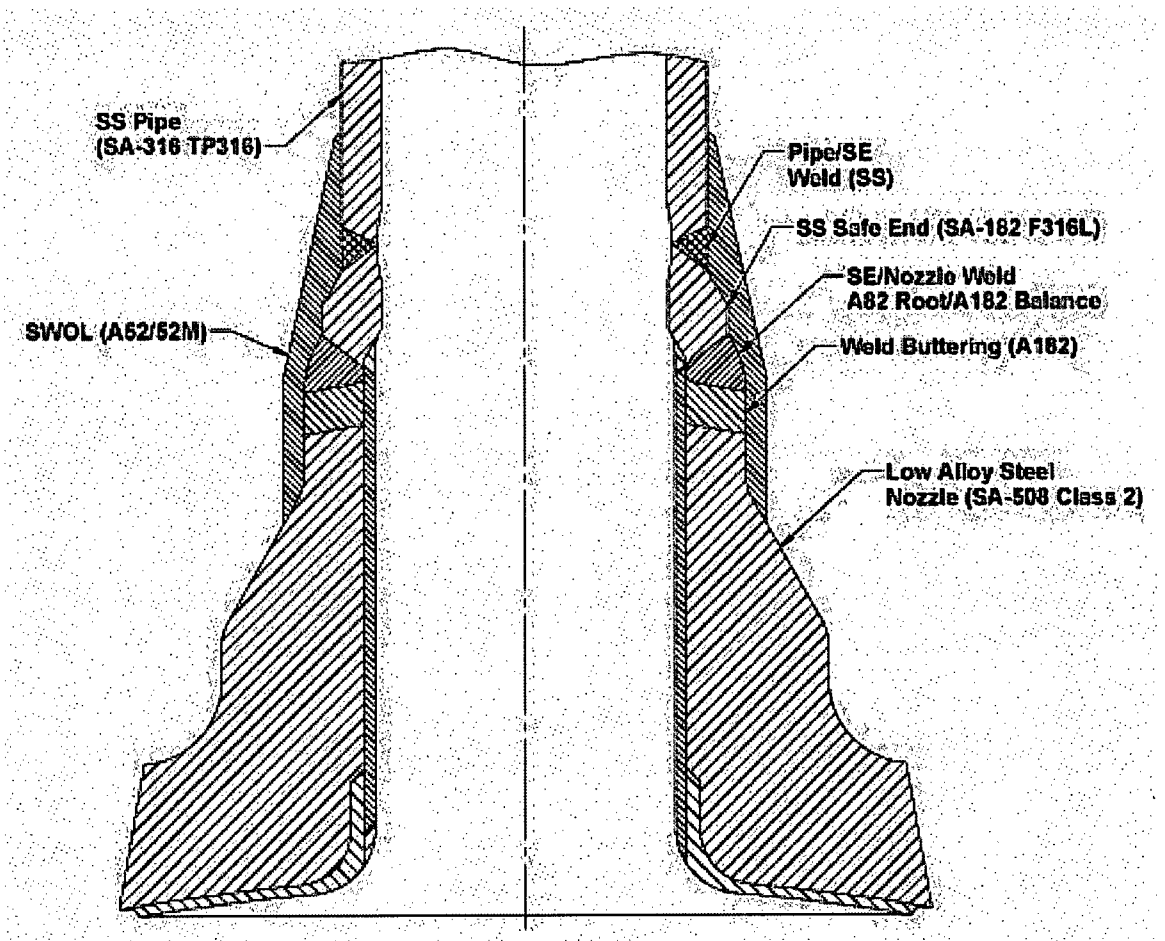


Figure 1 - Typical SWOL Configuration

Attachment 1

Alternative Requirements for Dissimilar Metal Weld Overlays

In lieu of the requirements of IWA-4410 and IWA-4611, a defect exceeding the applicable acceptance criteria in austenitic stainless steel or austenitic nickel alloy piping, components, or associated welds may be accepted by analysis in accordance with IWB-3640 by addition of a repair weld overlay. The weld overlay shall be applied by deposition of weld reinforcement (weld overlay) on the outside surface of the piping, component, or associated weld, including ferritic materials when necessary, provided the following requirements are met.

1. General Requirements

   (a) A full-structural weld overlay shall be applied by deposition of weld reinforcement (weld overlay) on the outside surface of the low alloy steel nozzles (P-No. 3) to the safe end (P-No. 8 or 43), inclusive of the N06082 or W86182 weld that joins the two items. The design of the overlay is extended to include the adjacent stainless steel to stainless steel weld joints (P-No. 8 to P-No. 8 with P-No. 6 filler material).

   (b) (deleted)

   (c) Weld overlay filler metal shall be austenitic nickel alloy (28 percent Cr minimum, ERNiCrFe-7 or ERNiCrFe-7A) applied 360 deg. 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.

   (d) Prior to deposition of the weld overlay, the surface to be weld overlaid shall be examined by the liquid penetrant method. Indications with major dimension greater than 1/16 in. (1.5 mm) 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 repair of indications identified in 1(d) 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 with major dimension greater than 1/16 in. (1.5 mm) prior to the application of the structural layers of the weld overlay.

(e) Weld overlay deposits shall meet the following requirements. The austenitic nickel alloy weld overlay shall consist of at least two weld layers deposited from a filler material with a Cr content of at least 28 percent. The first layer of weld metal deposited may not be credited toward the required thickness. Alternatively, a diluted first 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 24 percent 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.

(f) This alternative is only for welding in applications predicted not to have exceeded thermal neutron fluence of 1×10^{17} (E< 0.5 eV) neutrons per cm^2 prior to welding.

(g) A new weld overlay shall not be installed over the top of an existing weld overlay that has been in service.

