September 17, 2007

Mr. Christopher M. Crane
President and Chief Nuclear Officer
Exelon Generation Company, LLC
4300 Winfield Road
Warrenville, IL 60555

SUBJECT: BRAIDWOOD STATION, UNITS 1 AND 2 EVALUATION OF INSERVICE INSPECTION PROGRAM RELIEF REQUEST I2R-48 PERTAINING TO STRUCTURAL WELD OVERLAYS ON PRESSURIZER SPRAY, RELIEF, SAFETY, AND SURGE NOZZLE SAFE ENDS (TAC NOS. MD4590, AND MD4591)

Dear Mr. Crane:

By letter dated February 23, 2007, Exelon Generation Company, LLC (the licensee) submitted Relief Request (RR) I2R-48 for relief from the American Society of Mechanical Boiler and Pressure Vessel Code (ASME Code) Section XI, to the 1989 Edition for Braidwood Station, Units 1 and 2 (Braidwood) for the second 10-year interval. Relief was requested from the installation, and inspection requirements of the ASME Code pertaining to the installation of structural weld overlays on the pressurizer spray, relief, safety, and surge nozzle safe ends.

The Nuclear Regulatory Commission (NRC) staff concludes, based on the enclosed safety evaluation, that pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, Section 50.55a(a)(3)(i), RR I2R-48 for Braidwood is authorized for the installation of full structural weld overlays on the dissimilar and similar metal welds of the pressurizer nozzles at Braidwood for the remaining service life of the components, on the basis that compliance with the ASME Code of record would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety. Relief from the inspection requirements of Appendix VIII to the ASME Code Section XI, is authorized through the end of the second inservice inspection interval which ends July 28, 2008 for Braidwood, Unit 1, and October 16, 2008 for Braidwood, Unit 2.

Sincerely,

/RA/

Russell Gibbs, Chief
Plant Licensing Branch III-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. STN 50-456 and STN 50-457

Enclosure:
Safety Evaluation

cc w/encl: See next page

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Warrenville, IL 60555

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The Nuclear Regulatory Commission (NRC) staff concludes, based on the enclosed safety evaluation, that pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, Section 50.55a(a)(3)(i), RR I2R-48 for Braidwood is authorized for the installation of full structural weld overlays on the dissimilar and similar metal welds of the pressurizer nozzles at Braidwood for the remaining service life of the components, on the basis that compliance with the ASME Code of record would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety. Relief from the inspection requirements of Appendix VIII to the ASME Code Section XI, is authorized through the end of the second inservice inspection interval which ends July 28, 2008 for Braidwood, Unit 1, and October 16, 2008 for Braidwood, Unit 2.

Sincerely,
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Russell Gibbs, Chief
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Division of Operating Reactor Licensing
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Docket Nos. STN 50-456 and STN 50-457
Enclosure:
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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED RELIEF TO REQUEST I2R-48

PERTAINING TO STRUCTURAL WELD OVERLAYS

ON PRESSURIZER SPRAY, RELIEF, SAFETY, AND SURGE NOZZLE SAFE ENDS

EXELON GENERATION COMPANY, LLC

BRAIDWOOD STATION, UNITS 1 AND 2

DOCKET NOS. STN 50-456, AND STN 50-457

1.0 INTRODUCTION

By letter dated February 23, 2007, Exelon Generation Company LLC, (the licensee) submitted a request relief request (RR) I2R-48 from the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, 1989 Edition with no addenda at Braidwood Station, Units 1 and 2 (Braidwood). RR I2R-48 pertains to the structural weld overlays of dissimilar metal welds (DMW) and similar metal welds of pressurizer spray, relief, safety, and surge nozzles.

RR I2R-48 is based on ASME Code Case N-504-2, “Alternative Rules for Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping, Section XI, Division 1,” with modifications; ASME Code Case N-638-1, “Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW [Gas Tungsten-Arc Welding] Temper Bead Technique,” with modifications; and alternatives to Appendix VIII, Supplement 11, “Qualification Requirements for Full Structural Overlaid Wrought Austenitic Piping Welds,” to the 1995 Edition with the 1996 Addenda of ASME Code, Section XI.

2.0 REGULATORY EVALUATION

Pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, 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 pre service examination requirements, set forth in the ASME Code, Section XI, “Rules for Inservice Inspection (ISI) of Nuclear Power Plant Components,” to the extent practical within the limitations of design, geometry, and materials of construction of the components. The regulations require that inservice examination of components and system pressure tests conducted during the first 10-year interval and subsequent intervals comply with the requirements in the latest edition and addenda of Section XI of the ASME Code incorporated by reference in 10 CFR 50.55a(b) 12 months prior to the start of the 120-month interval, subject to the limitations and modifications listed therein. The ISI code of record for the second 10-year ISI interval at Braidwood is the 1989 Edition of the ASME Code, Section XI, with no addenda.

In accordance with 10 CFR 50.55a(g)(6)(ii)(C)(1), the implementation of Supplements 1 through 8, 10, and 11 of Appendix VIII to Section XI, of the 1995 Edition with the 1996 Addenda of the ASME Code, was required on a phased schedule ending on November 22, 2002. Supplement 11 was required to be implemented by November 22, 2001. Additionally, 10 CFR 50.55a(g)(6)(ii)(C)(2) requires licensees implementing the 1989 Edition and earlier editions of paragraph IWA-2232 of Section XI of the ASME Code to implement the 1995 Edition with the 1996 Addenda of Appendix VIII and supplements to Appendix VIII of Section XI, Division 1, of the ASME Code.

