Entergy

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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,

Bryan Ford

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

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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.

<u>Enclosure</u> [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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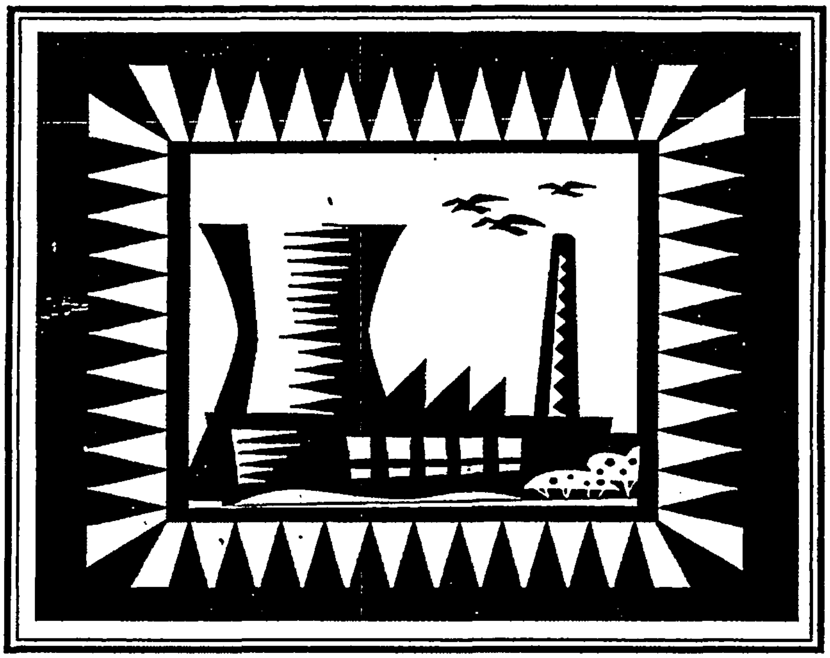
Seventh International Symposium on Environmental Degradation of Materials in Nuclear Power Systems - Water Reactors

Proceedings and Symposium Discussions



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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	1¼Cr-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	8.99	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	71.99	68.93
Cr	30.06	16.27	1.26	29.95	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	-	-	-	0.56	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