(h) Appendix 1 shall be used for ambient-temperature temper bead welding

2. Crack Growth and Design

(a) Crack Growth Calculation of Flaws in the Original Weld or Base Metal.

The size of all flaws detected or postulated in the original weld or base material shall be used to define the life of the overlay, which is 20 years beyond the current license expiration date of August 26, 2025. Crack growth in the original weld and base metal, due to both stress corrosion and fatigue shall be evaluated. If the flaw is at or near the boundary of two different materials, evaluation of the flaw growth in both materials is required.

(1) For the DCPP Unit 2 pressurizer repair overlays, the initial flaw size for crack growth shall be based on the postulated

flaw, since no pre-overlay ultrasonic examination is performed.

(2) For postulated flaws in the original weld or base metal the axial flaw length shall be set at 1.5 inches (38 mm) or the combined width of the weld plus buttering, whichever is greater. The circumferential flaw length shall be assumed to be 360 degrees.

(a) Since no examination is performed prior to application of the overlay, initial inside surface connected planar flaws equal to at least 75 percent through the original wall thickness shall be assumed, in both the axial and circumferential directions, consistent with the overlay inservice inspection volume in Figure 2.

(b) In determining the expected life of the overlay, any planar flaw found by the overlay preservice examination of paragraph 3(b), which exceeds the depth of (a) above, shall be used as part of the initial flaw depth in determining the expected life of the overlay. The flaw depth assumed is the detected flaw depth plus the postulated worst-case flaw depth (i.e., 75 percent of original wall) in the unqualified ultrasonic examination region of the pipe wall thickness.

(b) Structural Design and Sizing of the Overlay

The design of the weld overlay shall satisfy the following, using the assumptions and flaw characterization restrictions in 2(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 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, or 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 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), the end transition slope of the overlay shall not exceed 30 degrees. 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 in the underlying base material or weld, the flaws shall be assumed to be 100 percent through the original wall thickness of the item for the entire circumference of the item.

(5) For axial flaws in the underlying base material or weld, the flaws shall be assumed to be 100 percent through the original wall thickness of the item for the entire axial length of the flaw or combined flaws, as applicable.

(6) For the Diablo Canyon Unit 2 full structural overlays, since ultrasonic examination is not performed prior to installation of the overlay, the assumed flaw in the underlying base material or weld is to be based on the limiting case of the two below:

(a) 100 percent through wall for the entire circumference, or

(b) 100 percent through wall for 1.5 in. (38 mm) or the combined width of the weld plus buttering, whichever is greater, in the axial direction.

(7) The overlay design thickness shall be verified using only the weld overlay thickness conforming to the deposit analysis requirements of 1(e). The combined wall thickness at the weld overlay and the effects of any discontinuities (e.g., another weld overlay or reinforcement for a branch connection) within a distance of $2.5\sqrt{Rt}$ from the toes of the weld overlay, including the flaw size assumptions defined in 2(b)(4), (5), or (6) above, shall be evaluated and shall meet the requirements of IWB-3640.

(8) 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. Examination

In lieu of all other examination requirements, the examination requirements herein shall be met for the life of the weld overlay. 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 the PDI implementation of ASME Section XI, Appendix VIII, Supplement 11, 2001, Edition no Addenda, or as updated requirements are mandated by the NRC.

(a) Acceptance Examination

(1) The weld overlay shall have a surface finish of 250 micro-in. (6.3 micrometers) RMS or better and a contour that provides for ultrasonic examination in accordance with procedures qualified per PDI implementation of Appendix VIII requirements. The weld overlay shall be inspected to verify acceptable configuration.

(2) The weld overlay and the adjacent base material for at least ½-in. (13 mm) 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 NB-5300. The adjacent base metal shall satisfy the surface examination acceptance criteria for base material of the Construction Code or NB-2500. If ambient temperature temper bead welding is used, the liquid penetrant examination of the completed weld overlay shall be conducted after the three tempering layers (i.e., layers 1, 2, and 3) over the ferritic steel have been in place for at least 48 hours.

(3) The acceptance examination volume, A-B-C-D, in Fig.1(a) plus the heat-affected zone beneath the fusion zone C-D shall be ultrasonically examined to assure adequate fusion (i.e., adequate bond) with the base metal and to detect 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. If ambient temperature temper bead welding is used, the ultrasonic examination of the completed weld overlay shall be conducted after the three tempering layers (i.e., layers 1, 2, and 3) over the ferritic steel have been in place for at least 48 hours.

Planar flaws detected in the weld overlay acceptance examination shall meet the preservice examination standards of

Table IWB-3514-2. In applying the acceptance standards to planar indications within the volume, E-F-G-H, in Fig. 1(b), the thickness "t_1" shall be used as the nominal wall thickness in Table IWB-3514-2. For planar indications outside this examination volume, the nominal wall thickness shall be "t_2" as shown in Fig. 1(c), for volumes A-E-H-D and F-B-C-G.

Laminar flaws shall meet the following.

(a) 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 percent of the weld surface area and that no linear dimension of the laminar flaw area exceeds 3.0 in. (76 mm), or 10 percent of the nominal pipe circumference, whichever is greater.

(b) The reduction in coverage of the examination volume, A-B-C-D in Fig. 1(a) due to laminar flaws shall be less than 10 percent. The uninspectable volume is the volume in the weld overlay underneath the laminar flaws for which coverage cannot be achieved with angle beam examination.

(c) Any uninspectable 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 preservice examination standards of Table IWB-3514-2, with nominal wall thickness as defined above for planar flaws. Both axial and circumferential planar flaws shall be assumed.