Pursuant to 10 CFR 50.55a(g)(4)(iv), ISI items may meet the requirements set forth in subsequent editions and addenda of the ASME Code that are incorporated by reference in 10 CFR 50.55a(b), subject to the limitations and modifications listed therein, and subject to Nuclear Regulatory Commission (NRC) approval. Portions of editions and addenda may be used provided that related requirements of the respective editions and addenda are met.

Pursuant to 10 CFR 50.55a(a)(3), alternatives to ASME 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.

3.0 RELIEF REQUEST I2R-48

3.1 ASME Code Components Affected

Code Class: 1

Reference: IWA-4000, “Repair Procedures”

Examination Category: R-A

Item Number: See Table 1 for listing (at the end of this safety evaluation)

Description: Structural weld overlays (SWOL) of the pressurizer surge, spray, safety and relief nozzles, dissimilar welds, including the SWOL of the adjacent safe-end to pipe, reducer and elbow welds on pressurizer surge, spray, safety and relief nozzles.

Component Numbers: See Table 1 for listing (at the end of this safety evaluation)

3.2 Applicable Code Edition and Addenda

ASME Code, Section XI, 1989 Edition with No Addenda.

ASME Section XI, 1995 Edition, including Addenda through 1996, Appendix VIII, “Performance Demonstration for Ultrasonic Examination Systems.”

Pressurizer Code of Construction, ASME Section III, 1971 Edition, through Summer 1973 Addenda, with Code Case 1528-3.

3.3 Applicable Code Requirement

ASME Section XI, 1989 Edition with No Addenda, IWA-4000.

ASME Code, Section XI, 1995 Edition including Addenda through 1996, Appendix VIII, Supplement 11, "Qualification Requirements for Full Structural Overlaid Wrought Austenitic Piping Welds."

The licensee included ASME Code Cases N-504-2 and N-638-1 as applicable code requirements in relief request I2R-48. The NRC staff notes that code cases are not ASME Code requirements but rather alternative to the ASME Code requirements. However, licensees may use NRC approved code cases as alternatives to perform repair or replacement of piping components to satisfy the ASME Code requirements.

3.4 Proposed Alternative and Basis for Use

Pursuant to 10 CFR 50.55a(a)(3)(i), the licensee proposes applying SWOLs designed in accordance with ASME Code Case N-504-2 and Section XI Nonmandatory Appendix Q with modifications, and ASME Code Case N-638-1 for temper bead welding with modifications. Final ultrasonic testing (UT) of the finished SWOL will be performed using UT of the Performance Demonstration Initiative (PDI) program which was developed by Electric Power Research Institute (EPRI) in lieu of ASME Code, Section XI, Appendix VIII, Supplement 11.

ASME Code Case N-504-2, currently approved for use in Regulatory Guide (RG) 1.147 with additional requirements of Appendix Q to the 2005 Addenda of ASME Section XI, allows a flaw to be reduced to an acceptable size by deposition of weld reinforcement on the outside surface of the pipe without flaw removal. The SWOL will extend around the full circumference of the applicable DMW as required by ASME Code Case N-504-2. The specific thickness and length will be determined according to the guidance provided in ASME Code Case N-504-2. The SWOL will completely cover the DMW and the adjacent stainless steel safe-end to pipe/fitting welds (similar metal welds) with Alloy 52M material that is resistant to primary water stress corrosion cracking (PWSCC). The SWOL also would cover the similar metal welds which are located adjacent to the dissimilar metal welds to provide the weld geometry required to perform the final volumetric examinations and obtain the required examination coverage volume.

Prior to installation of the SWOL, Braidwood will complete a bare metal visual examination of all the pressurizer surge, safety, relief, and spray nozzles immediately after the insulation is removed in the area around the nozzle and DMW area to ensure that no through wall cracks exist prior to applying the overlay. Prior to applying the overlay, the entire overlay base metal area will be cleaned, including a distance at least 1.5 times the nozzle end thickness beyond the overlay on the nozzle end and 1.5 inch beyond the overlay area on the pipe/fitting end.

At the completion of the cleaning, a liquid penetrant test (PT) will be performed of the overlay area with acceptance criteria that no indication greater than 1/16 inch is permitted. If any indication is found to be greater than 1/16 inch, the indication will be removed or reduced below the acceptance criteria, and the PT performed again. If any indication(s) does require repair, the repair will be completed and the welded area will again be inspected with a PT for final acceptance.

All scheduled second interval examinations of selected adjacent similar metal welds have been completed. There were no recordable indications noted during any of these weld examinations. Any sample expansion of the examination scope due to unacceptable flaws in the adjacent welds recorded during the associated SWOL examination will be based on an evaluation of the unacceptable flaw characteristics. This evaluation will include whether other elements in the segment or segments are subject to the same root cause conditions. No additional examinations will be performed if there are no additional elements identified as being susceptible to the same root cause conditions. If the evaluation does identify a common degradation mechanism, then further examinations would be performed on those elements. EGC performed a review of past SWOL industry submittals and found that recordable flaws associated with the adjacent similar metal weld were attributed to initial construction and were not service induced.