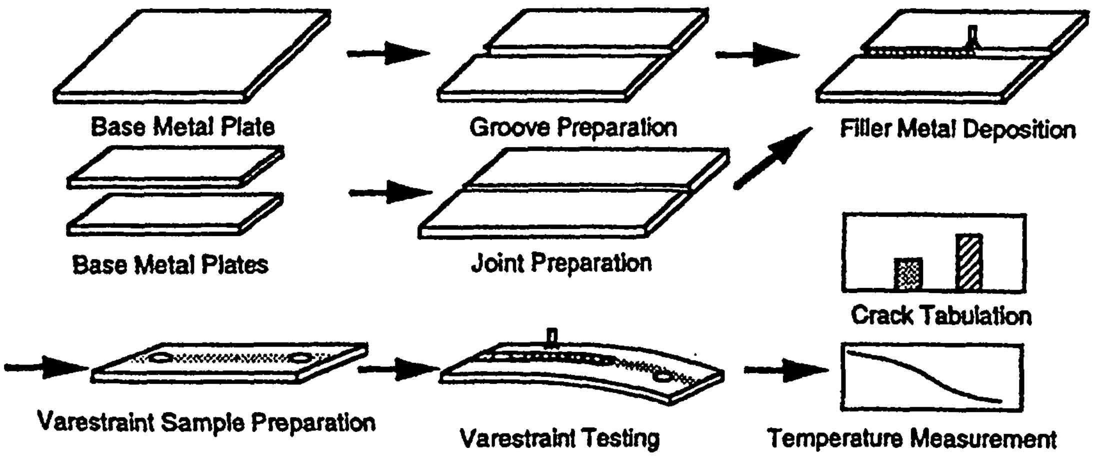


Figure 1. Flow chart of experimental procedure used in this study

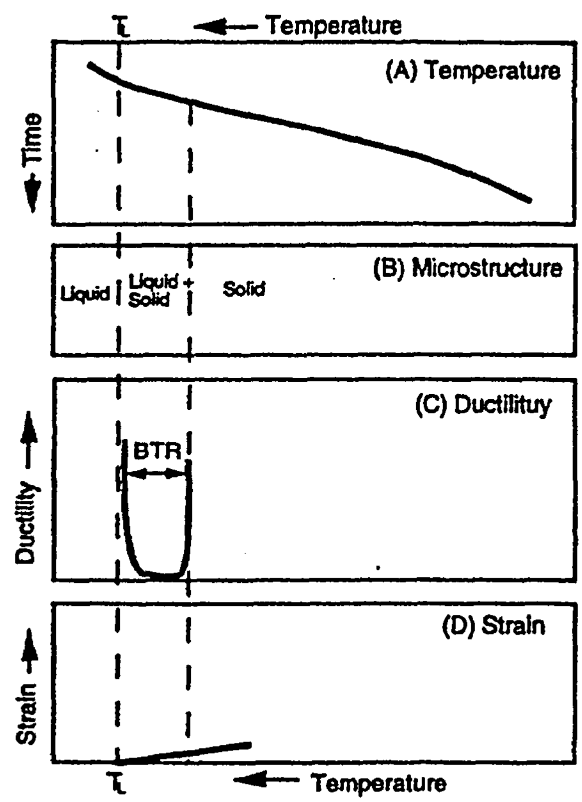


Figure 2. Theoretical basis for using BTR as a weldability index

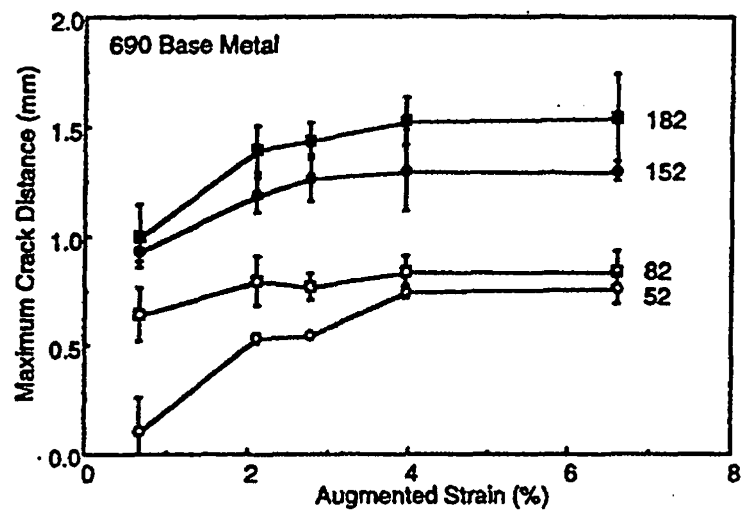


Figure 3. Typical longitudinal-Varestraint test results, MCD for the four filler materials with 690 base metal

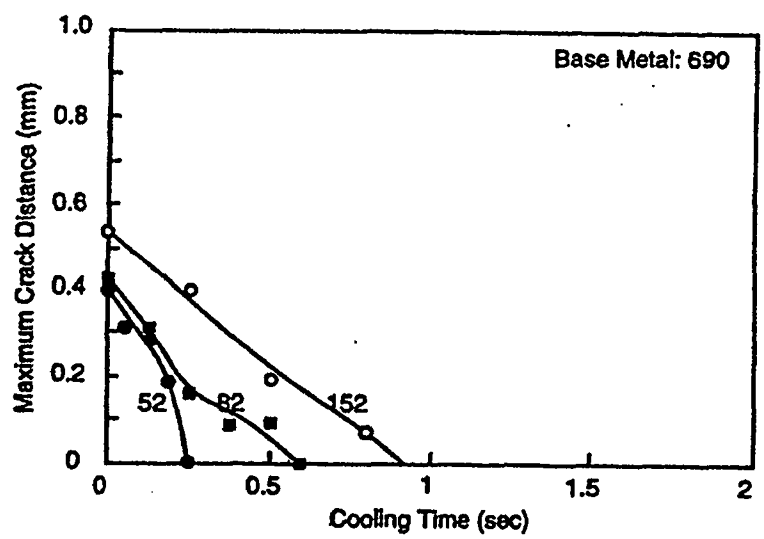
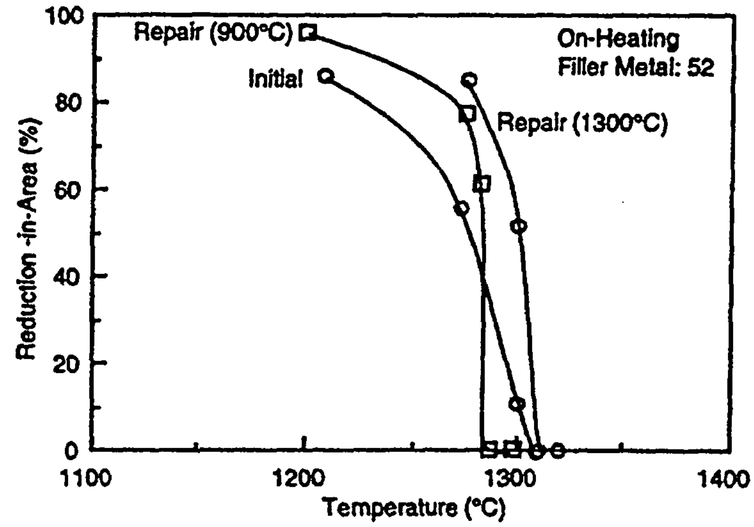
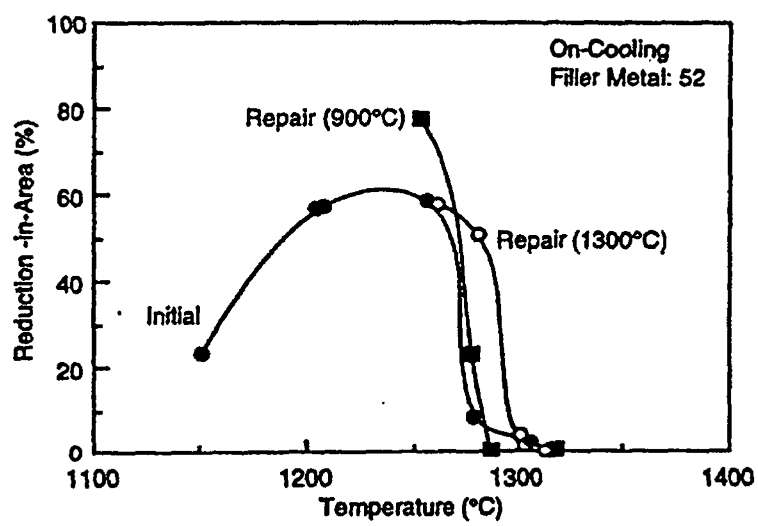


