October 10, 2007

Robert J. Duncan II, Vice President
Shearon Harris Nuclear Power Plant
Carolina Power & Light Company
Post Office Box 165, Mail Code: Zone 1
New Hill, North Carolina 27562-0165

SUBJECT: SHEARON HARRIS NUCLEAR POWER PLANT, UNIT 1 – INSERVICE INSPECTION RELIEF REQUEST NO. 1 REGARDING PROPOSED ALTERNATIVE TO THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS BOILER AND PRESSURE VESSEL CODE REQUIREMENTS FOR PRESSURIZER NOZZLE WELD OVERLAY REPAIRS (TAC NO. MD5535)

Dear Mr. Duncan:

By letter dated May 14, 2007, as supplemented by letter dated July 19, 2007, Carolina Power and Light Company, the licensee for the Shearon Harris Nuclear Power Plant, Unit No. 1 (HNP), now doing business as Progress Energy Carolinas, Inc., requested approval for Inservice Inspection Relief Request No. 1. The request proposed an alternative to the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) requirements for weld overlay repairs, to support the installation of full structural weld overlays on dissimilar metal welds of pressurizer nozzles at HNP during refueling outage 14 (RFO-14) in fall 2007.

The U. S. Nuclear Regulatory Commission (NRC) staff has reviewed the licensee's submittal and determined that the proposed alternatives to the requirements of the ASME Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," will provide an acceptable level of quality and safety. Therefore, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.55a(a)(3)(i), the NRC staff authorizes the use of Inservice Inspection Relief Request No. 1 for the installation of full structural weld overlays on the dissimilar metal welds of the pressurizer nozzles at HNP.

The effective period of the proposed alternative is the third inservice inspection interval, which ends on May 1, 2017. All other requirements of the ASME Code, Section XI, for which relief has not been specifically requested and approved remain applicable, including third party review by the Authorized Nuclear Inservice Inspector.

The NRC staff's safety evaluation is enclosed. If you have any questions regarding this matter, please contact Marlayna Vaaler at (301) 415-3178.

Sincerely,

/RA/

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

Docket No. 50-400

Enclosure: Safety Evaluation

cc w/enclosure: See next page

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cc:

David T. Conley
Associate General Counsel II -
Legal Department
Progress Energy Service Company, LLC
Post Office Box 1551
Raleigh, North Carolina 27602-1551

Resident Inspector / Harris NPS
c/o U. S. Nuclear Regulatory Commission
5421 Shearon Harris Road
New Hill, North Carolina 27562-9998

Ms. Margaret A. Force
Assistant Attorney General
State of North Carolina
Post Office Box 629
Raleigh, North Carolina 27602

Public Service Commission
State of South Carolina
Post Office Drawer 11649
Columbia, South Carolina 29211

Ms. Beverly Hall, Section Chief
Division of Radiation Protection
N.C. Department of Environment
and Natural Resources
3825 Barrett Drive
Raleigh, North Carolina 27609-7721

Mr. J. Paul Fulford
Manager, Performance Evaluation and
Regulatory Affairs PEB 5
Carolina Power & Light Company
Post Office Box 1551
Raleigh, North Carolina 27602-1551

Mr. Chris L. Burton
Director of Site Operations
and Acting Plant General Manager
Shearon Harris Nuclear Power Plant
Carolina Power & Light Company
Post Office Box 165, Mail Zone 1
New Hill, North Carolina 27562-0165

Mr. Robert P. Gruber
Executive Director
Public Staff NCUC
4326 Mail Service Center
Raleigh, North Carolina 27699-4326

Chairman of the North Carolina
Utilities Commission
Post Office Box 29510
Raleigh, North Carolina 27626-0510

Mr. Tony Gurley, Chair
Board of County Commissioners
of Wake County
P. O. Box 550
Raleigh, North Carolina 27602

Mr. Carl Thompson, Chair
Board of County Commissioners
of Chatham County
P. O. Box 87
Pittsboro, North Carolina 27312

Mr. Thomas J. Natale, Manager
Support Services
Shearon Harris Nuclear Power Plant
Carolina Power & Light Company
P. O. Box 165, Mail Zone 1
New Hill, North Carolina 27562-0165

Mr. David H. Corlett, Supervisor
Licensing/Regulatory Programs
Shearon Harris Nuclear Power Plant
Carolina Power & Light Company
P. O. Box 165, Mail Zone 1
New Hill, NC 27562-0165

Mr. John H. O'Neill, Jr.
Pillsbury Winthrop Shaw Pittman, LLP
2300 N Street NW.
Washington, DC 20037-1128

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

REGARDING REQUEST TO USE A PROPOSED ALTERNATIVE TO ASME CODE

REQUIREMENTS FOR PRESSURIZER NOZZLE WELD OVERLAY REPAIRS

CAROLINA POWER AND LIGHT COMPANY

PROGRESS ENERGY CAROLINAS, INC

SHEARON HARRIS NUCLEAR POWER PLANT, UNIT 1

DOCKET NO. 50-400

1.0 INTRODUCTION

By letter dated May 14, 2007 (Reference No. 1), Carolina Power and Light Company (CP&L), the licensee for the Shearon Harris Nuclear Power Plant, Unit No. 1 (HNP), now doing business as Progress Energy Carolinas, Inc., submitted for staff review and approval HNP Inservice Inspection (ISI) Relief Request (RR) No. 1. The submittal requested relief from the requirements of the American Society of Mechanical Engineers Code (ASME Code), Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," Article IWA-4000, "Repair/Replacement Activities," for mitigating primary water stress corrosion cracking (PWSCC) on dissimilar metal welds (DMW) of pressurizer nozzles using full structural weld overlays. This request supports the installation of full structural weld overlays on DMWs of pressurizer nozzles at HNP during refueling outage 14 (RFO-14) in fall 2007.

By letter dated July 19, 2007 (Reference No. 2), the licensee submitted a response to the U.S. Nuclear Regulatory Commission (NRC) staff's request for additional information, clarifying the locations where stainless steel butter material may be used if sensitivity to stainless steel base metal impurities is discovered.