The licensee will address flaw evaluations in accordance with ASME Code Case N-504-2(g) Item 2 and shrinkage stress effects analyses in accordance with ASME Code Case N-504-2(g) Item 3 through the approved overlay designs. The licensee will complete these documents and approve for use prior to the Braidwood, Unit 1 fall 2007 refueling outage (A1R13) and the Braidwood, Unit 2 spring 2008 refueling outage (A2R13).

3.5 Commitments

Within 14 days after the completion of the last ultrasonic examination of the weld overlays during the fall 2007 Braidwood, Unit 1 refueling outage (A1R13) and the spring 2008 Braidwood, Unit 2 refueling outage (A2R13), the licensee commits to providing the results of the ultrasonic testing of the structural weld overlays on the Braidwood pressurizer spray, relief, safety and surge nozzle safe-ends to the NRC (6 locations total). The results will include:

- A listing of indications detected (The licensee notes that the recording criteria of the ultrasonic testing procedure to be used for the testing of the Braidwood pressurizer overlays (PDI-UT-8) requires that all indications, regardless of amplitude, be investigated to the extent necessary to provide accurate characterization, identity and location. Additionally, the procedure requires that all indications, regardless of amplitude, that cannot be clearly attributed to the geometry of the overlay configuration, be considered flaw indications).

- The disposition of all indications using the standards of ASME Section XI, IWB-3514-2 and/or IWB-3514-3 criteria and, if possible,

- The type and nature of the indications (the licensee notes that ultrasonic testing procedure PDI-UT-8 requires that all suspected flaw indications are to be plotted on a cross sectional drawing of the weld and that the plots should accurately identify the specific origin of the reflector.)

Also, included in the results will be a discussion of any repairs to the overlay material and/or base metal and the reason for the repair. Subsequent inservice examination of the structural weld overlays on pressurizer will be performed in accordance with ASME Section XI, Appendix Q, Q-4300 or alternate schedules as/if mandated in future NRC regulations.

3.6 Duration of the Proposed Alternative

The licensee proposed that the duration of the proposed alternatives associated with the SWOL is the remaining service life of the components including future plant life extension. Relief from the Appendix VIII inspection requirements is requested through the end of the current [second] ISI interval. The current ISI inspection interval for Braidwood, Unit 1 ends on July 28, 2008. The current ISI inspection interval for Braidwood, Unit 2 ends on October 16, 2008.

Subsequent inservice examinations (which would be performed starting in the third ISI inspection interval) will be scheduled and performed in accordance with the requirements of Nonmandatory Appendix Q or alternate schedules as/if mandated in future NRC regulations.

4.0 STAFF EVALUATION

The staff focused its evaluation on the proposed modification to ASME Code Cases N-504-2 and N-638-1 and the differences between the PDI program and Supplement 11 of Appendix VIII to the ASME Code, Section XI.

4.1 NRC Staff Evaluation of Modifications to Code Case N-504-2

The purpose of ASME Code Case N-504-2 is to repair degraded austenitic stainless steel piping by deposition of weld reinforcement (weld overlay) on the outside surface of the pipe. However, the licensee will be applying ASME Code Case N-504-2 for the weld overlay of the ferritic (P3) nozzle material, nickel alloy (F43/P43) weld material, and austenitic stainless steel base (P8, safe end and pipe/fitting) and weld materials.

ASME Code Case N-504-2 is accepted for use in the current NRC RG 1.147, Rev. 14 with conditions, and has been used extensively in primary system piping of boiling water reactor plants. More recently, ASME N-504-2 has been applied to pressurized water reactor applications for the weld overlay repair of dissimilar metal welds with known flaws or to apply SWOL as a PWSCC mitigation technique. Industry operating experience in the area has shown that PWSCC in Alloy 82/182 will blunt at the interface with stainless steel base metal, ferritic base metal, or Alloy 52M weld metal. The 360 degree full structural weld overlay will control growth in any PWSCC crack and maintain weld integrity. The applied SWOL will also induce compressive stress in the existing DMW or similar metal weld, thus potentially impeding growth of any reasonably shallow cracks. Furthermore, the SWOL will be sized to meet all structural requirements without considering the presence of the existing welds.

Paragraph (b) of ASME Case N-504-2 requires that reinforcement weld metal be low carbon (0.035 percent maximum) austenitic stainless applied 360 degrees around the circumference of the pipe, and be deposited in accordance with a qualified welding procedure specification identified in the plant's Repair Program. In lieu of Paragraph (b) requirement, the licensee proposed to use an austenitic nickel alloy (28 percent minimum) weld metal using a welding procedure specification for groove welding which has been qualified in accordance with the Repair/Replacement Code and Owner's requirements and identified in the Repair/Replacement Plan.

The NRC staff notes that the use of Alloy 52/52M/152 material is consistent with weld filler material used to perform similar weld overlays at operating boiling water reactor (BWR)

facilities. The NRC staff finds that the proposed use of weld material Alloy 52/52M/152 for the full structural overlays provides an acceptable level of quality and safety and is, therefore, acceptable.

Paragraph (e) of ASME Code Case N-504-2 requires that the weld reinforcement consists of a minimum of two weld layers having as-deposited delta ferrite content of at least 7.5 ferrite number (FN). The first layer of weld metal with delta ferrite content of at least 7.5 FN shall constitute the first layer of the weld reinforcement design thickness.

