November 15, 2007

Mr. Dale E. Young, Vice President
Crystal River Nuclear Plant (NA1B)
ATTN: Supervisor, Licensing & Regulatory Programs
15760 W. Power Line Street
Crystal River, Florida 34428-6708

SUBJECT: CRYSTAL RIVER UNIT 3 – RELIEF REQUEST #07-003-RR REGARDING STRUCTURAL WELD OVERLAYS (TAC NO. MD5552)

Dear Mr. Young:

By letter dated May 15, 2007, the Florida Power Corporation (the licensee) requested Nuclear Regulatory Commission (NRC) staff review and approval of Relief Request (RR) #07-003-RR to allow the installation of preemptive full structural weld overlays (SWOLs) that are planned to mitigate susceptibility to primary water stress corrosion cracking. The licensee submitted Revision 1 to the relief request by letter dated September 13, 2007, and supplemented the RR by letter dated October 23, 2007. The proposed approach is an alternative to the requirements of American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Section XI.

The NRC staff has reviewed the licensee's submittal and determined that #07-003-RR, Revision 1, as supplemented by letter dated October 23, 2007, will provide an acceptable level of quality and safety. Therefore, pursuant to Title 10 of the *Code of Federal Regulations*, Part 50, Paragraph 55a(a)(3)(i), the NRC staff authorizes the use of the #07-003-RR, Revision 1, as supplemented by letter dated October 23, 2007, for the SWOL of the dissimilar and similar metal welds of the hot leg surge line, pressurizer surge line, spray line including the safe end, and relief nozzles. The effective period of this relief is the third 10-year inservice inspection interval, which ends in August 2008.

The bases for the NRC staff's conclusions are contained in the enclosed Safety Evaluation. If you have any questions regarding this issue, please contact Stewart Bailey at (301) 415-1321 or snb@nrc.gov.

Sincerely,

/RA/

Thomas H. Boyce, Chief
Plant Licensing Branch II-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-302

Enclosure: Safety Evaluation

cc w/enclosure: See next page

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OFFICIAL RECORD

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO RELIEF REQUEST #07-003-RR, REVISION 1

FLORIDA POWER CORPORATION, ET AL.

CRYSTAL RIVER UNIT 3 NUCLEAR GENERATING PLANT

DOCKET NO. 50-302

1.0 INTRODUCTION

By letter dated May 15, 2007, the Florida Power Corporation (the licensee) requested Nuclear Regulatory Commission (NRC) staff review and approval of Relief Request (RR) #07-003-RR, to allow the installation of preemptive full structural weld overlays (SWOLs) that are planned to mitigate primary water stress corrosion cracking (PWSCC) susceptibility at Crystal River Unit 3 (CR-3). By letter dated September 13, 2007, the licensee submitted Revision 1 to the RR in response to an NRC request for additional information (RAI). On October 23, 2007, the licensee supplemented the RR with a response to an NRC staff RAI. The proposed approach is an alternative to the requirements of American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (Code), Section XI.

A dissimilar metal butt weld (DMBW) is defined as a butt weld that joins two pieces of metals that are not of the same material. In the proposed alternative, the DMBW joins a ferritic pressurizer nozzle to an austenitic stainless steel safe end. In the case of the pressurizer spray DMBW, the safe end is a nickel-based Alloy 600 material, a DMBW connects the ferritic pressurizer spray nozzle to the Alloy 600 safe end, and another DMBW connects the Alloy 600 safe end to the austenitic stainless steel pressurizer spray piping. For this application, the licensee is proposing to overlay both DMBWs and the Alloy 600 safe end. The DMBW for the reactor coolant hot leg surge nozzle connects the hot leg surge nozzle to the austenitic stainless steel surge piping. The dissimilar metal weld itself is made of nickel-based Alloy 82/182 material.

The industry has experienced degradation of the Alloy 82/182 weld material because it is susceptible to PWSCC in the pressurized water reactor (PWR) environment. Alloy 600 base material is also susceptible to PWSCC. For the proposed alternative, the weld overlay is a process by which a PWSCC-resistant weld metal is deposited on the outside surface of the susceptible material to form a new pressure boundary.

DMBWs consisting of Alloy 82/182 weld metal are frequently used in PWR construction to connect stainless steel pipe and safe ends to vessel and pipe nozzles, generally constructed of carbon or low alloy ferritic steel. The licensee stated that these welds have shown a propensity for PWSCC degradation, especially in components subjected to higher operating temperatures, such as the pressurizer and the hot leg pipe. For the upcoming CR-3 15th refueling outage, SWOLs are scheduled to be applied to DMBWs on pressurizer nozzles, the pressurizer spray

nozzle safe end, the spray pipe-to-spray nozzle safe end DMBW, and the "A" hot leg surge pipe-to-nozzle DMBW. The licensee does not plan to perform ultrasonic testing (UT) examinations of the subject welds prior to weld overlay installation.