A DMW is defined as a weld that joins two pieces of metal of different types. In the proposed alternative, the dissimilar metal weld joins the ferritic (i.e. carbon steel) pressurizer nozzle to the austenitic stainless steel safe end. The DMW itself is made of nickel-based Alloy 82/182. The proposed weld overlay repair is a process in which weld filler metal that is resistant to stress corrosion cracking is deposited on the outside surface of the nozzle, safe end, and degraded pipe, including the original weld.

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 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, which is 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.

HNP is in the third inspection interval. The current ASME Code edition and addenda for HNP is the 2001 Edition through the 2003 Addenda of the ASME Code, Section XI. However, as required by 10 CFR 50.55a(b)(2)(xxiv), the licensee will use Appendix VIII, "Performance Demonstration for Ultrasonic Examinations," to the 2001 Edition of the ASME Code, Section XI, with no addenda, to establish the specimen set and qualification requirements for ultrasonic examination of the weld overlay.

3.0 PROPOSED ALTERNATIVE

3.1 ASME Code Components Affected

The licensee will install a full structural weld overlay on the following six Code Class 1 DMWs:

1.	14" Pressurizer Surge Line Nozzle to Safe End weld	(II-PZR-01NSEW-15)
2.	4" Pressurizer Spray Line Nozzle to Safe End weld	(II-PZR-01NSEW-16)
3.	6" Pressurizer A Safety Line Nozzle to Safe End weld	(II-PZR-01NSEW-17)
4.	6" Pressurizer B Safety Line Nozzle to Safe End weld	(II-PZR-01NSEW-18)
5.	6" Pressurizer C Safety Line Nozzle to Safe End weld	(II-PZR-01NSEW-19)
6.	6" Pressurizer Relief Line Nozzle to Safe End weld	(II-PZR-01NSEW-20)

In addition, due to the close proximity of the adjacent safe end to reactor coolant system (RCS) pipe weld, the following safe end to pipe welds will be overlaid along with the corresponding DMW:

1.	14" Pressurizer Surge Line Safe End to RCS pipe weld	(1-RC-FW-3)
2.	4" Pressurizer Spray Line Safe End to RCS pipe weld	(1-RC-FW-328)
3.	6" Pressurizer A Safety Line Safe End to RCS pipe weld	(1-RC-FW-330)
4.	6" Pressurizer B Safety Line Safe End to RCS pipe weld	(1-RC-FW-334)
5.	6" Pressurizer C Safety Line Safe End to RCS pipe weld	(1-RC-FW-329)
6.	6" Pressurizer Relief Line Safe End to RCS pipe weld	(1-RC-FW-456)

3.2 Code Requirements

ASME Code, Section XI, Article IWA-4221, requires that repairs and the installation of replacement items be performed in accordance with the Owner's Requirements and the original Construction Code of the component or system. Alternatively, IWA-4221 allows for the use of later Editions/Addenda of the Construction Code or ASME Code, Section III.

Articles IWA-4420 and IWA-4600 of the AMSE Code, Section XI, provide defect removal and alternative welding methods when the requirements of IWA-4221 cannot be met.

Article IWA-4530 of the AMSE Code, Section XI, requires the performance of preservice examinations based on Article IWB-2200 for ASME Code Class 1 components.

The ASME Code, Section XI, Table IWB-2500, Categories B-F and B-J, prescribe preservice and ISI requirements for ASME Code Class 1 butt welds.

Appendix VIII, Supplement 11, of the ASME Code, Section XI, specifies performance demonstration requirements for ultrasonic examination of weld overlays.

3.3 Proposed Alternative

Pursuant to 10 CFR 50.55a(a)(3)(i), the licensee proposes the following as alternatives to the ASME Code requirements specified above.

The licensee will install preemptive full structural weld overlays in accordance with the proposed alternatives specified in Attachments 2 and 3 to HNP ISI RR No. 1. These alternatives are based on the methodology of ASME Code, Section XI, Code Case N-740.

The proposed alternatives for design, fabrication, examination, pressure testing, and ISI of preemptive full structural weld overlays are described in Attachment 2 to the May 14, 2007, submittal. The proposed alternative applicable to ambient temperature temper bead welding is described in Attachment 3 to HNP ISI RR No. 1. The option described in Attachment 3 will be applied to the six DMWs identified above as an alternative to the post-weld heat treatment requirements of the ASME Code, Section III.

The licensee will perform ultrasonic examinations of the proposed preemptive full structural weld overlays in accordance with Appendix VIII, Supplement 11, of the 2001 Edition with no addenda of the ASME Code, Section XI, except as modified by the Performance Demonstration Initiative (PDI) Program. The proposed PDI alternatives to Appendix VIII, Supplement 11, of the ASME Code are specified in Attachment 6 to HNP ISI RR No. 1.

3.4 Basis for Alternative

PWSCC of Alloy 600 components and welds exposed to pressurized water reactor (PWR) primary coolant has become a growing concern in the nuclear industry over the past decade. In particular, DMWs made with Nickel Alloy 82 and 182 weld metal exposed to elevated operating temperatures, such as pressurizer nozzle to safe end DMWs, are believed to pose a heightened propensity to PWSCC. Due to this concern, HNP has concluded that the application of preemptive, full structural weld overlays to the pressurizer nozzle to safe end DMWs is the most appropriate course of action to ensure reactor coolant system pressure boundary integrity, as well as improve the ability to inspect these welds in the future.

Structural weld overlays have been used for several years on piping of both boiling water reactors (BWRs) and PWRs to arrest the growth of existing flaws while establishing a new structural pressure boundary. No evidence of PWSCC has been found in the subject pressurizer nozzle to safe end DMWs at HNP. However, PWSCC is difficult to detect except when the inspection is performed in accordance with the stringent requirements of the ASME Code, Section XI, Appendix VIII. The DMWs included in this request have been evaluated and do not meet the surface or geometric requirements contained in Appendix VIII. Therefore, inspection of these welds cannot be performed to Appendix VIII standards without modifying the weld geometry or configuration.