In lieu of the Paragraph (e) requirement, the licensee will not measure delta ferrite for weld overlay repairs because the deposited Alloy 52M is 100 percent austenitic and contains no delta ferrite due to the high nickel composition (approximately 60 percent nickel). The austenitic nickel alloy weld overlay shall consist of at least two weld layers deposited from a filler material with a chromium (Cr) content of at least 28 percent. When welding over an austenitic base material or austenitic filler metal material weld and the associated dilution zone from an adjacent ferritic base material, a diluted first layer of at least 24 percent Cr is acceptable, provided the Cr content of the deposited weld metal is determined by chemical analysis of a representative coupon. Alternatively, the first weld layer may be considered “sacrificial,” and will not be credited for the reinforcement design thickness.

The NRC staff finds that paragraph (e) of Code Case N-504-2 is not applicable to RR I2R-48 because the delta ferrite requirement does not apply to the Alloy 52M weld metal that will be used for the weld overlay.

Paragraph (h) of ASME Code Case N-504-2 requires that the completed repair be pressure tested in accordance with IWA-5000. If the flaw penetrated the original pressure boundary prior to welding, or if any evidence of the flaw penetrating the pressure boundary is observed during the welding operation, a system hydrostatic test shall be performed in accordance with IWA-5000. If the system pressure boundary has not been penetrated, a system leakage, inservice, or functional test shall be performed in accordance with IWA-5000.” Nonmandatory Appendix Q (mandated through RG 1.147, Rev. 14, as a condition of using ASME Code Case N-504-2) states, “Ultrasonic examination personnel shall be certified in accordance with the Owner’s written practice. Procedures and personnel shall be qualified in accordance with Appendix VIII.”

In lieu of performing a hydrostatic test, the licensee proposed to perform a system leakage test at system nominal operating pressure in accordance with IWA-5000 as modified by ASME Code Case N-416-3 in accordance with the Braidwood ISI Program. Prior to the system leakage test, UT of the finished SWOL using EPRI PDI demonstrated weld overlay examination procedures and qualified examiners shall be performed.

The licensee states that the Braidwood second interval ISI program uses the 1989 Edition of Section XI along with ASME Code Case N-416-3 (approved for use through RG 1.147, Rev. 14) for nondestructive examination (NDE) and pressure testing of welded repairs/replacements. ASME Code Case N-416-3 permits a system leakage test in lieu of a hydrostatic test, provided that NDE is performed in accordance with the methods and acceptance criteria of the applicable Subsection of the 1992 Edition of ASME Code, Section III. The 1992 Edition of ASME Code, Section III, Subsection NB, does not address the structural weld overlay configuration, so the NDE requirements of Nonmandatory Appendix Q performed using EPRI

PDI demonstrated procedures with qualified examiners shall be used. The licensee stated that at the time of relief request preparation there were no known flaws penetrating the pressure boundary that would require hydrostatic testing, and through-wall flaws are not expected. The bare metal visual and liquid penetrant testing of the existing DMW and adjacent base metal prior to applying the SWOL will be used to confirm this assumption.

The NRC staff finds that the use of ASME Code Case N-416-3 as a modification to paragraph (h) of ASME Code Case N-504-2 is acceptable because ASME Code Case N-416-3 requires a combination of a volumetric examination and system pressure test to verify the integrity of the weld overlay, and the performance of an ultrasonic examination in accordance with Appendix Q satisfies the intent of the NDE requirement in ASME Code Case N-416-3.

4.2 NRC Staff Evaluation of Modifications to Code Case N-638-1

Paragraph (a) of Code Case N-638-1 requires that the maximum area of an individual weld on the ferritic material based on the finished surface be 100 square inches, and the depth of the weld shall not be greater than one-half of the ferritic base metal thickness. The licensee proposed that the maximum area of an individual weld based on the finished surface over the ferritic material shall not exceed 300 square inches. If any of the Braidwood SWOL repairs exceed 300 square inches over the ferritic material, additional relief will be requested. In addition, the licensee stated that the one half base metal thickness limitation applies only to excavation repair and is not applicable to this application.

The licensee stated that although the final design for the SWOL has not been complete at the time of development of this relief request, it is anticipated that the SWOL will require welding on more than 100 square inches of surface on the low alloy steel base material. The SWOL will extend to the transition taper of the low alloy steel nozzle to provide an adequate weld geometry so that qualified UT of the required volume can be performed. There have been a number of temper bead SWOL repairs successfully applied to safe-end to nozzle welds in the nuclear industry, and an SWOL repair having a 300-square-inch surface area was approved for the Susquehanna Steam Electric Station (Letter from Richard J. Laufer, NRC, to Bryce L. Shriver, PPL Susquehanna, “Susquehanna Steam Electric Station, Unit 1: Relief from ASME Code, Section XI Appendix VIII, Supplement 11, Requirements and ASME Code Cases N-504-2 and N-638 Requirements, dated January 20, 2006, ADAMS Accession Number ML051220568.)

The licensee stated that ASME Code Case N-432-1, which is approved for use in RG 1.147, allows temper bead welding on low alloy steel nozzles without limiting the temper bead weld surface area. The two additional conditions required by ASME Code Case N-432-1 that are not required by Code Case N-638-1 are that temper bead welds have preheat applied and that the procedure qualification be performed on the same specification, type, grade and class of material. The elevated preheat would present a radiation exposure burden when performing the repair.