2.0 REGULATORY EVALUATION

Pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.55a(g)(4), ASME Code Class 1, 2, and 3 components (including supports) must meet the requirements, except the design and access provisions and the preservice examination requirements, set forth in the ASME Code, Section XI, "Rules for Inservice Inspection (ISI) of Nuclear Power Plant Components," to the extent practical within the limitations of design, geometry, and materials of construction of the components. The regulations require that inservice examination of components and system pressure tests conducted during the first 10-year interval and subsequent intervals comply with the requirements in the latest edition and addenda of Section XI of the ASME Code incorporated by reference in 10 CFR 50.55a(b) 12 months prior to the start of the 120-month interval, subject to the limitations and modifications listed therein.

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

The ASME Code of record for the current, third 10-year ISI interval at CR-3 is Section XI, 1989 Edition, no addenda, and the 1995 Edition, including addenda through the 1996 Addenda, for Section XI, Appendix VIII.

3.0 PROPOSED #07-003-RR, REVISION 1

3.1 Component Affected

The licensee stated that ASME Code components associated with this request are the high safety significant Class 1 dissimilar metal piping welds with Alloy 82/182 weld metal and Alloy 600 base material that are believed to be susceptible to PWSCC. Eight locations (seven DMBWs and the pressurizer spray nozzle safe end) are scheduled to have preemptive full SWOLs applied during the upcoming refueling outage.

1. Pressurizer weld No. B4.1.9, surge nozzle buttering, and B4.1.10, safe end-to-surge nozzle weld.
2. Pressurizer weld No. B4.1.3, relief nozzle #1 buttering, and B4.1.4, flange-to-relief nozzle #1 weld.
3. Pressurizer weld No. B4.1.5, relief nozzle #2 buttering, and B4.1.6, flange-to-relief nozzle #2 weld.
4. Pressurizer weld No. B4.1.7, relief nozzle #3 buttering, and B4.1.8, flange-to-relief nozzle #3 weld.
5. Pressurizer weld No. B4.1.1, safe end-to-spray nozzle-weld
6. Pressurizer spray nozzle safe end Mk No. 45.
7. Spray pipe-to-pressurizer spray nozzle safe end weld No. B4.5.52.
8. "A" hot leg pipe weld No. B4.1.11, surge nozzle buttering, and B4.1.12, surge pipe-to-surge nozzle weld.

All subject welds are ASME Code Class 1 welds and are located in the reactor coolant system

pressure boundary. The Code examination category is R-A, "Risk-Informed Piping Examinations,"

The component materials are:

1. Pressurizer nozzles are carbon steel A 508 Class 1 (P-No. 12A Sub 1).
2. “A” hot leg pipe surge nozzle is carbon steel A 105 Grade II (P-No. 1).
3. Pressurizer surge nozzle safe end is A 336 Class F8M (P-No.8).
4. Relief nozzle flanges are SA-182 Grade F316 (P-No. 8).
5. Welds are Alloy 82/182 (F-No. 43).
6. Pressurizer spray nozzle safe end is NiCrFe SB-166 Alloy 600 (P-No. 43).
7. Elbow attached to the pressurizer surge nozzle safe end is A 403 WP316 (P-No. 8).
8. Piping attached to the “A” hot leg surge nozzle buttering and to the pressurizer spray nozzle safe end is wrought seamless austenitic stainless steel A 376 TP 316 (P-No. 8)

3.2 Applicable Code Requirements

The licensee stated that CR-3 is currently in the third 10-year ISI interval. The ASME Code of record for the current 10-year ISI interval is Section XI, 1989 Edition, no addenda. This is also the version used for the repair/replacement program. The code of record for ASME, Section XI, Appendix VIII, is the 1995 Edition, including addenda through the 1996 Addenda.

The applicable Code requirement for which the relief is requested is ASME Code Section XI, 1989 Edition, no addenda, IWA-4120(a), IWA-4340(a), and Section XI, 1995 Edition, including addenda through the 1996 Addenda, Appendix VIII, Supplement 11. The licensee proposed #07-003-RR, Revision 1, to permit the implementation of scheduled SWOLs at CR-3, as an alternative to the applicable Code requirement.

3.3 Reason for Request

DMBWs have shown a propensity for PWSCC degradation, especially in components subjected to higher operating temperatures, such as the pressurizer and the hot leg pipe. SWOLs are scheduled to be applied to DMBWs on pressurizer nozzles, the pressurizer spray nozzle safe end, the spray pipe-to-spray nozzle safe end DMBW and the “A” hot leg surge pipe-to-nozzle DMBW during the upcoming CR-3 15th refueling outage. Repair/replacement activities associated with SWOL repairs are required to address the materials, welding parameters, as low as reasonably achievable (ALARA) concerns, operational constraints, examination techniques and procedure requirements for repairs.