Currently, there are no generically accepted ASME Code approved criteria for a licensee to preemptively apply a full structural weld overlay to DMWs constructed of Alloy 82/182 weld material. Although HNP will perform repair and replacement activities in accordance with the 2001 Edition with 2003 Addenda of the ASME Code, Section XI, this edition of the ASME Code does not include requirements for application of preemptive, full structural weld overlays. At this time, preemptive, full structural weld overlay requirements are not presently included in any Edition/Addenda of the ASME Code, Section XI (including Code Cases), approved by the NRC.

However, nozzle to safe end weld overlays have been applied as repairs to other plants in accordance with ASME Code Cases N-504-2 and N-638-1, which are conditionally accepted for use in Regulatory Guide (RG) 1.147, "Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1." Application of these code cases to nozzle DMWs requires a series of relief requests since Code Case N-504-2 was written specifically for stainless steel pipe-to-pipe welds, and Code Case N-638-1 contains some restrictions and requirements that are not applicable to weld overlays.

The ASME Code, Section XI, Appendix VIII, Supplement 11, contains the Qualification Requirements for Full Structural Overlaid Wrought Austenitic Piping Welds. The PDI has addressed these qualification requirements with a qualification program that uses samples resulting from the Tri-party Agreement between the NRC, the BWR Owner's Group, and Electric Power Research Institute (EPRI). These samples have a flaw population density greater than allowed by the current ASME Code requirements. This program, along with the associated Code Cases, forms the basis for the proposed alternative contained in HNP ISI RR No. 1.

3.5 <u>Duration of the Alternative</u>

HNP ISI Relief Request No. 1 is applicable for the third inspection interval at HNP, which began on May 2, 2007, and ends on May 1, 2017.

4.0 <u>STAFF EVALUATION</u>

As previously noted, Attachment 2 to HNP ISI RR No. 1 contains requirements for the design and nondestructive examination (NDE) of the weld overlay, and Attachment 3 contains requirements for the ambient temperature temper bead welding technique. The proposed methodology and associated requirements for the weld overlay follow the criteria laid out in Code Case N-740, "Dissimilar Metal Weld Overlay for Repair of Class 1, 2, and 3 Items

Section XI, Division 1," of the ASME Code, Section XI. Code Case N-740 combines the requirements in Code Case 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." The NRC has endorsed Code Cases N-504-2 and N-638-1, but not Code Case N-740. Therefore, the staff evaluated the acceptability of HNP ISI RR No. 1 based on the requirements of Code Case N-504-2 and N-638-1, and separately considered any exceptions to these Code Cases applicable to HNP.

4.1 General Requirements

Section 1.0, *General Requirements*, of Attachment 2 to HNP ISI RR No.1 provides requirements for the specification of the base metal and existing weld (carbon steel, stainless steel, and Alloy 82/182), weld overlay filler metal (Alloy 52M), surface condition of the base metal, and chromium content of the weld overlay deposits. These requirements are in keeping with the ASME Code, Section XI, Article IWA-4221, which states that repairs and installation of replacement items shall be performed in accordance with the Owner's Requirements and the original Construction Code of the component or system, and are therefore acceptable.

In addition, Paragraph 1.0(e) of Attachment 2 to HNP ISI RR No.1 requires that a new weld overlay shall not be installed on top of an existing weld overlay that has been in service. The staff finds this acceptable because installation of a weld overlay over an existing weld overlay could indicate a problem with the existing weld overlay that may not be resolved by the application of another weld overlay.

In the May 14, 2007, letter, the licensee stated that as an alternative to the post-weld heat treatment requirements of the Construction Code and Owner's Requirements, the provisions for ambient temperature temper bead welding may be used on the ferritic nozzle as described in Attachment 3 to HNP ISI RR No. 1, and as further evaluated by the staff in section 4.6 of this safety evaluation.

4.2 Crack Growth Considerations and Design

Section 2.0, *Crack Growth Considerations and Design*, of Attachment 2 to HNP ISI RR No.1 provides the requirements for weld overlay design, design basis flaw size, and the crack growth calculation. The crack growth calculation assures that growth of a crack in the base metal will be mitigated or minimized by the installation of the weld overlay.

The licensee stated that the design basis for full structural weld overlays is to maintain the original design margins with no credit taken for the underlying PWSCC-susceptible weldments. The assumed design basis flaw for the purpose of sizing the weld overlays is 360 degrees and 100 percent through the original wall thickness of the DMWs. Regarding the crack growth analysis for the preemptive full structural weld overlay, a flaw originating from the inside diameter with a depth of 75 percent and a circumference of 360 degrees will be assumed. A 75 percent through-wall flaw is the largest flaw that could remain undetected in the base metal.

A preservice volumetric examination will be performed after application of the weld overlay using an ASME Code, Section XI, Appendix VIII (as implemented through PDI), examination procedure. This examination will verify that there is no cracking in the upper 25 percent of the original weld and base material. The preservice examination will also demonstrate that the assumption of a 75 percent through-wall crack is conservative. The PDI procedure is not qualified to examine the lower 75 percent of the pipe wall thickness. Therefore, a conservative approach is to assume that a 75 percent through-wall crack exists in the lower 75 percent of the pipe wall thickness.

The licensee stated that if no flaws are identified in the upper 25 percent of the original weld, the assumed flaw depth for the crack growth calculation will be 75 percent through-wall in the original weld. If any crack-like flaws are found during the preservice examination in the upper 25 percent of the original weld or base metal, an analyzed flaw (the postulated 75 percent through-wall flaw plus the portion of the as-found flaw in the upper 25 percent) will be used for the crack growth calculation. The staff finds that the proposed flaw size to be used in the crack growth calculation is conservative and, therefore, acceptable.