(4) After completion of all 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 in Fig. 2 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 outer 25 percent of the base material, underlying weld, or into the weld overlay. Any uninspectable examination volume in the outer 25 percent of the underlying weld or base material, as applicable, as shown in Fig. 2, shall be assumed to contain the largest circumferential and axial planar flaw within that volume for flaw growth evaluation.

(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 percent of the base metal shall meet the design analysis requirements of 2 (b).

(3) Planar flaws detected in the outer 25 percent of the underlying weld or base material thickness as depicted in the examination volume of Fig. 2 shall be evaluated in accordance with IWB-3640.

c. Inservice Inspection

(1) The inservice inspection requirements of ASME Section XI Appendix Q, Subarticle Q-4300, shall apply for the life of the weld overlays.

(2) Flaws due to stress corrosion cracking in the weld overlay that exceed the inservice examination acceptance standards of Table IWB-3514-2 shall not be accepted.

4. Pressure Testing

A system leakage test shall be performed in accordance with IWA-5000.

5. Documentation

Use of this alternative shall be documented on Form NIS-2.

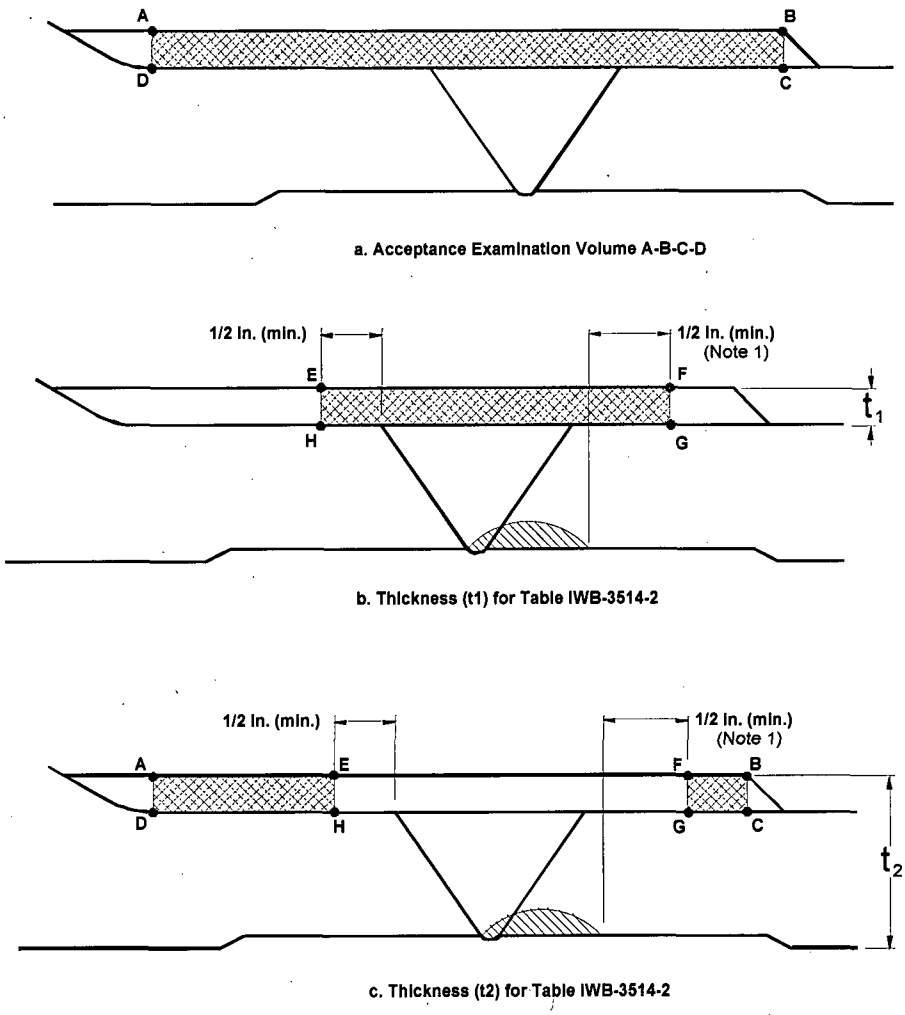
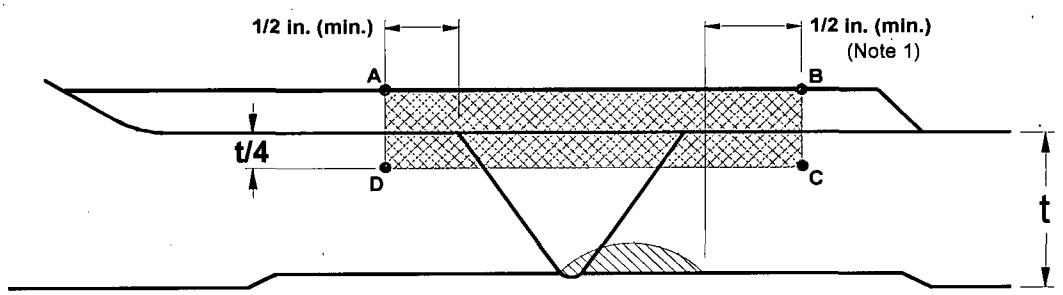


Fig. 1 Acceptance Examination Volume and Thickness Definitions

Notes:

(1) For axial or circumferential flaws, the axial extent of the examination volume shall extend at least ½ in. (13mm) beyond the toes of the original weld.

(2) The weld includes the weld end butter, where applied.



Examination Volume A-B-C-D

NOTES:

(1) For axial or circumferential flaws, the axial extent of the examination volume shall extend at least ½ in. (13mm) beyond the as-found flaw and at least ½ in. (13mm) beyond the toes of the original weld.

(2) The weld includes weld end butter, where applied.