ASME Code, Section XI, 1989 Edition, no addenda, IWA-4120(a) and IWA-4340(a), 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 DMBWs or associated Alloy 600 base material will be performed. Also, comprehensive and generically approved criteria are not currently available for application of SWOL repairs to DMBWs constructed of Alloy 82/182 weld material or associated Alloy 600 base material for mitigation of potential PWSCC.
In addition, ASME Code, Section XI, 1995 Edition including addenda through the 1996 Addenda, Appendix Vlll, Supplement 11, cannot be implemented as written for ultrasonic

examination of a structural weld overlay repair. Attachment 2 of the licensee's September 13, 2007, letter includes a discussion of the Performance Demonstration Initiative (PDI) program alternatives and their bases with respect to Appendix VIII, Supplement 11, requirements.

3.4 Proposed Alternatives and Basis

The licensee proposes to use #07-003-RR, Revision 1, under the provisions of 10 CFR 50.55a(a)(3)(i) as alternatives to the above applicable code requirements.

This alternative is the result of the industry's experience with mitigative weld overlay modifications for flaws suspected or confirmed to be caused by PWSCC, and directly applies to the Alloy 52M weld material that is primarily being used for these SWOLs.

3.4.1 Structural Weld Overlay Assembly

The licensee stated that the SWOLs will satisfy all the structural design requirements of the pipe for the original DMBWs and the pressurizer spray nozzle safe end. The SWOLs will completely cover the existing DMBWs, will extend onto the ferritic nozzle and austenitic stainless steel material on each end of the weld and completely cover the pressurizer spray nozzle safe end. The SWOLs will extend around the entire circumference of the nozzle.

3.4.2 Weld Overlay Design

The SWOLs will be designed as full structural overlays. Postulated 100 percent through-wall flaws shall be assumed for all PWSCC-susceptible welds and the pressurizer spray nozzle safe end for SWOL length and thickness sizing in accordance with #07-003-RR, Revision 1. No ultrasonic examination will be performed prior to SWOL application. For flaw growth evaluations, since no ultrasonic examination will be performed prior to weld overlay application, postulated 75 percent through-wall flaws will be assumed as specified in #07-003-RR, Revision 1, for the welds and the Alloy 600 pressurizer spray nozzle safe end.

3.4.3 Examinations

The licensee stated that all examinations will meet the requirements of #07-003-RR, Revision 1, Attachment 3, excluding qualification of the ultrasonic examination for the completed SWOLs. The ultrasonic examination qualification will be in accordance with ASME Code, Section XI, 1995 Edition including addenda through the 1996 Addenda, Appendix VIII, Supplement 11, with the alternatives that are used to comply with the PDI program.

The licensee stated that ultrasonic examination will not be performed on the DMBWs prior to the SWOLs being applied. Since the structural integrity at the DMBW locations will be restored by the SWOLs, the licensee stated the ultrasonic examination of the DMBWs prior to SWOL application is unnecessary and the increased personnel dose that would be incurred performing the examinations is also undesirable and not consistent with good ALARA practice.

3.4.4 Required Activities

The licensee stated that it will submit preliminary analysis of the residual stresses and flaw

growth of the repaired weldment, including crack growth calculations, prior to Mode 4 of restart from Refueling Outage 15. The licensee submitted this information on November 1, 2007. The final report on the analysis of the residual stresses and flaw growth of repaired weldment, including crack growth calculations, will be submitted within 60 days after plant restart from refueling outage 15.

The licensee stated that it will submit the ultrasonic examination results of the weld overlays, along with a discussion of any repairs to the overlay material and/or base metal and reason for the repair, within 60 days after completion of the ultrasonic examination of the weld overlays, and will notify the NRC as soon as practical if any cracks are detected that exceed the preservice examination acceptance standards in ASME Code, Section XI, Table IWB-3514-2.

During the inservice examination, the acceptance standards of Table IWB-3514-2 shall be met for the weld overlay. If the acceptance standards of Table IWB-3514-2 cannot be met, the weld overlay shall meet the acceptance criteria of IWB-3600. Planar flaws in the outer 25 percent of the base metal thickness shall meet the design analysis requirements. However, flaws due to stress corrosion cracking in the weld overlay shall result in removal of the weld overlay and the item shall be repaired or replaced.

3.4.5 Contingency for Hot Cracking

The licensee stated that, during some recent DMBW 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. The flaw characteristics observed above are indicative of hot cracking. This phenomenon has not been observed on the ferritic steel or ENiCrFe-3 (Alloy 182) DMBW portions of the assemblies when welding Alloy 52M thereon. Studies have determined that this problem may occur when using Alloy 52M filler metal on austenitic stainless steel materials with high sulfur content.