As part of the weld overlay design, the licensee will perform nozzle-specific stress analyses to establish a residual stress profile in each pressurizer nozzle. Severe internal diameter weld repairs will be assumed in these analyses that effectively bound any actual weld repairs that may have occurred during the service life of the pressurizer nozzles. The analyses will then simulate application of the weld overlays to determine the final residual stress profiles. Post-weld overlay residual stresses at normal operating conditions will be shown to result in beneficial compressive stresses on the inside surface of the components, assuring that further crack initiation due to PWSCC is highly unlikely. The assumption of severe, or deep, inner diameter weld repairs is appropriate as this would result in high tensile stress regions in the original weld, prior to application of the weld overlay.

The licensee will also perform fracture mechanics analyses to predict crack growth for postulated flaws. Crack growth due to PWSCC and fatigue will be analyzed for the original DMW. The crack growth analyses will consider all design loads and transients, in addition to the post-weld overlay and through-wall residual stress distributions. The analyses will demonstrate that the postulated cracks will not grow beyond the design basis for the weld overlays. The licensee will also demonstrate by analysis that the weld overlay does not impact the conclusions of the existing stress reports for the pressurizer nozzles. The stress and fatigue criteria of the ASME Code, Section III, will be met for regions of the weld overlays remote from assumed cracks.

The licensee will measure shrinkage following the weld overlay application. Shrinkage stresses at other locations in the affected piping systems arising from the weld overlays will be demonstrated not to have an adverse effect. The clearances of affected supports and restraints will be checked after the weld overlay repair, and will be reset to within the design ranges as required. Lastly, the licensee will evaluate the total added weight on the piping systems due to the weld overlays for potential impact on piping system stresses and dynamic characteristics. The as-built dimensions of the weld overlays will be measured and evaluated to demonstrate that they meet or exceed the minimum design dimensions of the overlays. The staff finds that the licensee's proposed analyses and shrinkage measurements are consistent with paragraph (g) of Code Case N-504-2 and are, therefore, acceptable.

In the May 14, 2007, submittal, the licensee stated that Alloy 52M weld metal has a demonstrated sensitivity to certain impurities, such as sulfur, when deposited onto austenitic stainless steel base material. While the licensee does not anticipate this situation at HNP, should this condition be found to exist, a butter layer of austenitic stainless steel filler metal will be applied across the austenitic stainless steel base material (safe end, safe end to pipe weld, or pipe) prior to installing the weld overlay. The welding procedure for applying the austenitic stainless steel butter layer will be qualified in accordance with the ASME Code, Section IX, for the applicable base materials, filler metals, and welding variables. In the supplemental letter dated July 19, 2007, the licensee noted that the austenitic stainless steel butter layer will not be deposited onto the existing Alloy 82/182 weld or carbon steel base material of the pressurizer nozzle. The butter layer, if required, will only be applied to the stainless steel safe end, the safe end to pipe weld, or the pipe.

Because the thermal expansion coefficients for the austenitic stainless steel weld metal and the austenitic stainless steel base material are essentially the same, the differential thermal expansion between the weld overlay (Alloy 52M) and base material (stainless steel) versus that of the weld overlay (Alloy 52M) and butter layer (stainless steel) will be the same. Therefore, the deposition of an austenitic stainless steel butter layer onto an austenitic stainless steel base material prior to deposition of the Alloy 52M weld overlay will have no adverse impact caused by weld shrinkage. Regardless, if the butter layer is applied, any effects of the stainless steel butter layer over the stainless steel base metal will be reconciled by the weld overlay design and residual stress analyses.

The licensee stated that if an austenitic stainless steel butter layer is installed, it will not be included as part of the structural weld overlay design thickness. Additionally, the austenitic stainless steel butter layer will not adversely impact the ability to ultrasonically examine the weld overlay or base metal.

The staff finds that the installation, if necessary, of a butter layer on the base metal is acceptable because the austenitic stainless steel butter layer will not cause adverse chemical or metallurgical interaction with the austenitic stainless steel base metal or Alloy 52M weld overlay metal.

The licensee stated in paragraphs 3.0(a) and (b) of Attachment 2 to HNP ISI RR No. 1 that any planar flaws in the weld overlay shall meet the preservice acceptance standards of IWB-3514. Therefore, if a planar flaw is identified in the weld overlay that exceeds the acceptance standards of IWB-3514, the planar flaw will be rejected and removed. This is consistent with the ASME Code, Section XI, nonmandatory Appendix Q, the provisions of which are included as a conditional requirement for the use of Code Case N-504-2 by the NRC in RG 1.147, and is therefore acceptable.

The acceptance standards established by the licensee in paragraphs 3.0(a) and (b) of Attachment 2 to HNP ISI RR No. 1 appear to be in conflict with those stated in paragraph 2.0(b)(4). However, the licensee clarified in a note that, although planar flaws are considered in the IWB-3640 evaluation of the combined wall thickness in paragraph 2.0(b)(4), these planar flaws must first meet the acceptance standards of IWB-3514 as required by paragraphs 3.0(a) and (b).

The licensee’s paragraph 2.0(b)(4) is to address two specific design issues: (1) design thickness of the weld overlay; and (2) compliance of the weld overlay design with IWB-3640. With respect to the design thickness of the weld overlay, no structural credit is taken for the original weld (i.e., flaws in the original weld are assumed to be 100 percent through-wall for the entire circumference), while the weld overlay thickness credited in the design must consist of weld layers that contain at least 24 percent chromium. Regarding the applicability of IWB-3640 to the weld overlay design, paragraph 2.0(b)(4) ensures that the "combined wall thickness at the weld overlay" (i.e., the wall thickness of the pipe at the original weld and the weld overlay thickness) meets the requirements of IWB-3640 when evaluating the following anomalies in the weld overlay region:

1. Planar flaws identified during the acceptance and preservice examinations of the weld overlay.

2. Postulated flaws assumed in the original weld for design purposes. (Flaws were assumed to be 100 percent through-wall for the entire circumference.)