Fig. 2 Preservice and Inservice Examination Volume

Appendix 1
Ambient Temperature Temper Bead Welding

1 GENERAL REQUIREMENTS

(a) This appendix applies to dissimilar austenitic filler metal welds between P-No. 3 materials and their associated welds and welds joining P-No. 8 or 43 materials to P-No. 3 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 percent to 1.0 percent nickel, quenching and tempering, and application of a fine grain practice.

(b) The maximum area of an individual weld overlay based on the finished surface over the ferritic base material shall be 500 sq. in. (325,000 sq. mm).

(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 in. (3 mm), 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 in. (10mm).

(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 in. (130 mm), 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 WELDING QUALIFICATIONS

The welding procedures and the welding operators shall be qualified in accordance with Section IX and the requirements of 2.1 and 2.2.

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°F (66°C).

(d) The test assembly cavity depth shall be at least 1 in. (25 mm). 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 in. (150 mm). The qualification test plate shall be prepared in accordance with Fig. 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 2.1(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 2.1 (e) 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. 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.

(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, Fig. 11, Type A. The test shall consist of a set of 3 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 Section IX.

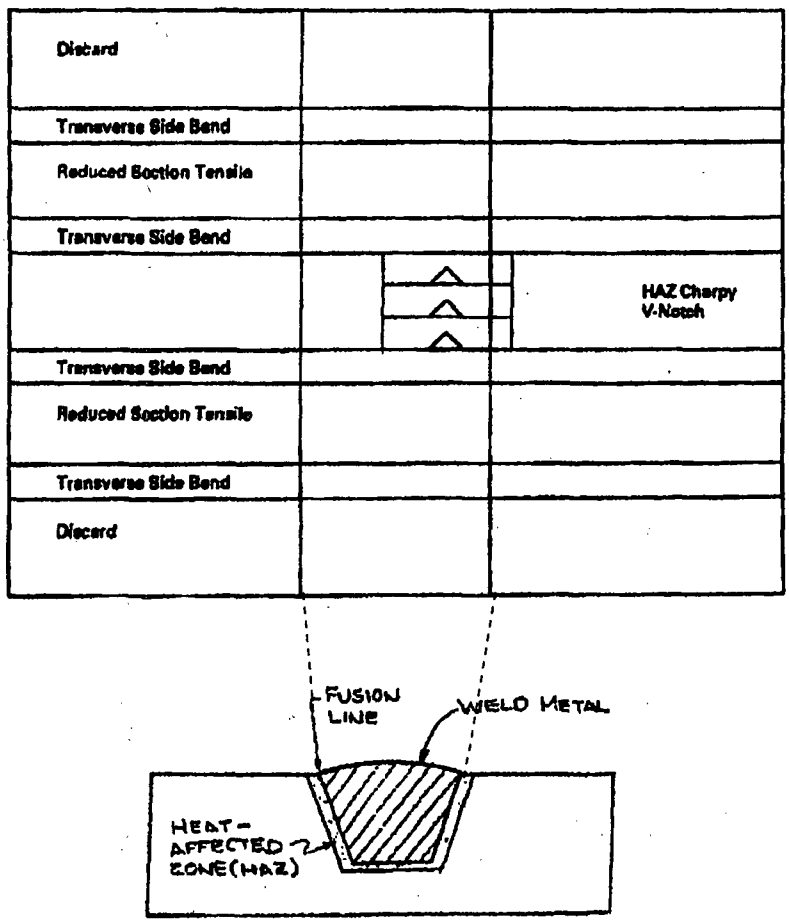
3.0 WELDING PROCEDURE REQUIREMENTS

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 (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 (QW-432) for P-No. 8 or 43 to P-No. 1, 3, or 12 (A, B, or C) 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 in. (3mm) overlay thickness with the heat input for each layer controlled to within ±10 percent of that used in the procedure qualification test. The heat input of the first three layers shall not exceed 45kJ/in. (1.8 kJ/mm) 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°F (180°C) 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:
  (1) Temperature measurement (e.g., pyrometers, temperature indicating crayons, thermocouples) during welding. When it is impractical to use interpass temperature measurements described in this paragraph due to situations where the weldment area is not accessible, such as internal bore welding or when there are extenuating radiological concerns, either paragraph 3(e)(2) or paragraph 3(e)(3) may be used.
  (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.



GENERAL NOTE: Base metal Charpy impact specimens are not shown.

Fig. 1-1 QUALIFICATION TEST PLATE

Attachment 2

Barrier Layer to Prevent Hot Cracking in High Sulfur Stainless Steel

Background

During recent dissimilar metal weld (DMW) overlay activities, where use of ERNiCrFe-7A (Alloy 52M) and ERNiCrFe-7 (Alloy 52) has been used for the filler metal, flaws in the first layer have occurred in the portion of the overlay deposited on the austenitic stainless steel portions (safe ends, pipe etc.) of the assemblies in some cases.

Discussion

The flaw characteristics observed above are indicative of hot cracking. This phenomenon has not been observed when welding Alloy 52M on the ferritic steel or ENiCrFe-3 (Alloy 182) DMW portions of the assemblies.

Further studies have determined that this problem may occur when using Alloy 52M filler metal on austenitic stainless steel materials with high sulfur content.

Recent limited tests and evaluations have concluded that welding with Alloy 52M on stainless steel base material with 0.020 wt% sulfur results in cracking while welding on stainless steel base materials with less than 0.010 wt% have resulted in no cracking.