Tests and evaluations recently performed by AREVA have resulted in the conclusion that welding with Alloy 52M on stainless steel base material with 0.020 weight percent (w/o) sulfur results in cracking, while welding on stainless steel base materials with less than 0.010 w/o have resulted in no cracking.

To reduce the susceptibility of hot cracking due to welding Alloy 52M on the stainless steel base materials with high sulfur, AREVA has selected ER309L filler metal 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 consist of ERNiCr-3 (Alloy 82) being used locally at the interface between the Alloy 182 DMBW 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. The licensee stated that it will use the barrier layer on the stainless steel items prior to overlay since all the items have sulfur contents greater than 0.010 w/o. The barrier layer will use ER309L on the stainless steel and Alloy 82 on the stainless steel near the DMBW to stainless steel fusion zone only. The licensee also stated that structural credit will not be assumed for the

barrier layer in determining the required minimum overlay thickness. The barrier layer welding will be performed in accordance with ASME Code, Section IX, qualified welding procedure specifications. Penetrant testing will be performed on the barrier layer surface and its volume will be included in the final ultrasonic examination of the overlay.

3.4.6 Duration of the Proposed Request

The licensee stated that #07-003-RR, Revision 1, will be applied for the duration of up to and including the last outage of the current third 10-year ISI interval, which includes inservice examination requirements of Attachment 3 to #07-003-RR, Revision 1, for any applied weld overlays. The current ISI interval ends in August 2008.

4.0 STAFF EVALUATION

The licensee's proposed #07-003-RR, Revision 1, consists of 4 parts: (1) the technical basis for the weld overlay as discussed above, (2) Attachment 2 "PDI Program Modifications to ASME Code Section XI, Appendix VIII, Supplement 11," (3) Attachment 3, "Alternative Requirements for Dissimilar Metal Weld Overlays," and (4) Attachment 4, "Barrier Layer to Prevent Hot Cracking in High Sulfur Stainless Steel."

Attachment 3 of #07-003-RR, Revision 1, provides requirements for the weld overlay design and examination. The requirements of Attachment 3 are a stand-alone RR.

The licensee's initial proposal, #07-003-RR, Revision 0, was based on Code Case N-740-1 Draft February 2007, "Dissimilar Metal Weld Overlay for Repair of Class 1, 2, and 3 Items Section XI, Division 1" of the ASME Code, Section XI, which had not been approved by the NRC for use via Regulatory Guide (RG) 1.147. The NRC had requested the licensee resubmit the request based on proposed modifications to an ASME Code Committee approved Code case, or an NRC approved Code case, or a stand alone proposal.

The NRC staff has endorsed Code Cases N-504-2, "Alternative Rules for Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping Section XI, Division 1," and N-638-1, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW [gas tungsten arc welding] Temper Bead Technique Section XI, Division 1." RG 1.147, Revision 14, requires that the ASME Code, Section XI, Appendix Q, "Weld Overlay Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping Weldments," be used when Code Case N-504-2 is used. Therefore, the NRC staff used the requirements of Code Cases N-504-2, N-638-1, and Appendix Q to evaluate #07-003-RR, Revision 1.

The NRC staff evaluated the updated #07-003, Revision 1. However, the NRC staff's safety evaluation also includes a discussion of the original #07-003-RR, Revision 0, as part of the review process.

4.1 General Requirements

Code Case N-504-2 and/or Appendix Q of the ASME Code, Section XI, require certain specifications and surface conditions of the applicable base metal (carbon steel, stainless steel, and Alloy 82/182) and weld overlay filler metal. Section 1.0 of Enclosure 3 of #07-003-RR,

Revision 1, provides the corresponding requirements.

Code Case N-504-2 and/or Appendix Q of the ASME Code, Section XI, were generated for the weld overlay of austenitic stainless steel piping and weldments. In the September 13, 2007, letter, the licensee identified that the weld overlays will be applied to the components and materials as specified in Section 3.1 of this Safety Evaluation, above, and will use an Alloy 52M weld material for the overlay in conjunction with an ER309L weld material as a barrier layer over the stainless steel materials, with an Alloy 82 weld material as an interface between the barrier layer and the existing Alloy 182 DMBW. The licensee has stated that the stainless steel items to be overlaid have sulfur contents greater than 0.010 w/o, which is approaching the percentage which has been seen to cause hot cracking in Alloy 52M weld overlays. Therefore, use of the ER309L material, which is compatible with the existing stainless steel materials, is an acceptable practice, as it will be applied in accordance with ASME Code, Section IX, qualified welding procedure specifications. However, ER309L welding on Alloy 182 may result in cracking of the ER309L material. Use of Alloy 82 material as an interface between the ER309L and the existing Alloy 182 DMBW is appropriate to prevent cracking of the ER309L material, as Alloy 82 has not demonstrated sensitivity to higher sulfur concentrations in stainless steel. Use of the barrier layer is acceptable as the licensee has stated it will not be used to determine the required minimum overlay thickness. The materials selected, while different from the specifications of Code Case N-504-2 and ASME Code, Section XI, Appendix Q, are appropriate for the base materials and existing butt weld materials, and have been approved for use by the NRC for weld overlay for several licensees.