3. Discontinuities within a distance of $2.5\sqrt{Rt}$ from the toes of the weld overlay. (Examples of discontinuities include another weld overlay or reinforcement for a branch connection.)

The licensee concluded that planar flaws identified in the weld overlay must first meet the acceptance standards of IWB-3514 as required by HNP ISI RR No. 1, Attachment 2, paragraphs 3.0(a) and (b). However, when evaluating the combined wall thickness at the weld overlay in accordance with IWB-3640, planar flaws accepted per paragraphs 3.0(a) and (b) must also be considered in the evaluation. The staff finds this approach acceptable as any planar flaws detected in the weld overlay will satisfy the acceptance standards of IWB-3514, and the flaw growth analysis will be performed in accordance with IWB-3600.

4.3 Examination and Inspection

Section 3.0, *Examination and Inspection*, of Attachment 2 to HNP ISI RR No. 1 provides requirements for the acceptance examination, preservice examination and inservice examination of the weld overlay after installation. The length, surface finish, and flatness requirements are specified in the weld overlay design to provide the required examination volume for the weld overlay as shown in Figures 1 and 2 of Attachment 2 to HNP ISI RR No. 1.

The ultrasonic examinations in the proposed alternative are in accordance with the ASME Code, Section XI, Appendix VIII, Supplement 11, as implemented through the PDI. These examinations are considered more sensitive for the detection of 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 appropriately evaluating procedures and personnel.

The U.S. nuclear utilities created the PDI program to implement performance demonstration requirements contained in Appendix VIII to Section XI of the ASME Code. To this end, the PDI has developed a program for qualifying equipment, procedures, and personnel in accordance with the ultrasonic testing criteria of the ASME Code, Appendix VIII, Supplement 11. Prior to the Supplement 11 program, EPRI maintained a performance demonstration program (the precursor to the PDI program) for weld overlay qualification under the Tri-party Agreement between the NRC, the BWR Owner's Group, and EPRI, as discussed in the NRC letter dated July 3, 1984 (Reference No. 3). Later, the NRC staff recognized the EPRI PDI program for weld overlay qualifications as an acceptable alternative to the Tri-party Agreement in its letter dated January 15, 2002 (Reference No. 4).

However, the PDI program does not fully comport with the existing requirements of the ASME Code, Appendix VIII, Supplement 11. The PDI presented these differences at public meetings in which the NRC participated (Reference Nos. 5 and 6). Based on the discussions at these meetings, and subsequent successful use of the PDI program, the NRC staff determined that the PDI program provides an acceptable level of quality and safety.

The NRC staff evaluated the differences HNP ISI RR No. 1 identified in the PDI program against Supplement 11 to Appendix VIII of the ASME Code. The NRC staff concludes that these differences continue to provide an acceptable level of quality and safety and, therefore, the proposed alternative is acceptable.

4.3.1 Acceptance Examination

Section 3.0(a), *Acceptance Examination of the Overlay*, of Attachment 2 to HNP ISI RR No. 1 requires a surface examination for each of the installed weld overlays, with the acceptance criteria based on the Construction Code or NB-5300 of the ASME Code, Section III. In addition, the adjacent base metal shall satisfy the surface examination acceptance criteria for base material of the Construction Code or NB-2500 of the ASME Code, Section III.

Per Section 3.0(a)(3) of Attachment 2 to HNP ISI RR No. 1, any planar flaws found in the weld overlay during either the acceptance or preservice examination are required to meet the preservice examination requirements of Table IWB-3514-2 of the ASME Code, Section XI. This is consistent with the ASME Code, Section XI, nonmandatory Appendix Q, the provisions of which are included as a conditional requirement for use of Code Case N-504-2 by the NRC in RG 1.147, and is therefore acceptable.

In paragraph 3.0(a)(3) of Attachment 2 to HNP ISI RR No. 1, the licensee proposed the following acceptance criteria for laminar:

1. Per paragraph 3.0(a)(3)(i), Table IWB-3514-3 of the ASME Code, Section XI, has been restricted so that the total laminar flaw shall not exceed 10 percent of the weld surface area and no linear dimension of the laminar flaw shall exceed 3 inches.

2. Per Section 3.0(a)(3)(ii), the reduction in coverage due to laminar flaws shall be less than 10 percent. The dimensions of the uninspectable volume are dependent on the coverage achieved during the angle beam examination of the weld overlay.

3. Per Section 3.0(a)(3)(iii), any uninspectable volume in the weld overlay shall be assumed to contain the largest radial planar flaw that could exist within that volume. This assumed flaw shall meet the inservice examination standards of Table IWB-3514-2 of the ASME Code, Section XI. Alternately, the assumed flaw shall be evaluated to meet the requirements of IWB-3640. Both axial and circumferential flaws shall be assumed.

The staff finds that the above requirements to limit the size of laminar flaws and potential flaws in the uninspectable volume are acceptable because the requirements are consistent with the provisions of the ASME Code, Section XI, nonmandatory Appendix Q, and adequately address the staff's concerns regarding laminar flaws in the weld overlay.

Regarding hydrogen cracking concerns, the licensee stated that the NDE required by paragraphs 3.0(a)(2) and 3.0(a)(3) of Attachment 2 to HNP ISI RR No. 1 is capable of detecting hydrogen cracking in ferritic materials. If hydrogen cracking were to occur, the licensee stated that it would occur in the heat-affected zone (HAZ) of the ferritic base material either below or immediately adjacent to the weld overlay. Therefore, it is unnecessary to examine the entire 1.5T (T is the wall thickness of piping) band defined in Code Case N-638-1. Since hydrogen cracking is not a concern in austenitic materials, the weld overlay itself is not considered susceptible. However, if hydrogen cracking occurs in the ferritic base material below the weld overlay, it will be detected by the ultrasonic examination that examines the entire weld overlay volume including the interface and HAZ beneath the weld overlay. If hydrogen cracking occurs in the ferritic base material immediately adjacent to the weld overlay, it will be detected by the liquid penetrant examination which is performed on each side of the weld overlay.