The NRC staff notes 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 in ASME Code Case N-638-3 and EPRI Report 1011898, *Justification for the Removal of the 100 Square Inch Temper bead Weld Repair Limitation*. The EPRI report cites evaluations of a 12-inch diameter nozzle weld overlay to demonstrate adequate tempering of the weld heat affected zone, 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 NRC staff finds that the proposed 300-square inch weld area on the ferritic material is acceptable because the stress analysis presented in EPRI report 1012898 shows that the structural integrity of ferritic material is not adversely affected by a 300-square inch weld overlay area. In addition, the NRC staff finds that the one half base metal thickness limitation of paragraph (a) of Code Case N-638-1 applies only to excavation repair and is not applicable to RR I2R-48 which is related to deposit welds on the outside surface of piping components.

Paragraph 4.0(b) of ASME Code Case N-638-1 requires that the final weld surface and the band around the area defined in paragraph 1.0(d) 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 Appendix I to Section XI of the ASME Code.

In lieu of the paragraph 4.0(b) requirements, the licensee proposed the two following modifications: (a) for the SWOLs, full UT of the 1.5T band will not be performed. Instead, UT will be performed on the actual weld overlay, meeting the requirements of ASME Code Section XI, Nonmandatory Appendix Q-4100, and (b) when austenitic filler materials are used, the SWOL will be examined using the surface and ultrasonic methods after three tempering weld layers (i.e., layers 1, 2, and 3) are completed and have been in place for at least 48 hours.

The licensee stated that later editions of the ASME Code as well as later revisions to ASME Code Case N-638 (Rev. 2 and later) removed the requirement for the 1.5T examination band. This is in line with the less restrictive requirements for UT of the ferritic nozzle because hydrogen cracking away from the temper bead weld is not considered a concern in later editions of the ASME Code and ASME Code Case N-638. ASME Code Case N-638 applies 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 an SWOL repair. However, it is believed that for this type of repair, any major base material cracking would take place in the heat-affected zone directly below the weld overlay or in the underlying Alloy 82/182 weld deposit and not in the required 1.5T examination band of material out beyond the overlay. If this type of cracking were to occur, it would be detected by the UT of the SWOL using PDI demonstrated procedures with PDI qualified inspectors.

The NRC staff notes that the post weld overlay area, as defined under ASME Code, Section XI, Nonmandatory Appendix Q is one-half inch on either side of the overlay for surface examination and the completed overlay for UT examination. In RG 1.147, Rev. 14, the NRC staff imposes a condition on ASME Code Case N-504-2 which requires that when ASME Code Case N-504-2 is used, the requirements of Appendix Q to the ASME Code, Section XI must be followed. The issues of cracking and/or distortion of the weld and base metal were not specifically addressed in the ASME Code case development. Since the weld overlays are fabricated from austenitic materials with inherent toughness, no cracking in the overlays is expected to occur due to the

shrinkage associated with the weld overlay. With respect to the ferritic portion of the overlays, many temper bead weld overlays have been applied in the nuclear industry at these nozzles to safe-end locations. The stiffness and high toughness inherent in the low-alloy steel material is expected to protect against any cracking and limit any distortion that might occur in the low-alloy steel material. ASME Code Case N-504-2 requires that impact of axial shrinkage on the weld and piping system shall be measured and evaluated after the weld overlay is deposited. In addition, any cracking that might occur would be detected by the final NDE of the weld overlay required under Appendix Q, which provides additional assurance of the deposition of a defect free, structurally sound overlay. The assessment of the shrinkage stresses on the piping, and post-weld NDE volumes under Appendix Q, provides reasonable assurance that defect free welds will result in continued structural integrity of the piping. The NRC staff finds that the alternative testing under Appendix Q will provide an acceptable level of quality and safety. Therefore, the NRC staff authorizes the licensee's proposed alternative to the 1.5T band UT examination requirement under ASME Code Case N-638-1.

With regard to the 48-hour hold time requirement in ASME Code Case N-638-1, the licensee provided a modification based on EPRI's white paper, "Repair and Replacement Applications Center: Temperbead Welding Applications 48-Hour Hold Requirements for Ambient Temperature Temperbead Welding." The modification specifies that final NDE of the SWOLs will start after 48 hours from the completion of the third temper bead weld overlay layer.

The licensee stated that Braidwood will be applying the alternate hold time to weld overlays only; this alternative will not be applied to excavations requiring repair by temper bead welding. The referenced EPRI white paper addresses previous concerns regarding the 48-hour hold time prior to final NDE. Areas of concern addressed through this report include material microstructure, sources for hydrogen introduction, tensile stress and temperature, and diffusivity and solubility of hydrogen in steels. The report concludes that there is no technical basis for waiting 48 hours after the weld overlay cools to ambient temperature before beginning to perform final NDE of the completed weld overlay. The licensee indicated that past and recent experience performing NDE on temper bead weld overlays has not found any indication of hydrogen cracking of these welds either during initial NDE after the 48-hour hold time or subsequent inservice inspection examinations. The licensee stated further that ultrasonic examinations will be performed using EPRI PDI weld overlay demonstrated examination procedures with PDI qualified inspectors.

The NRC staff finds that the licensee has provided sufficient technical basis to support performing nondestructive examinations after the 48-hour hold time starting from the third temperbead overlay layer. Therefore it is acceptable that the proposed 48-hour hold time will begin after completion of the third weld layer.