In the September 13, 2007, letter, the licensee stated that the Cr [chromium] content on the first layer was verified by weld deposition on an ASTM A 106 Grade B pipe mockup using double-up progression (starting at bottom and welding upward to the top on each side). Welding was performed in the 6G position with Cr measured at 90 degree increments starting at 45 degrees from top. All welding parameters were recorded and the 28 percent minimum Cr was attained.

The ASTM A 106 Grade B material used in the mockup is different than the nozzles to be overlaid. However, the Cr concentration in the ASTM A 106 Grade B material is on the order of 0.25 percent as published in trade literature. This is a very low concentration. Because the Cr content used for the mock-up was so low, the staff concludes that the mockup demonstrates that the first layer applied in the field application of the overlays will achieve a minimum concentration of 28 percent Cr. This is the target value of chromium approved in other licensee overlay RRs, and is the value necessary to prevent PWSCC. The licensee stated further that the same heat of wire will be used in situ for the first layer and the same welding parameters will be specified in the welding procedure specification as was used in the mockup for the first layer.

Attachment 3, Paragraph 1(c)(1) of the September 13, 2007, letter discusses construction code post-weld heat treatment (PWHT) exemptions and provides clarifications regarding the definition of nominal weld thickness and base metal thickness. It was the intent of the licensee to use the weld overlay thickness as the nominal thickness in ASME Section III, Table NB 4622.7(b)1, “Exemptions to Mandatory PWHT,” to determine if PWHT could be exempted. The NRC questioned the use of the weld overlay thickness as opposed to the ferritic nozzle thickness to determine if the application of the overlay could be exempt from PWHT requirements, and subsequently, the elimination of temper bead welding requirements, which are an alternative to PWHT requirements. In its October 23, 2007, response to a staff RAI, the licensee stated that temper bead welding is required and will be performed on all overlay welds, and that all provisions of the temper bead welding will be complied with, including the hold on

nondestructive examination (NDE), until 48 hours after completion of the third temper bead layer.

4.2 Crack Growth Considerations and Design

Code Case N-504-2 and Appendix Q of the ASME Code, Section XI, provide requirements for the overlay design and the crack growth calculation. Section 2 of Attachment 3 to #07-003-RR, Revision 1, provides the corresponding requirements.

The licensee stated that ultrasonic examination will not be performed on the DMBWs prior to the SWOLs being applied. Section 2 of Attachment 3 to #07-003-RR, Revision 1, specifies that for full structural overlays, when ultrasonic examination is not performed prior to installation of the weld overlay, the assumed flaw in the underlying base material or weld shall 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 inches or the combined width of the weld plus buttering, whichever is greater in the axial direction, and the stress corrosion cracking susceptible base material, when applicable. In addition to the design flaws, the proposed alternative also requires crack growth calculations for as-found flaws and postulating flaws in the base metal to verify that flaws in the base metal will not grow to unacceptable size.

Paragraph 2(a) of Attachment 3 to #07-003-RR, Revision 1, states that flaw characterization and evaluation requirements shall be based on the postulated flaw, if ultrasonic examination of the weldment is not performed. Paragraph 2(a)(2) of Attachment 3 to #07-003-RR, Revision 1, for postulated flaws in the original weld or base metal, requires the axial flaw length to be set at 1.5 inches (38 mm) or the combined width of the weld plus buttering, whichever is greater, and the stress corrosion cracking susceptible base material, when applicable. The circumferential flaw length shall be assumed to be 360 degrees.

Paragraph 2(a)(2)(b) requires that if 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 examination volume. Any actual flaw that exceeds the depth of these assumptions would be detectable by the qualified post weld overlay preservice ultrasonic examination, which is qualified to detect flaws in the outer 25 percent of the base material. If any flaw is detected in this outer 25 percent that extends into the area beyond that which the examination procedure is qualified for flaw detection, the flaw will be assumed to be connected to the inner diameter for the purposes of determining the expected life of the overlay. The NRC staff finds that Paragraph 2(a)(2) is acceptable because the assumed flaw size for the crack growth calculation is conservative.