Paragraphs 3.0(a)(2), 3.0(a)(3), and 3.0(b)(1) of Attachment 2 to HNP ISI RR No. 1 require that when ambient temperature temper bead welding is performed over ferritic materials, the liquid penetrant and ultrasonic examinations will not be performed until at least 48 hours after completing the third layer of the weld overlay. This requirement deviates from Code Case N-638-1, which requires that the liquid penetrant and ultrasonic examinations not be performed until at least 48 hours after the weld reaches ambient temperature.

This 48 hour hold time is specified to allow sufficient time for hydrogen cracking to occur (if it is to occur) in the HAZ of ferritic materials prior to performing NDE, so that if hydrogen cracking does occur, NDE would be able to detect it. However, based on extensive research and industry experience, EPRI has provided a technical basis for starting the 48 hour hold after completion of the third temper bead weld layer rather than waiting for the weld overlay to cool to ambient temperature. EPRI has documented their technical basis for this conclusion in technical report 1013558, "Temper Bead Welding Applications – 48 Hour Hold Requirements for Ambient Temperature Temper Bead Welding" (Reference No. 7). The technical data provided by EPRI in their report is based on testing performed on SA-508, Class 2 low alloy steels and other P-Number 3, Group 3 materials. The conclusions of the EPRI report are bounding and applicable to the P-Number 3 materials at HNP.

After evaluating all of the issues relevant to hydrogen cracking, such as the microstructure of susceptible materials, availability of hydrogen, applied stresses, temperature, and diffusivity and solubility of hydrogen in steels, EPRI concluded that: "...there appears to be no technical basis for waiting 48 hours after cooling to ambient temperature before beginning the NDE of the completed weld. There should be no hydrogen present, and even if it were present, the temper bead welded component should be very tolerant of the moisture...." EPRI also notes that over 20 weld overlays and 100 repairs have been performed using temper bead techniques on low alloy steel components during the last 20 years. During this time, there has never been an indication of hydrogen cracking during the NDE performed after the 48 hour hold, or by subsequent ISI throughout the continuing service life of the components.

In addition, the ASME Code, Section XI Committee published a White Paper (Reference No. 8) to support the 48 hour hold time alternative. The ASME White Paper asserts that the introduction of hydrogen to the ferritic HAZ is limited to the first weld layer since this is the only weld layer that makes contact with the ferritic base material. While potential for the introduction of hydrogen to the ferritic HAZ is negligible during subsequent weld layers, these layers provide a heat source that accelerates the dissipation of hydrogen from the ferritic HAZ in non-water backed applications. (Weld layers beyond the third layer are not designed to provide tempering to the ferritic HAZ when performing ambient temperature temper bead welding.) Furthermore, the solubility of hydrogen in austenitic materials such as Alloy 52M is much higher than that of ferritic materials, while the diffusivity of hydrogen in austenitic materials is lower than that of ferritic materials. As a result, hydrogen in the ferritic HAZ tends to diffuse into the austenitic weld metal, which has a much higher solubility for hydrogen. This diffusion process is enhanced by the heat supplied in subsequent weld layers. The ASME White Paper concludes that there is sufficient delay time to facilitate the detection of potential hydrogen cracking when NDE is performed 48 hours after completion of the third weld layer.

The staff finds that a 48 hour hold time after completion of the third weld layer before commencing NDE is acceptable because the licensee has provided sufficient technical justification to demonstrate that undetectable hydrogen cracking in the weld overlay would not likely occur after the proposed time delay of 48 hours.

4.3.2 Preservice Examination

Section 3.0(b), *Preservice Inspection*, of Attachment 2 to HNP ISI RR No. 1 requires an ultrasonic examination of the installed weld overlay and the upper (outer) 25 percent of the original pipe wall thickness. The required examination volume is defined in Figure 2 of Attachment 2 to HNP ISI RR No. 1. Paragraph 3.0(b)(2) requires that any flaws in the weld overlay meet the acceptance standards of Table IWB-3514-2 of the ASME Code, Section XI, otherwise the weld overlay will be removed. The staff finds that the preservice examination requirements are acceptable because they are consistent with the NRC position on disposition of preservice flaws in the weld overlay.

4.3.3 Inservice Examination

Section 3.0(c), *Inservice Inspection*, of Attachment 2 to HNP ISI RR No. 1 requires an inservice inspection be conducted using ultrasonic examination of the installed weld overlay and the upper (outer) 25 percent of the original pipe wall thickness. The required examination volume is defined in Figure 2 of Attachment 2 to HNP ISI RR No. 1.

Paragraph 3.0(c)(3) of Attachment 2 to HNP ISI RR No. 1 states that if the weld overlay does not meet the acceptance standards of Table IWB-3514-2, it can be accepted under the criteria of IWB-3600. The staff finds using the acceptance criteria of IWB-3600 to disposition flaws in the weld overlay acceptable only if the flaw growth is caused by thermal fatigue, which would be insignificant. Because flaw growth by PWSCC could be significant, paragraph 3.0(c)(3) continues: “however, flaws identified as PWSCC in the weld overlay cannot be accepted by IWB-3600 analytical evaluation.” The staff finds prohibition of the use of an analytical evaluation under IWB-3600 to disposition PWSCC-induced flaws consistent with the NRC position and, therefore, acceptable.

Each weld overlay will be ultrasonically examined during the first or second refueling outage following application. For weld overlay examinations that show no new cracking in the weld overlay or no indication of crack growth, the subject weld will be placed into a population group to be examined on a sample basis in the future. Twenty-five percent of this population shall be examined every ten years. If a planar indication is detected in the weld overlay during the first

ISI and is accepted per Table IWB-3514-2 of the ASME Code, Section XI, the weld overlay will be reexamined during future refueling outage(s) per paragraph 3.0(c)5 of Attachment 2 to HNP ISI RR No. 1. Additionally, per paragraph 3.0(c)(6) of Attachment 2 to HNP ISI RR No. 1, any weld overlay examination volumes that fail to meet the acceptance criteria described in paragraph 3.0(c)(3) will be removed, to include the original defective weld, and will be corrected by a repair or replacement activity in accordance with IWA-4000.

