April 17, 2008

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

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

Dear Mr. Levis:

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

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

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

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

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

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

Sincerely,

/RA/

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

Docket No. 50-354

Enclosure: As stated

cc w/encl: See next page

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

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO RELIEF REQUEST HC-RR-I2-W02

PSEG NUCLEAR LLC

HOPE CREEK GENERATING STATION

DOCKET NO. 50-354

1.0 INTRODUCTION

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

2.0 REGULATORY EVALUATION

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

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

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

3.0 TECHNICAL EVALUATION

3.1 Code Requirements for which Relief is Requested

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

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

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

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

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

- Code Case N-504-3 was prepared specifically for overlaying austenitic stainless steel piping material with an austenitic stainless steel weld filler metal. An alternate application for nickel-based austenitic materials is needed due to the specific materials and configuration of the existing nickel-based alloy weld and buttering.

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

- Code Case N-504-3, Requirement (e) requires the first two layers of the weld overlay to have a ferrite content of at least 7.5 Ferrite Number (FN). These measurements were not

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

nuclear industry, and weld overlay repairs having 300 square inches surface area were recently approved for Susquehanna Steam Electric Station Unit 1 and D.C. Cook Unit 1.

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

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

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

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

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

would have been detected by the NDE of the weld overlay and adjacent ferritic steel surfaces as required by Code Case N-504-3 and Non-mandatory Appendix Q.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Code Case N-638-1 Limitation

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

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

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

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

provisions is acceptable to the NRC staff, provided that all conditions and provisions specified in RG 1.147, Revision 15 are complied with, or modifications to those conditions and provisions are otherwise found to be acceptable by the staff.

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

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

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

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

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

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

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

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

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

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

4.0 CONCLUSION

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

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

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