However, the NRC staff had concerns regarding Paragraphs 2(a)(2)(c) and 2(a)(2)(d) of the May 15, 2007, application because they are not consistent with Code Case N-504-2 and Appendix Q of the ASME Code, Section XI. Paragraph 2(a)(2)(c) stated that, if the ultrasonic examination procedure is qualified for greater than the outer 25% of the original wall thickness, the initial flaw sizes may be assumed consistent with the depth to which the examination procedure is qualified. In the September 13, 2007, response to the NRC staff's request for additional information, the licensee stated the ultrasonic examination procedures are qualified for the outer 25 percent of the original base metal/weld thickness only. Therefore, Paragraph 2(a)(2)(c) would not be applicable. The NRC staff expressed concern regarding Paragraph 2(a)(2)(d) in that it discusses inside-surface-connected planar flaws found by the

overlay preservice inspection. The procedures typically used for preservice examination are only qualified to detect flaws in the outer 25 percent of the base metal/weld and the overlay region. As such, the NRC questioned how it would be determined that the flaw is inside-surface connected. In the September 13, 2007, letter, the licensee altered Paragraph 2(a)(2)(d), stating that the flaw depth assumed is the detected flaw depth plus the postulated worst-case flaw depth in the unqualified ultrasonic examination region of the pipe wall thickness. The NRC staff finds this acceptable, as the assumed flaw size for the crack growth calculation is conservative.

Paragraphs g(2) and g(3) of Code Case N-504-2 require evaluations of residual stresses and flaw growth of the repaired weldments. Similar evaluations are required in Attachment 3 to #07-003-RR, Revision 1. Paragraph 2(b)(8) of #07-003-RR, Revision 1, states that 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 shall be evaluated. The licensee further stated that the shrinkage evaluation is performed to assure that any other item affected by the shrinkage due to the SWOL has not been adversely affected based on initial assumed axial values. Measurements are performed in situ to confirm the shrinkage limits assumed have been maintained. In addition, the licensee is performing analysis of the crack growth calculations to demonstrate that crack growth in the weld overlay or base metal is acceptable and residual stress distribution in the weld overlay and original weld demonstrate favorable stress distribution. The licensee submitted the preliminary results of the evaluations by letter dated November 1, 2007, and will submit the final evaluations within 60 days of the plant restart.

The licensee is performing the necessary analyses to support weld overlay and the licensee will provide the results of the stress analyses of the nozzles as a result of SWOL in a timely manner. Therefore the NRC staff finds this acceptable.

4.3 PDI Program Modifications to Section XI, Appendix VIII, Supplement 11

The ultrasonic examinations in the proposed alternative are in accordance with ASME Code, Section XI, Appendix VIII, Supplement 11, as implemented through the PDI. These examinations are considered more sensitive for detecting fabrication and service-induced flaws than the ASME Code Section III radiographic or ultrasonic examination methods. Furthermore, construction-type flaws have been included in the PDI qualification sample sets for evaluating procedures and personnel, providing additional confidence that flaws will be detected during the preservice examination.

The U.S. nuclear utilities created the PDI program to implement performance demonstration requirements contained in Appendix VIII of Section XI of the ASME Code. To this end, the PDI program has developed a program for qualifying equipment, procedures, and personnel in accordance with the UT criteria of Appendix VIII, Supplement 11. Prior to the Supplement 11 program, the Electric Power Research Institute (EPRI) was maintaining a performance demonstration program (the precursor to the PDI program) for weld overlay qualification under the Tri-party Agreement with the NRC, Boiling Water Reactor Owners Group, and EPRI, as discussed in the NRC letter dated July 3, 1984 (Agencywide Documentation and Management System (ADAMS) Accession No. 8407090122). Later, the NRC staff recognized the EPRI PDI program for weld overlay qualifications as an acceptable alternative to the Tri-party Agreement, as discussed in the NRC letter dated January 15, 2002, to the PDI Chairman (ADAMS Accession No. ML020160532).

The PDI program is routinely assessed by the staff for consistency with the current ASME Code and proposed changes. The PDI program does not fully comport with the existing requirements of Supplement 11. PDI presented the differences at public meetings in which the NRC participated (Memorandum from Donald G. Naujock to Terence Chan, "Summary of Public Meeting Held January 31 - February 2, 2002, with PDI Representatives," March 22, 2002 (ADAMS Accession No. ML010940402), and Memorandum from Donald G. Naujock to Terence Chan, "Summary of Public Meeting Held June 12 through June 14, 2001, with PDI Representatives," November 29, 2001 (ADAMS Accession No. ML013330156). Based on the discussions at these public meetings, the staff determined that the PDI program provides an acceptable level of quality and safety.

The NRC staff evaluated the differences identified in the PDI program with Supplement 11 in the September 13, 2007, submittal. The NRC staff concludes that differences provide an acceptable level of quality and safety and, therefore, the proposed alternative to Supplement 11 is acceptable.

4.4 Examination and Inspection

Code Case N-504-2 and/or Appendix Q of the ASME Code, Section XI, require certain acceptance, preservice, and inservice examinations of the installed weld overlay. Section 3 of Attachment 3 to #07-003-RR, Revision 1, provides corresponding requirements.