The successive examination requirements contained in Section 3.0(c) of Attachment 2 to HNP ISI RR No. 1 ensure that cracks identified by inservice inspections are appropriately monitored. Section 3.0(c) requires that the weld overlay be reexamined during the first or second refueling outage following application. If additional crack growth or a new crack is discovered during the successive examination, then reexamination of the weld overlay would be performed within the next two refueling outages. However, if the successive examination of the weld overlay reveals no additional indication of crack growth or new cracking, the weld overlay shall be placed into a population to be examined on a sample basis. Twenty-five percent of this population shall be examined once every ten years. The licensee stated that the successive examination schedule is identical to that specified in paragraph Q-4300 of the ASME Code, Section XI, nonmandatory Appendix Q, which has been imposed as a condition for using Code Case N-504-2 by the NRC in RG 1.147. The staff finds the successive examination requirements proposed by Section 3.0(c) of HNP ISI RR No. 1 consistent with nonmandatory Appendix Q to the ASME Code, Section XI, and, therefore, acceptable.

4.4 Pressure Testing

Section 4.0, *Pressure Testing*, of Attachment 2 to HNP ISI RR No. 1 requires a system leakage test be performed in accordance with IWA-5000 after a weld overlay is installed. The staff finds this requirement acceptable because it is consistent with paragraph (h) of Code Case N-504-2.

4.5 Documentation

Section 5.0, *Documentation*, of Attachment 2 to HNP ISI RR No. 1 requires that use of the proposed alternative be documented on ASME Form NIS-2, “Owner’s Report for Repairs or Replacements.” The staff finds this requirement acceptable because it is consistent with paragraph (m) of Code Case N-504-2.

4.6 Proposed Ambient Temperature Temper Bead Welding

The requirements for the proposed ambient temperature temper bead welding technique are discussed in Attachment 3 to HNP ISI RR No. 1 and are based on Code Case N-638-1 with the exceptions discussed below.

Paragraph 1.0(a) of Code Case N-638-1 limits the maximum area of an individual weld to 100 square inches on the ferritic base material using temper bead welding. However, the proposed alternative allows for a weld surface area up to 300 square inches on the ferritic base material. The licensee stated that the technical justification for allowing weld overlays on ferritic materials with surface areas up to 500 square inches is provided in the White Paper supporting the changes to ASME Code Case N-638-3, and EPRI Report 1011898, “Justification for the Removal of the 100 Square Inch Temper Bead Weld Repair Limitation” (Reference No. 9).

The EPRI report cites evaluations of a 12-inch diameter nozzle weld overlay to demonstrate adequate tempering of the weld HAZ, residual stress evaluations demonstrating acceptable residual stresses in weld overlays ranging from 100 to 500 square inches, and service history in which weld repairs exceeding 100 square inches were NRC approved and applied to DMW nozzles in several BWR and PWR applications. Some of the cited repairs are greater than 15 years old, and have been inspected several times with no evidence of any continued degradation. The above theoretical arguments and empirical data have been verified in practice by extensive field experience with temper bead weld overlays, with ferritic material coverage ranging from less than 10 square inches up to and including 325 square inches.

The staff finds that the proposed 300 square inch weld area on the ferritic material is acceptable because the stress analysis presented in EPRI Report 1011898 shows that the structural integrity of ferritic material is not adversely affected by a 300 square inch weld overlay area.

Paragraph 2.1(g) of Attachment 3 to HNP ISI RR No. 1 requires that the Charpy V-notch test acceptance criteria be based on the average lateral expansion values rather than the average of all three values. Specifically, Paragraph 2.1(g) requires that "...the average lateral expansion value of the three HAZ Charpy V-notch specimens shall be equal to or greater than the average lateral expansion value of the three unaffected base metal specimens...." The proposed requirement deviates from Code Case N-638-1, paragraph 2.1(J), which requires that "...average values of the three HAZ impact tests shall be equal to or greater than the average values of the three unaffected base metal tests...."

Paragraph 2.1(g) aligns the proposed Charpy V-notch acceptance criteria with that of Article NB-4330, "Impact Test Requirements," of the ASME Code, Section III, and Articles IWA-4620, "Temperbead Welding of Similar Materials," and IWA-4630, "Temperbead Welding of Dissimilar Materials," of the ASME Code, Section XI. The staff finds that Paragraph 2.1(g) of Attachment 3 to HNP ISI RR No. 1 is acceptable because the proposed acceptance criteria for Charpy V-notch tests are consistent with the associated requirements of the ASME Code, Section III and Section XI.

Paragraph 3.0(c) of Code Case N-638-1 requires the deposition and removal of at least one weld reinforcement layer for "similar materials" (i.e., ferritic materials). This requirement is only applicable when welding is performed using ferritic filler weld metal. Since only austenitic filler weld metal (i.e., Alloy 52M) will be used to fabricate the proposed weld overlays, depositing and removing a weld reinforcement layer is not required. Therefore, this requirement is not included in the proposed alternative. The staff agrees with the licensee that paragraph 3.0(c) of Code Case N-638-1 is not applicable to the proposed weld overlays.

Paragraph 3.0 of Code Case N-638-1 does not address monitoring or verification of welding interpass temperatures. However, paragraph 3.0(e) of Attachment 3 to HNP ISI RR No. 1 requires use of a contact pyrometer to measure preheat and interpass temperature. The paragraph also requires that in the first three layers, the interpass temperature be measured every three to five passes. After the first three layers, interpass temperature measurements will be taken every six to ten passes for the subsequent layers. Contact pyrometers will be calibrated in accordance with approved calibration and control program documents. The licensee stated that the proposed interpass temperature controls are based on field experience with depositing weld overlays. Interpass temperature beyond the third layer has no impact on the metallurgical properties of the low alloy steel HAZ. The staff finds that the proposed interpass temperature measurements are acceptable because they provide adequate monitoring of the weld overlay temperature such that the metallurgical properties of the low alloy steel pressurizer nozzle will not be negatively affected by the temperature of the weld overlay.