Based on the above evaluation, the NRC staff finds that the proposed modifications to the requirements of ASME Code Cases N-504-2 and N-638-1 for preemptive weld full structural overlay of the subject welds are acceptable, because they will provide an acceptable level of quality and safety.

4.3 NRC Staff Evaluation of Alternatives to Appendix VIII to Section XI of the ASME Code

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

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

Evaluations of the differences identified in the PDI program with ASME Code, Supplement 11, Paragraphs 1.1(b), 1.1(d)(1), 1.1(e)(1), 1.1(e)(2), 1.1(e)(2)(a)(1), 1.1(e)(2)(a)(2), 1.1(e)(2)(a)(3), 1.1(e)(2)(b)(1), 1.1(e)(2)(b)(2), 1.1(e)(2)(b)(3), 1.1(f)(1), 1.1(f)(3), 1.1(f)(4), 2.0, 2,1, 2.2(d), 2.3, 3.1, 3.2(a), and 3.2(b) are as follows:

Paragraph 1.1(b) of Supplement 11 states limitations to the maximum thickness for which a procedure may be qualified. The ASME Code states that "[t]he specimen set must include at least one specimen with overlay thickness within minus 0.10-inch to plus 0.25-inch of the maximum nominal overlay thickness for which the procedure is applicable." The ASME Code requirement addresses the specimen thickness tolerance for a single specimen set, but is confusing when multiple specimen sets are used. The PDI proposed alternative states that "the specimen set shall include specimens with overlay not thicker than 0.10-inch more than the minimum thickness, nor thinner than 0.25-inch of the maximum nominal overlay thickness for which the examination procedure is applicable." The proposed alternative provides clarification on the application of the tolerance. The tolerance is unchanged for a single specimen set; however, the proposed alternative clarifies the tolerance for multiple specimen sets by providing tolerances for both the minimum and maximum thicknesses. The proposed wording eliminates confusion while maintaining the intent of the overlay thickness tolerance. Therefore, the NRC staff finds this PDI program alternative maintains the intent of the Supplement 11 requirements and is acceptable.

Paragraph 1.1(d)(1) requires that all base metal flaws be cracks. PDI determined that certain Supplement 11 requirements pertaining to location and size of cracks would be extremely difficult to achieve. For example, flaw implantation requires excavating a volume of base material to allow a pre-cracked coupon to be welded into this area. This process would add

weld material to an area of the specimens that typically consists of only base material, and could potentially make ultrasonic examination more difficult and not representative of actual field conditions. In an effort to satisfy the requirements, PDI developed a process for fabricating flaws that exhibit crack-like reflective characteristics. Instead of all flaws being cracks, as required by Paragraph 1.1(d)(1), the PDI weld overlay performance demonstrations contain at least 70 percent cracks with the remainder being fabricated flaws exhibiting crack-like reflective characteristics. The fabricated flaws are semi-elliptical with tip widths of less than 0.002 inch. The licensee provided further information describing a revision to the PDI program alternative to clarify when real cracks, as opposed to fabricated flaws, will be used: "Flaws shall be limited to the cases where implantation of cracks produces spurious reflectors that are uncharacteristic of actual flaws." The NRC staff has reviewed the flaw fabrication process, compared the reflective characteristics between actual cracks and PDI-fabricated flaws, and found the fabricated flaws for this application provide assurance that the PDI program meets the intent of the Supplement 11 requirements. Therefore, the NRC staff finds the proposed alternative to the Supplement 11 requirements is acceptable.

Paragraph 1.1(e)(1) requires that at least 20 percent but less than 40 percent of the flaws shall be oriented within ±20 degrees of the axial direction (of the piping test specimen). Flaws contained in the original base metal heat affected zone satisfy this requirement; however, PDI excludes axial fabrication flaws in the weld overlay material. PDI has concluded that axial flaws in the overlay material are improbable because the overlay filler material is applied in the circumferential direction (parallel to the girth weld); therefore, fabrication anomalies would also be expected to have major dimensions in the circumferential direction. The NRC finds this approach to implantation of fabrication flaws is reasonable for meeting the intent of the Supplement 11 requirements. Therefore, the NRC staff concludes that the PDI's application of flaws oriented in the axial direction is acceptable.

Paragraph 1.1(e)(1) also requires that the rules of IWA-3300 shall be used to determine whether closely spaced flaws should be treated as single or multiple flaws. PDI treats each flaw as an individual flaw and not as part of a system of closely spaced flaws. PDI controls the flaws going into a test specimen set such that the flaws are free of interfering reflections from adjacent flaws. In some cases this permits flaws to be spaced closer than what is allowed for classification as a multiple set of flaws by IWA-3300, thus potentially making the performance demonstration more challenging than the existing requirements. Hence, the NRC staff concludes that PDI's application for closely spaced flaws is acceptable.

Paragraph 1.1(e)(2) requires that specimens be divided into base metal and overlay grading units. The PDI program adds clarification with the addition of the word "fabrication" and ensures flaw identification by ensuring all flaws will not be masked by other flaws with the addition of "Flaws shall not interfere with ultrasonic detection or characterization of other flaws." PDI's alternative provides clarification and assurance that the flaws are identified. Therefore, the NRC staff finds the PDI alternative to the Supplement 11 requirements is acceptable.