Figure 4. Typical spot-Varestraint test results, HAZ crack susceptible region of the three filler materials with 690 base metal



(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.

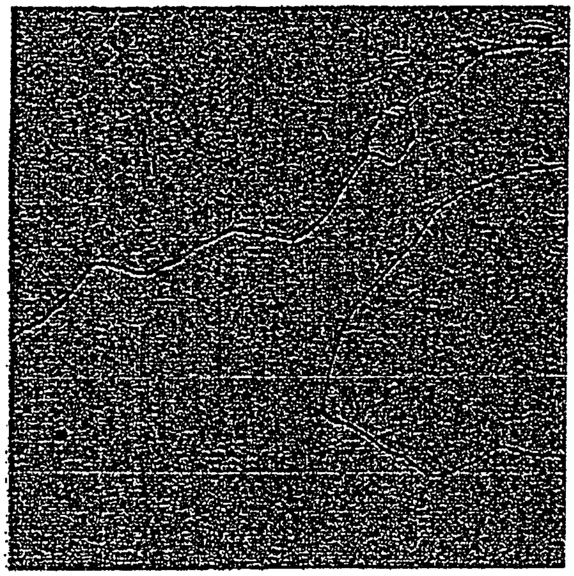


Figure 6.
Microstructure of the initial 52 weld metal.200X

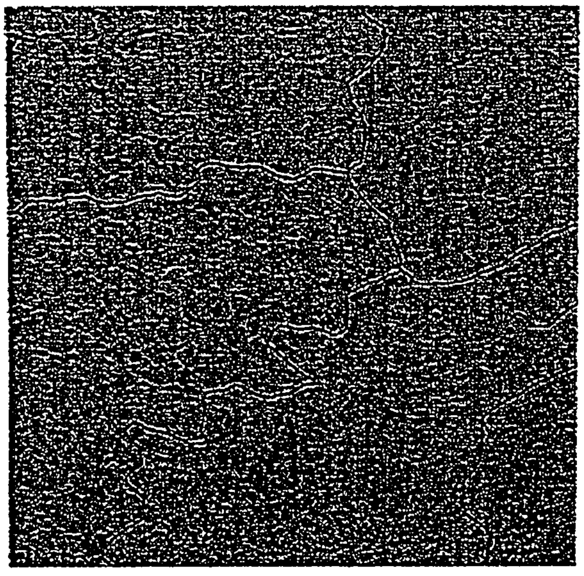


Figure 7
Microstructure of the 52 weld metal
after ten times repair simulations
at a peak temperature of 900^0 C. 200X

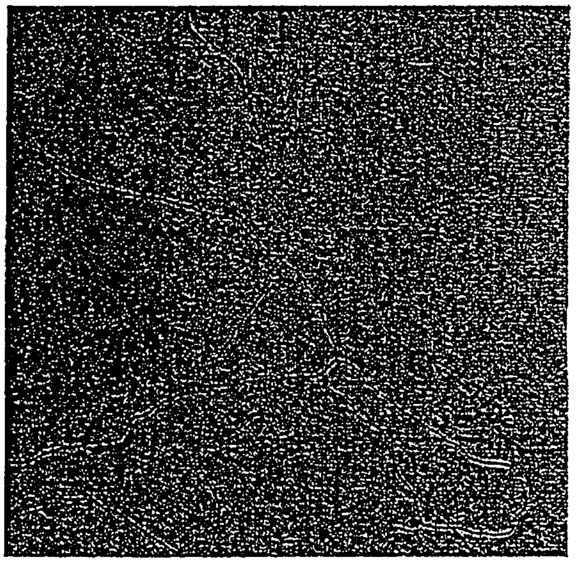


Figure 8
Microstructure of the 52 weld metal
after ten times repair simulations
at a peak temperature of 1300^0 C. 200X

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)

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.

<u>Welder Qualification and Welding Procedures</u>

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.

<u>Welding Wire Material</u>

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.

<u>Weld Overlay Design</u>

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.