To reduce the susceptibility of hot cracking occurrence due to welding Alloy 52M on the stainless steel base materials with high sulfur, ER309L was selected as the preferred filler metal to provide a barrier layer between the Alloy 52M and the high sulfur stainless steel base material. This filler metal is compatible with the base material and promotes primary weld metal solidification as ferrite rather than austenite. The ferrite is more accommodating of residual elements therein and in the underlying base material thereby significantly reducing the susceptibility to hot cracking. ER309L is also compatible with the Alloy 52M subsequently welded thereon. However, the barrier layer will necessarily consist of ERNiCr-3 (Alloy 82) being used locally at the interface between the Alloy 182 DMW and the stainless steel item. ER309L welding on Alloy 182 may result in cracking of the ER309L weld. Welding on high sulfur stainless steel with Alloy 82 has not been a concern relevant to hot cracking occurrence.

A mockup assembly was fabricated to evaluate the interactive effects, such as hot cracking and lack of fusion, between the Alloy 182 DMW, the stainless steel base material, the ER309L and Alloy 82 barrier layer, and the subsequent Alloy 52M weld overlay. The mockup assembly consisted of a stainless steel pipe (0.020 wt% sulfur) with an Alloy 182 groove weld performed therein. The barrier layer and overlay were welded in the same sequence as performed in the field (barrier layer ER309L and Alloy 82 and then two layers of Alloy 52M overlay). The barrier layer and overlay welding

parameters used in the mockup were similar to those used in the field however slightly reduced wire feed rates were used for conservatism.

The following examinations were performed on the final mockup and no recordable indications were detected:

Penetrant testing (PT) was performed on the:

- High sulfur stainless steel base material
- Alloy 182 Groove Weld
- ER309L Barrier Layer
- Alloy 82 Barrier Layer
- Alloy 52M Overlay

Limited PDI ultrasonic testing (UT)

- 0-degree Transducer with Full Coverage
- 45-degree Transducer with Full Coverage
- OD Creeper Transducer with Full Coverage
- 60-degree Transducer with limited coverage, (focal depth exceeded UT procedure allowable in places due to overlay being of insufficient thickness. Only two layers of Alloy 52M were deposited)

Metallographic examination searching for any type of discontinuity, flaw or other anomaly has been performed on 8 specimens that were removed in approximate 45-degree circumferential increments around the pipe. (See Figure 1 for typical photomicrograph). Final metallography of all the specimens has shown no conditions causing concern.

Conclusion

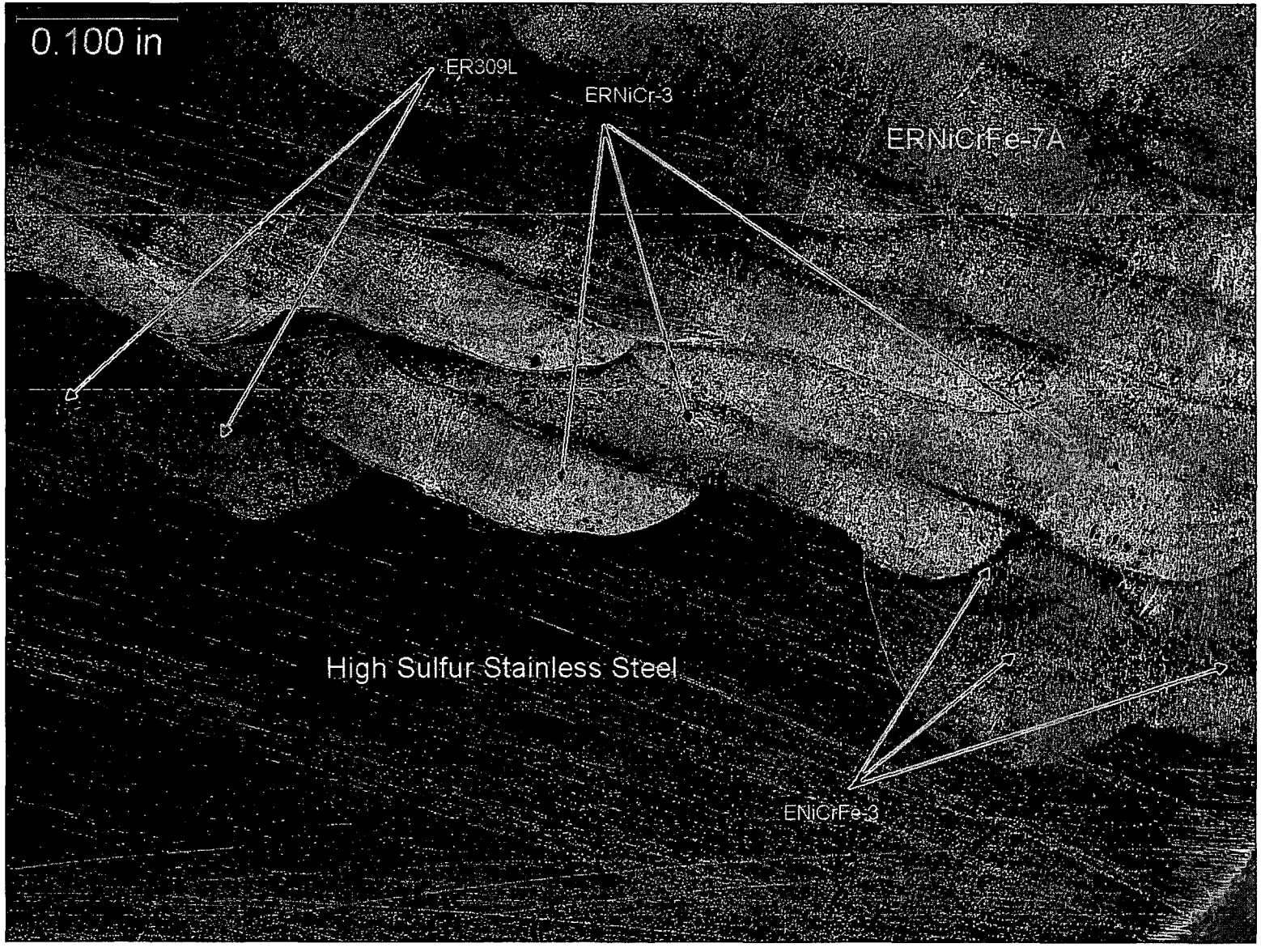
More tests and evaluations would be necessary to accurately determine the threshold where the base metal sulfur content would require barrier layer welding.