Paragraph 1.1(e)(2)(a)(1) requires that a base grading unit shall include at least 3 inches of the length of the overlaid weld, and the base grading unit includes the outer 25 percent of the overlaid weld and base metal on both sides. The PDI program reduced the criteria to 1 inch of the length of the overlaid weld and eliminated from the grading unit the need to include both sides of the weld. The proposed change permits the PDI program to continue using test specimens from the existing weld overlay program which have flaws on both sides of the welds.

These test specimens have been used successfully for testing the proficiency of personnel for over 16 years. The weld overlay qualification is designed to be a near-side (relative to the weld) examination, and it is improbable that a candidate would detect a flaw on the opposite side of the weld due to the sound attenuation and re-direction caused by the weld microstructure. However, the presence of flaws on both sides of the original weld (outside the PDI grading unit) may actually provide a more challenging examination, as candidates must determine the relevancy of these flaws, if detected. The NRC staff determined that PDI's use of the 1-inch length of the overlaid weld base grading unit and elimination from the grading unit the need to include both sides of the weld, as described in the PDI program alternative, is an acceptable alternative to the Supplement 11 requirements. Therefore, the NRC staff finds the proposed alternative acceptable.

Paragraph 1.1(e)(2)(a)(2) requires, when base metal cracking penetrates into the overlay material, that a portion of the base grading unit shall not be used as part of the overlay grading unit. The NRC staff finds that the PDI program adjusts for the changes in Paragraph 1.1(e)(2)(a)(2) and conservatively states that when base metal flaws penetrate into the overlay material, no portion of it shall be used as part of the overlay fabrication grading unit. The NRC staff finds that the PDI program also provided clarification by the addition of the term "flaws" for "cracks" and the addition of "fabrication" to "overlay grading unit." The NRC staff concludes that the PDI program alternative provides clarification and conservatism and, therefore, is acceptable.

Paragraph 1.1(e)(2)(a)(3) requires that for unflawed base grading units, at least 1 inch of unflawed overlaid weld and base metal shall exist on either side of the base grading unit. This is to minimize the number of false identifications of extraneous reflectors. The PDI program stipulates that unflawed overlaid weld and base metal exists on all sides of the grading unit and flawed grading units must be free of interfering reflections from adjacent flaws which addresses the same concerns as the ASME Code. Hence, the NRC staff concludes that the PDI's application of the variable flaw-free area adjacent to the grading unit meets the intent of the Supplement 11 requirements and is, therefore, acceptable.

Paragraph 1.1(e)(2)(b)(1) requires that an overlay grading unit shall include the overlay material and the base metal-to-overlay interface of at least 6 square inches. The overlay grading unit shall be rectangular, with minimum dimensions of 2 inches. The PDI program reduces the base metal-to-overlay interface to at least 1 inch (in lieu of a minimum of 2 inches) and eliminates the minimum rectangular dimension. This criterion is necessary to allow use of existing examination specimens that were fabricated in order to meet NRC Generic Letter 88-01 (Tri-party Agreement, July 1984). This criterion is at least as more challenging to meet as that of the ASME Code because of the variability associated with the shape of the grading unit. Based on the above, the NRC staff concludes that PDI's application of the grading unit is an acceptable alternative to the Supplement 11 requirements and is acceptable.

Paragraph 1.1(e)(2)(b)(2) requires that unflawed overlay grading units shall be surrounded by unflawed overlay material and unflawed base metal-to-overlay interface for at least 1 inch around its entire perimeter. The PDI program redefines the area by noting unflawed overlay fabrication grading units shall be separated by at least 1 inch of unflawed material at both ends and sufficient area on both sides to preclude interfering reflections from adjacent flaws. The NRC staff determined that the relaxation in the required area on the sides of the specimens, while still ensuring no interfering reflections, may provide a more challenging

demonstration than required by the ASME Code because of the possibility for having a parallel flaw on the opposite side of the weld. Therefore, the NRC staff concludes that the PDI's application is an acceptable alternative to the Supplement 11 requirements.

Paragraph 1.1(e)(2)(b)(3) requirements are retained in the PDI program. In addition, the PDI program requires that initial procedure qualification contain three times the number of flaws required for a personnel qualification. To qualify new values of essential variables, the equivalent of at least one personnel qualification set is required. The NRC staff concludes that PDI's additions enhance the ASME Code requirements and are, therefore, acceptable because it provides for a more stringent qualification criteria.

Paragraph 1.1(f)(1) requirements are retained in the PDI program, with the clarification change of the term "flaws" for "cracks." In addition, the PDI program includes the requirements that sizing sets shall contain a distribution of flaw dimensions to verify sizing capabilities. The PDI program also requires that initial procedure qualification contain three times the number of flaws required for a personnel qualification. To qualify new values of essential variables, the equivalent of at least one personnel qualification set is required. The NRC staff concludes that PDI's additions enhance the ASME Code requirements and are, therefore, acceptable because it provides a more stringent qualification criteria.

Paragraphs 1.1(f)(3) and 1.1(f)(4) requirements are clarified by the PDI program by replacing the term "cracking" with "flaws" because of the use of alternative flaw mechanisms. The NRC staff concludes that this clarification in the PDI program meets the intent of the ASME Code requirements and is acceptable.

Paragraph 2.0 is clarified in PDI by the addition of the sentence, "[T]he overlay fabrication flaw test and the base metal flaw test may be performed separately." The NRC staff concludes that the PDI program did not change the intent of the ASME Code but provided additional clarification. Therefore, the NRC staff finds this alternative in PDI acceptable.