Acceptance Examination

Section 3(a) of #07-003-RR, Revision 1, requires liquid penetrant examinations of installed SWOL and the acceptance criteria of the construction code or NB-5300 of the ASME Code, Section III. The licensee states that if ambient temper bead welding is required, the liquid penetrant examination of the completed weld overlay shall be conducted after the three tempering layers (i.e., layers 1, 2, and 3) have been in place for at least 48 hours after completion of the third temper bead layer over the ferritic steel. The NRC staff questioned when temper bead welding is, and is not, needed. In its letter dated October 23, 2007, the licensee responded that temper bead welding is required and will be performed on all overlay welds, and that all provisions of the temper bead welding will be complied with, including the hold on NDE until 48 hours after completion of the third temper bead layer. Section 3(a) also requires ultrasonic examinations of the installed weld overlay to assure adequate fusion and to detect fabrication defects. The required examination surface and volume are defined in Figure 1 of the RR. Any planar indication found in the weld overlay that is rejected by IWB-3514-2 will be removed. The proposed acceptance criteria are consistent with Code Case N-504-2 and Appendix Q of the ASME Code, Section XI, except Paragraph 3(a)(3).

Paragraph 3(a)(3) of Attachment 3 to #07-003-RR, Revision 1, requires that ". . . for planar indications outside this examination volume, the nominal wall thickness shall be "t2" as shown in Fig 1(c) for volumes A-E-H-D and F-B-C-G . . ." Figure 1(c) is shown in Attachment 3 to #07-003-RR, Revision 1. Volumes A-E-H-D and F-B-C-G are defined in Figure 1(c) and refer to the portion of the weld overlay that is a minimum of one-half inch away from the original weld or flaw. The NRC staff notes that UT is not qualified to examine inner 75 percent of the base metal after weld overlay installation. Therefore, the "t2" dimension, which is the weld overlay thickness plus pipe thickness, should not be a parameter for the acceptance criteria of IWB-3514-2 because the "t2" dimension includes the 75-percent depth of the base metal. If the "t2" dimension was used, larger flaws would be allowed to remain in service in the weld overlay.

The NRC staff recognizes that PWSCC is not a concern in pressurizer nozzles that are made of low alloy steel and safe ends that are made of stainless steel, as these have not had a history of PWSCC, and there is no presumptive need to assume flaws in these base metals. If larger flaws are allowed to remain in service in this portion of the weld overlay, the structural integrity of the portion of the weld overlay that covers the original weld will not be adversely affected. Therefore, the NRC staff finds that the use of the "t2" dimension is acceptable provided that the base metal of the pressurizer nozzle is made of low alloy steel and safe ends are made of stainless steel. However, the NRC staff does not agree with the above argument if the base metal material is susceptible to PWSCC, such as Alloy 600 material. This would not be conservative.

The NRC staff notes that the purpose of the weld overlay is to repair the material susceptible to PWSCC. Volumes A-E-H-D and F-B-C-G as defined in Figure 1(c), pertain to the portion of the weld overlay that is not required to support the pressure boundary function of the weld overlay or base metal for all cases except for the pressurizer spray nozzle. In the case of the spray nozzle, the safe end is an Alloy 600 material, which is susceptible to PWSCC. Therefore, use of the full "t2" dimension is not appropriate, and the thickness "t1" as shown in Figure 1b should be used to evaluate flaws in the weld overlay on the Alloy 600 pressurizer spray safe end.

In the September 13, 2007, letter, the licensee responded to an NRC staff question regarding how actual or postulated flaws in the Alloy 600 base material will be evaluated to the end of the expected life of the overlay. The licensee stated that actual or postulated flaws in the Alloy 600 base material will be evaluated in the same manner as those in dissimilar metal welds. Attachment 3 to #07-003-RR, Revision 1, specifies that when applying the acceptance standards to planar indications within the volume E-F-G-H, in Figure 1(b), the thickness "t1" shall be used as the nominal wall thickness in Table IWB-3514-2. The licensee further clarified in a response to a request for additional information, dated October 23, 2007, that the thickness "t1" is planned to be used for evaluating flaws in the overlay above any material susceptible to PWSCC (i.e., Alloy 82, Alloy 182, or Alloy 600). The NRC finds that the use of the dimension "t1" in the evaluation of flaws above susceptible material is conservative and will provide an acceptable level of quality and safety.

Preservice Examination

Section 3(b) of Attachment 3 to #07-003-RR, Revision 1, requires a preservice examination of the installed weld overlay and the outer 25 percent of the original pipe wall thickness by UT. The required examination volume is defined in Figure 2 of Attachment 3 to #07-003-RR, Revision 1.