DCPP Unit 2 will use the barrier layer on all the stainless steel items prior to overlay. The barrier layer will use ER309L on the stainless steel and Alloy 82 on the stainless steel near the DMW to stainless steel fusion zone only.

Structural credit will not be assumed for the barrier layer in determining the required minimum overlay thickness since the alternative does not address the use of ER309L filler metal.

The barrier layer welding will be performed in accordance with ASME Section IX qualified welding procedure specification(s). PT will be performed on the barrier layer surface and its volume will be included in the final UT of the overlay.

Figure 1; High Sulfur Stainless Pipe Exhibiting Alloy 82 (ERNiCr-3) Deposit Between Alloy 182 (ENiCrFe-3), ER309L, and Alloy 52M (ERNiCrFe-7A) Deposits.



Performance Demonstration Initiative (PDI) Program Alternatives and their Bases with Respect to ASME Code Section XI, Appendix VIII Supplement 11 Requirements

Appendix VIII, Supplement 11	PDI Modification
1.0 SPECIMEN REQUIREMENTS	
1.1 General	
(b) The specimen set shall consist of at least three specimens having different nominal pipe diameters and overlay thicknesses. They shall include the minimum and maximum nominal pipe diameters for which the examination procedure is applicable. Pipe diameters within a range of 0.9 to 1.5 times a nominal diameter shall be considered equivalent. If the procedure is applicable to pipe diameters of 24 inches or larger, the specimen set must include at least one specimen 24 inches or larger but need not include the maximum diameter. The specimen set must include at least one specimen with overlay thickness within -0.1 inches to +0.25 inches of the maximum nominal overlay thickness for which the procedure is applicable.	**Modification**: (b) The specimen set shall consist of at least three specimens having different nominal pipe diameters and overlay thicknesses. They shall include the minimum and maximum nominal pipe diameters for which the examination procedure is applicable. Pipe diameters within a range of 0.9 to 1.5 times a nominal diameter shall be considered equivalent. If the procedure is applicable to pipe diameters of 24 inches or larger, the specimen set must include at least one specimen 24 inches or larger but need not include the maximum diameter. The specimen set shall include specimens with overlays not thicker than 0.1 inches more than the minimum thickness, nor thinner than 0.25 inches of the maximum nominal overlay thickness for which the examination procedure is applicable. **Basis:** To avoid confusion, the overlay thickness tolerance contained in the last sentence was reworded and the phrase "and the remainder shall be alternative flaws" was added to the next to last sentence in paragraph 1.1 (d) (1).
(d) Flaw Conditions	
(1) Base metal flaws. All flaws must be cracks in or near the butt weld heat-affected zone,	**Modification**: (1) Base metal flaws. All flaws must be in or near the butt weld heat-affected zone, open to the inside

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open to the inside surface, and extending at least 75% through the base metal wall. Flaws may extend 100% through the base metal and into the overlay material; in this case, intentional overlay fabrication flaws shall not interfere with ultrasonic detection or characterization of the cracking. Specimens containing IGSCC shall be used when available.	surface, and extending at least 75% through the base metal wall. Intentional overlay fabrication flaws shall not interfere with ultrasonic detection or characterization of the base metal flaws. Specimens containing IGSCC shall be used when available. At least 70% of the flaws in the detection and sizing tests shall be cracks and the remainder shall be alternative flaws. Alternative flaw mechanisms, if used, shall provide crack-like reflective characteristics and shall be limited by the following: (a) The use of alternative flaws shall be limited to when the implantation of cracks produces spurious reflectors that are uncharacteristic of actual flaws. (b) Flaws shall be semi elliptical with a tip width of less than or equal to 0.002 inches. **Basis:** This paragraph requires that all base metal flaws be cracks. Implanting a crack requires excavation of the base material on at least one side of the flaw. While this may be satisfactory for ferritic materials, it does not produce a useable axial flaw in austenitic materials because the sound beam, which normally passes only through base material, must now travel through weld material on at least one side, producing an unrealistic flaw response. To resolve this issue, the PDI program revised this paragraph to allow use of alternative flaw mechanisms under controlled conditions. For example, alternative flaws shall be limited to when implantation of cracks precludes obtaining an effective ultrasonic response, flaws shall be semi elliptical with a tip width of less than or equal to

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	0.002 inches, and at least 70% of the flaws in the detection and sizing test shall be cracks and the remainder shall be alternative flaws. To avoid confusion, the overlay thickness tolerance contained in paragraph 1.1(b), last sentence, was reworded and the phrase "and the remainder shall be alternative flaws" was added to the next to last sentence. Paragraph 1.1(d)(1) includes the statement that intentional overlay fabrication flaws shall not interfere with ultrasonic detection or characterization of the base metal flaws.
(e) Detection Specimens	
(1) At least 20% but less than 40% of the flaws shall be oriented within ±20 degrees of the pipe axial direction. The remainder shall be oriented circumferentially. Flaws shall not be open to any surface to which the candidate has physical or visual access. The rules of IWA-3300 shall be used to determine whether closely spaced flaws should be treated as single or multiple flaws.	**Modification:** (1) At least 20% but less than 40% of the base metal flaws shall be oriented within ±20 degrees of the pipe axial direction. The remainder shall be oriented circumferentially. Flaws shall not be open to any surface to which the candidate has physical or visual access. **Basis:** The requirement for axially oriented overlay fabrication flaws was excluded from the PDI Program as an improbable scenario. Weld overlays are typically applied using automated GTAW techniques with the filler metal applied in a circumferential direction. Because resultant fabrication induced discontinuities would also be expected to have major dimensions oriented in the circumferential direction axial overlay fabrication flaws are unrealistic. The requirement for using IWA-3300 for proximity flaw evaluation was excluded, instead indications will be sized based on their individual merits.
(2) Specimens shall be divided into base and overlay grading units. Each specimen shall	**Modification:** (2) Specimens shall be divided into base metal and overlay fabrication grading units. Each specimen