In RG 1.147 the NRC staff imposed the following condition on Code Case N-638-1: "...ultrasonic testing examinations shall be demonstrated for the repaired volume using representative samples which contain construction type flaws. The acceptance criteria of NB-5330 of Section III edition and addenda approved in 10 CFR 50.55a apply to all flaws identified within the repaired volume...."

In response to this condition, the licensee clarified that weld overlays for repair of cracks in piping are not addressed by the ASME Code, Section III. Section III of the ASME Code utilizes NDE procedures and techniques with flaw detection capabilities most applicable to volumetric examinations conducted by radiographic investigation. The licensee stated that radiography of the weld overlays is not appropriate because of the potential for reduced inspection sensitivity due to radioactive material in the reactor coolant system and water in piping and components.

As an alternative, the licensee proposed basing their weld acceptance criteria on ultrasonic investigation methods in accordance with Article IWA-4530 of the AMSE Code, Section XI, in addition to the preservice examination standards of Table IWB-3514. The staff finds that the acceptance criteria for ultrasonic examination proposed in HNP ISI RR No. 1 are acceptable because (a) the acceptance criteria for the overlay welds using ultrasonic examination are superior to the acceptance criteria using radiography contained in NB-5330 of the ASME Code, Section III, (b) the ultrasonic examination will provide reasonable assurance of the integrity of the weld overlays, and (c) the proposed alternative provides an acceptable level of quality and safety in accordance with 10 CFR 50.55a(a)(3)(i).

4.7 Commitments

In Enclosure 2 of the May 14, 2007, letter, the licensee committed to submit the following information to the NRC within fourteen days after completing the final ultrasonic examinations of the completed weld overlays during RFO-14:

1. Weld overlay examination results including a listing of any indications detected.

2. Disposition of all indications using the standards of the ASME Code, Section XI, IWB-3514-2 and/or IWB-3514-3 criteria and, if possible, the type and nature of the indications.

3. A discussion of any repairs to the weld overlay material and/or base metal and the reason for the repairs.

In addition, prior to entry into Mode 4 start-up from HNP's RFO-14, the licensee will submit to the NRC a stress analysis summary demonstrating that the pressurizer nozzles will perform their intended design functions after the weld overlay installation. The stress analysis report will include results showing that the requirements of NB-3200 and NB-3600 of the ASME Code, Section III, are satisfied. The stress analysis will also include results showing that the requirements of IWB-3000 of the ASME Code, Section XI, are satisfied. These results will demonstrate that the postulated crack, including its growth in the nozzles, will not adversely affect the integrity of the overlaid welds.

The NRC staff finds that the licensee's commitments to submit weld overlay examination results and a stress analysis summary are acceptable because they will provide reasonable assurance that the installation of the proposed weld overlay is successful and that the weld overlay will fulfill its intended function of mitigating potential PWSCC in the dissimilar metal welds of the pressurizer nozzles at HNP.

5.0 CONCLUSION

The NRC staff has reviewed the licensee's submittal and determined that HNP ISI RR No. 1, dated May 14, 2007, as supplemented by letter dated July 19, 2007, will provide an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the staff authorizes the use of HNP ISI RR No. 1 for the installation of full structural weld overlays on the dissimilar metal welds of the pressurizer nozzles at HNP. The effective period of HNP ISI RR No. 1 is the third inservice inspection interval, which ends on May 1, 2017.

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

6.0 REFERENCES

1. Letter from Progress Energy Carolinas, Inc. to the NRC, dated May 14, 2007, "Inservice Inspection Relief Request 1 – Proposed Alternative to AMSE Code Requirements for Weld Overlay Repairs." Agencywide Documents Access and Management System (ADAMS) Accession No. ML071420065.

2. Letter from Progress Energy Carolinas, Inc. to the NRC, dated July 19, 2007, "Response to the Request for Additional Information on the Inservice Inspection Relief Request 1 – Proposed Alternative to AMSE Code Requirements for Weld Overlay Repairs." ADAMS Accession No. ML072060530.

3. Letter from NRC to interested stakeholders, dated July 3, 1984, "Forwards Coordination Plan for NRC/EPRI/BWR Owners Group Training and Qualification Activities for NDE Personnel." ADAMS (Legacy Library) Accession No. 8407090122.

4. Letter from NRC to Michael Bratton, PDI Chairman, dated January 15, 2002, "Weld Overlay Performance Demonstration Administered by PDI as an Alternative for Generic Letter 88-01 Recommendations." ADAMS Accession No. ML020160532.

5. Memorandum from Donald G. Naujock to Terence Chan, dated November 29, 2001, "Summary of Public Meeting Held June 12 through June 14, 2001, with PDI Representatives." ADAMS Accession No. ML013330156.

6. Memorandum from Donald G. Naujock to Terence Chan, dated March 22, 2002, "Summary of Public Meeting Held January 31 - February 2, 2002, with PDI Representatives." ADAMS Accession No. ML010940402.

7. Electric Power Research Institute (EPRI) Report 1013558, dated December 2006, “Temper Bead Welding Applications – 48 Hour Hold Requirements for Ambient Temperature Temper Bead Welding.” ADAMS Accession No. ML070670060.

8. ASME Code, Section XI Committee White Paper, RRA 05-08 Technical Basis Paper, dated June 18, 2006, “N-638-x, Ambient Temperature Temperbead Welding: Begin 48 Hour Hold After 3rd Layer Completion.” ADAMS Accession No. ML070790679.

9. Electric Power Research Institute (EPRI) Report 1011898, “Justification for the Removal of the 100 Square Inch Temper Bead Weld Repair Limitation.”

Principal Contributor: Timothy Lupold

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