As stated in Paragraph 3(b)(2) of Enclosure 3 to #07-003-RR, Revision 1, planar flaws detected in the outer 25 percent of the base metal (or original weld) during the preservice examination, will be evaluated in accordance with IWB-3640 for the crack growth evaluation. The acceptance criteria of IWB-3640 will not be used to accept the flaws, the acceptance standards of table IWB-3514-2 will be used as the acceptance standard. Flaws exceeding the acceptance standards of Table IWB-3514-2 will be repaired. The NRC was concerned that flaws detected in the outer 25 percent of the base metal (or original weld) that could potentially extended to the area where the procedure was not qualified for detection would not be assumed to extend deeper into the base metal. In Enclosure 3 to #07-003-RR, Revision 1, the licensee states in Paragraph 2(a)(2)(d) that the flaw depth assumed is the detected flaw depth plus the postulated worst-case flaw depth in the unqualified ultrasonic examination region of the pipe

wall thickness.

The licensee will only use the actual UT-determined through-wall dimension in the crack growth analysis for those flaws that can be determined by the qualified UT examination to not encroach on the outer 25 percent depth of the base metal (or original weld) thickness. The NRC staff finds that this approach adequately addresses the flaw size to be used in the crack growth calculation. Therefore, the proposed preservice examination requirements in Paragraph 3(b) of Enclosure 3 to #07-003-RR, Revision 1, are acceptable.

Inservice Examination

Section 3(c) of Enclosure 3 to #07-003-RR, Revision 1, provides requirements for ultrasonic inservice examinations with examination volume defined in Figure 2 of the RR.

Paragraph 3(c)(4) of Enclosure 3 to #07-003-RR, Revision 1, allows flaws in the weld overlay to be accepted by IWX-3600 of the ASME Code, Section XI. The NRC staff questioned the appropriateness of evaluating PWSCC flaws in the overlay, when the overlay is designed to mitigate this specific mechanism in the base material and the overlay material is considered to not be susceptible to PWSCC. The licensee clarified this issue in #07-003 RR, Revision 1, stating that flaws due to stress corrosion cracking in the weld overlay shall result in removal of the weld overlay and the item shall be repaired or replaced. The staff finds this acceptable, as it would only be appropriate to apply criteria of IWB-3600 to flaws that are not caused by stress corrosion cracking, such as fatigue which should likely be insignificant. However, flaw growth by stress corrosion cracking could be significant and the staff would find such a growth mechanism in a weld overlay to be unacceptable.

4.5 Mandatory Appendix 1 – Ambient Temperature Temper Bead Welding

Code Case N-638-1 provides requirements for ambient temperature temper bead welding. Mandatory Appendix 1 to Enclosure 3 to #07-003-RR, Revision 1, contains the licensee's plan for ambient temperature temper bead welding. The major difference between the two documents is discussed below.

Paragraph 1(b) of Mandatory Appendix 1 to Enclosure 3 to #07-003-RR, Revision 1, states that the maximum area of the weld overlay based on the finished surface over the ferritic base material shall be 300 square inches. Code Case N-638-1 allows only I00 square inches over the ferritic base material. The staff asked the licensee to justify the 300 square inch surface area. In its September 13, 2007, letter, the licensee responded that the ASME has indicated that the inside diameter compressive stress levels remain essentially the same between the 100 square inch weld area and 500 square inch weld area in relation to weld overlay applications. The presentation slides entitled, "Bases for 500 Sq. In. Weld Overlay Over Ferritic Material," were provided to the NRC staff in a public meeting on January 10, 2007 (ADAMS Accession No. ML070470565). Additional justification is provided in EPRI Report 1014351, "Repair and Replacement Applications Center: Topical Report Supporting Expedited NRC Review of Code Cases for Dissimilar Metal Weld Overlay Repairs, December 2006."

Based on a review of the information provided, the staff finds that the 300 square inch weld area limit over the ferritic base metal is acceptable because the licensee has provided results of finite element analysis demonstrating that the stresses of a nozzle with a 500 square inch weld area will not adversely affect the integrity of the pressurizer nozzle.

The NRC staff finds that the requirements of #07-003-RR, Revision 1, with the associated Attachment 3, which includes Mandatory Appendix I, are consistent with the intent of the provisions of Code Cases N-504-2 and N-638-1 and Appendix Q of the ASME Code, Section XI and provide an acceptable level of quality and safety.

5.0 CONCLUSION

The NRC staff has reviewed the licensee's submittal and determined that #07-003-RR, Revision 1, as supplemented by letter dated October 23, 2007, will provide an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the NRC staff authorizes the use of the #07-003-RR, Revision 1, as supplemented by letter dated October 23, 2007, for the SWOL of the dissimilar and similar metal welds of the hot leg surge line, pressurizer surge line, spray line including the safe end, and relief nozzles at CR-3. The effective period of #07-003-RR, Revision 1, is the third 10-year ISI interval, which ends in August 2008.

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

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Date: November 15, 2007

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