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contain one or both types of grading units.	shall contain one or both types of grading units. Flaws shall not interfere with ultrasonic detection or characterization of other flaws.
(a)(1) A base grading unit shall include at least 3 inches of the length of the overlaid weld. The base grading unit includes the outer 25% of the overlaid weld and base metal on both sides. The base grading unit shall not include the inner 75% of the overlaid weld and base metal overlay material, or base metal-to-overlay interface.	**Modification:** (a)(1) A base metal grading unit includes the overlay material and the outer 25% of the original overlaid weld. The base metal grading unit shall extend circumferentially for at least 1 inch and shall start at the weld centerline and be wide enough in the axial direction to encompass one half of the original weld crown and a minimum of 0.50 inch of the adjacent base material. **Basis:** The phrase "and base metal on both sides," was inadvertently included in the description of a base metal grading unit. The PDI program intentionally excludes this requirement because some of the qualification samples include flaws on both sides of the weld. To avoid confusion several instances of the term "cracks" or "cracking" were changed to the term "flaws" because of the use of alternative flaw mechanisms. Modified to require that a base metal grading unit include at least 1 inch of the length of the overlaid weld, rather than 3 inches.
(a)(2) When base metal cracking penetrates into the overlay material, the base grading unit shall include the overlay metal within 1 inch of the crack location. This portion of the overlay material shall not be used as part of any overlay grading unit.	**Modification:** (a)(2) When base metal flaws penetrate into the overlay material, the base metal grading unit shall not be used as part of any overlay fabrication grading unit.
(a)(3) When a base grading	**Modification:** (a)(3) Sufficient unflawed

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unit is designed to be unflawed, at least 1 inch of unflawed overlaid weld and base metal shall exist on either side of the base grading unit. The segment of weld length used in one base grading unit shall not be used in another base grading unit. Base grading units need not be uniformly spaced around the specimen.	overlaid weld and base metal shall exist on all sides of the grading unit to preclude interfering reflections from adjacent flaws. **Basis:** Modified to require sufficient unflawed overlaid weld and base metal to exist on all sides of the grading unit to preclude interfering reflections from adjacent flaws, rather than the 1 inch requirement.
(b)(1) An overlay grading unit shall include the overlay material and the base metal-to-overlay interface of at least 6 square inches. The overlay grading unit shall be rectangular, with minimum dimensions of 2 inches.	**Modification:** (b)(1) An overlay fabrication grading unit shall include the overlay material and the base metal-to-overlay interface for a length of at least 1 inch. **Basis:** Modified to require sufficient unflawed overlaid weld and base metal to exist on all sides of the grading unit to preclude interfering reflections from adjacent flaws, rather than the 2 inch requirement.
(b)(2) An overlay grading unit designed to be unflawed shall be surrounded by unflawed overlay material and unflawed base metal-to-overlay interface for at least 1 inch around its entire perimeter. The specific area used in one overlay grading unit shall not be used in another overlay grading unit. Overlay grading units need not be spaced uniformly about the specimen.	**Modification:** (b)(2) Overlay fabrication grading units designed to be unflawed shall be separated by unflawed overlay material and unflawed base metal-to-overlay interface for at least 1 inch at both ends. Sufficient unflawed overlaid weld and base metal shall exist on both sides of the overlay fabrication grading unit to preclude interfering reflections from adjacent flaws. The specific area used in one overlay fabrication grading unit shall not be used in another overlay fabrication grading unit. Overlay fabrication grading units need not be spaced uniformly about the specimen.

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	Basis: Paragraph 1.1 (e)(2)(b)(2) states that overlay fabrication grading units designed to be unflawed shall be separated by unflawed overlay material and unflawed base metal-to-overlay interface for at least 1 inch at both ends, rather than around its entire perimeter.
(b)(3) Detection sets shall be selected from Table VIII-S2-1. The minimum detection sample set is five flawed base grading units, ten unflawed base grading units, five flawed overlay grading units, and ten unflawed overlay grading units. For each type of grading unit, the set shall contain at least twice as many unflawed as flawed grading units.	**Modification:** (b)(3) Detection sets shall be selected from Table VIII-S2-1. The minimum detection sample set is five flawed base metal grading units, ten unflawed base metal grading units, five flawed overlay fabrication grading units, and ten unflawed overlay fabrication grading units. For each type of grading unit, the set shall contain at least twice as many unflawed as flawed grading units. For initial procedure qualification, detection sets shall include the equivalent of three personnel qualification sets. To qualify new values of essential variables, at least one personnel qualification set is required.
(f) Sizing Specimen	
(1) The minimum number of flaws shall be ten. At least 30% of the flaws shall be overlay fabrication flaws. At least 40% of the flaws shall be cracks open to the inside surface.	**Modification:** (1) The minimum number of flaws shall be ten. At least 30% of the flaws shall be overlay fabrication flaws. At least 40% of the flaws shall be open to the inside surface. Sizing sets shall contain a distribution of flaw dimensions to assess sizing capabilities. For initial procedure qualification, sizing sets shall include the equivalent of three personnel qualification sets. To qualify new values of essential variables, at least one personnel qualification set is required.
(3) Base metal cracking used for length sizing demonstrations shall be oriented	**Modification:** (3) Base metal flaws used for length sizing demonstrations shall be oriented circumferentially.

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circumferentially.	
(4) Depth sizing specimen sets shall include at least two distinct locations where cracking in the base metal extends into the overlay material by at least 0.1 inch in the through-wall direction.	**Modification:** (4) Depth sizing specimen sets shall include at least two distinct locations where a base metal flaw extends into the overlay material by at least 0.1 inch in the through-wall direction.
2.0 CONDUCT OF PERFORMANCE DEMONSTRATION	
The specimen inside surface and identification shall be concealed from the candidate. All examinations shall be completed prior to grading the results and presenting the results to the candidate. Divulgence of particular specimen results or candidate viewing of unmasked specimens after the performance demonstration is prohibited.	**Modification:** The specimen inside surface and identification shall be concealed from the candidate. All examinations shall be completed prior to grading the results and presenting the results to the candidate. Divulgence of particular specimen results or candidate viewing of unmasked specimens after the performance demonstration is prohibited. The overlay fabrication flaw test and the base metal flaw test may be performed separately.
2.1 Detection Test	
Flawed and unflawed grading units shall be randomly mixed. Although the boundaries of specific grading units shall not be revealed to the candidate, the candidate shall be made aware of the type or types of grading units (base or overlay) that are present for each specimen.	**Modification:** Flawed and unflawed grading units shall be randomly mixed. Although the boundaries of specific grading units shall not be revealed to the candidate, the candidate shall be made aware of the type or types of grading units (base metal or overlay fabrication) that are present for each specimen.
2.2 Length Sizing Test	
(d) For flaws in base grading units, the candidate shall estimate the length of that part of the flaw that is in the outer 25% of the base wall thickness.	**Modification:** (d) For flaws in base metal grading units, the candidate shall estimate the length of that part of the flaw that is in the outer 25% of the base metal wall thickness.
2.3 Depth Sizing Test	
For the depth sizing test, 80% of the flaws shall be sized at a specific location on the surface of the specimen identified to the	**Modification:** (a) The depth sizing test may be conducted separately or in conjunction with the detection test.

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candidate. For the remaining flaws, the regions of each specimen containing a flaw to be sized shall be identified to the candidate. The candidate shall determine the maximum depth of the flaw in each region.	(b) When the depth sizing test is conducted in conjunction with the detection test and the detected flaws do not satisfy the requirements of 1.1(f), additional specimens shall be provided to the candidate. The regions containing a flaw to be sized shall be identified to the candidate. The candidate shall determine the maximum depth of the flaw in each region. (c) For a separate depth sizing test, the regions of each specimen containing a flaw to be sized shall be identified to the candidate. The candidate shall determine the maximum depth of the flaw in each region.

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3.0 ACCEPTANCE CRITERIA	
3.1 Detection Acceptance Criteria	
Examination procedures, equipment, and personnel are qualified for detection when the results of the performance demonstration satisfy the acceptance criteria of Table VIII-S2-1 for both detection and false calls. The criteria shall be satisfied separately by the demonstration results for base grading units and for overlay grading units.	**Modification**: Examination procedures are qualified for detection when: (a) All flaws within the scope of the procedure are detected and the results of the performance demonstration satisfy the acceptance criteria of Table VIII-S2-1 for false calls. (b) At least one successful personnel demonstration has been performed meeting the acceptance criteria defined in (c). (c) Examination equipment and personnel are qualified for detection when the results of the performance demonstration satisfy the acceptance criteria of Table VIII-S2-1 for both detection and false calls. (d) The criteria in (b) and (c) shall be satisfied separately by the demonstration results for base metal grading units and for overlay fabrication grading units.
3.2 Sizing Acceptance Criteria	
(a) The RMS error of the flaw length measurements, as compared to the true flaw lengths, is less than or equal to 0.75 inch. The length of base metal cracking is measured at the 75% through-base-metal position.	**Modification:** (a) The RMS error of the flaw length measurements, as compared to the true flaw lengths, is less than or equal to 0.75 inch. The length of base metal flaws is measured at the 75% through-base-metal position.
(b) All extensions of base metal cracking into the overlay material by at least 0.1 inch are reported as being intrusions	**Modification:** This requirement is omitted. **Basis:** The requirement for reporting all

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into the overlay material.	extensions of cracking into the overlay is omitted from the PDI Program because it is redundant to the RMS calculations performed in paragraph 3.2(c) and its presence adds confusion and ambiguity to depth sizing as required by paragraph 3.2(c). This also makes the weld overlay program consistent with the supplement 2 depth sizing criteria.

Commitments

1) PG&E will have the design analyses for the preemptive structural weld overlays at the plant for NRC review at the beginning of the DCPP 2R14 refueling outage.

2) PG&E will submit a report with details of the examination results of the structural weld overlays on the Diablo Canyon Unit 2 pressurizer spray, relief, safety and surge nozzle safe-ends to the NRC within 60 days after completion of the final installation ultrasonic examination. The results will include description(s) of any weld repairs to the weld overlay material and/or base material and the reason(s) for the weld repair(s).

3) The inservice inspection requirements of ASME Section XI, Appendix Q, Subarticle Q-4300 will be implemented for the life of the overlay with the exception that flaws detected in the overlay that are due to stress corrosion cracking that exceed the standards of Table IWB-3514-2 are not allowed.