Paragraph 2.1 states, in part, "... the candidate shall be made aware of the types of grading units (base or overlay) that are present for each specimen." In PDI, this is changed to "... the candidate shall be made aware of the types of grading units (base metal or overlay fabrication) that are present for each specimen." The NRC staff concludes that the PDI program did not change the intent of the ASME Code but provided additional clarification. Therefore, the NRC staff finds this alternative in PDI acceptable.

Paragraph 2.2(d) requirements are clarified by the PDI program by the addition of the terms "metal" and "fabrication". The staff determined that the clarifications provide acceptable classification of the terms they are enhancing. Therefore, the NRC staff concludes that the PDI program meets the intent of the ASME Code requirements and is acceptable.

Paragraph 2.3 requires that, for depth sizing tests, 80 percent of the flaws shall be sized at a specific location on the surface of the specimen identified to the candidate. This requires detection and sizing tests to be performed separately. The PDI revised the weld overlay program to allow sizing to be conducted either in conjunction with, or separately from, the flaw detection test. If performed in conjunction with detection and the detected flaws do not meet the Supplement 11 range criteria, additional specimens will be presented to the candidate with the regions containing flaws identified. Each candidate will be required to determine the

maximum depth of flaw in each region. For separate sizing tests, the regions of interest will also be identified and the maximum depth and length of each flaw in the region will similarly be determined. In addition, PDI stated that grading units are not applicable to sizing tests, and that each sizing region will be large enough to contain the target flaw, but small enough such that candidates will not attempt to size a different flaw. The NRC staff determined that the above clarification provides a basis for implementing sizing tests in a systematic, consistent manner that meets the intent of Supplement 11. Therefore, the NRC staff concludes that the PDI's method is acceptable.

Paragraph 3.1 requires that examination procedures, equipment and personnel (as a complete ultrasonic system) are qualified for detection or sizing of flaws, as applicable, when certain criteria are met. The PDI program allows procedure qualification to be performed separately from personnel and equipment qualification. Historical data indicate that, if ultrasonic detection or sizing procedures are thoroughly tested, personnel and equipment using those procedures have a higher probability of successfully passing a qualification test. In an effort to increase this passing rate, PDI has elected to perform procedure qualifications separately in order to assess and modify essential variables that may affect overall system capabilities. For a procedure to be qualified, the PDI program requires three times as many flaws to be detected (or sized) as shown in Supplement 11 for the entire ultrasonic system. The personnel and equipment are still required to meet the Supplement 11 requirement. Therefore, the PDI program criteria exceeds the ASME Code requirements for personnel, procedures, and equipment qualification. The NRC staff concludes that the PDI program criteria is acceptable.

Paragraph 3.2(a), in Supplement 11 states, "... [t]he length of base metal cracking is measured at the 75% through-base-metal position." In PDI, this is changed to "... The length of base metal flaws is measured at the 75% through-base-metal position." The NRC staff concludes that the PDI program did not change the intent of the ASME Code but provided additional clarification. Therefore, the NRC staff finds this alternative in PDI acceptable.

Paragraph 3.2(b) requires that all extensions of base metal cracking into the overlay material by at least 0.10 inch are reported as being intrusions into the overlay material. The PDI program omits this criterion because of the difficulty in actually fabricating a flaw with a 0.10-inch minimum extension into the overlay, while still knowing the true state of the flaw dimensions. However, the PDI program requires that cracks be depth-sized to the tolerance specified in the ASME Code which is 0.125 inch. Since the ASME Code tolerance is close to the 0.10-inch value of Paragraph 3.2(b), any crack extending beyond 0.10 inch into the overlay material would be identified as such from the characterized dimensions. The NRC staff determined that reporting of an extension in the overlay material is redundant for performance demonstration testing because of the flaw sizing tolerance. Therefore, the NRC staff concludes that PDI's omission of highlighting a crack extending beyond 0.10 inch into the overlay material is acceptable.

The NRC staff evaluated the differences between the PDI program and Supplement 11 that the licensee identified in its May 31, 2007 submittal. The NRC staff concludes that the PDI program provides an acceptable level of quality and safety and, therefore, the proposed alternative to use the PDI program is acceptable.

6.0 CONCLUSION

The NRC staff has reviewed the licensee's submittal and determined that the proposed alternatives to the requirements of the ASME Code, Section XI, will provide an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the NRC staff authorizes the use of RR I2R-48 for the installation of full structural weld overlays on the subject dissimilar and similar metal welds of the pressurizer nozzles at Braidwood Station Units 1 and 2. As requested, the effective period of RR I2R-48 is authorized for the remaining service life of the components. Relief from the inspection requirements of Appendix VIII to the ASME Code, Section XI, is authorized through the end of the second inservice inspection interval which ends on July 28, 2008 for Unit 1 and October 16, 2008 for Unit 2.

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.

Principal Contributor: J. Tsao, NRR

Date: September 17, 2007

Table 1: COMPONENT IDENTIFICATION						
For Unit 1 Pressurizer 1RY01S						
Nozzle	Nozl to safe end weld*	Item #	size	adjacent weld	configuration	Item #
Surge	1PZR-01-SE-01	R1.11 R1.15	14"	1RC-05-01	Safe end to pipe	R1.11
Spray	1PZR-01-SE-05	R1.11 R1.15	4"	1RC-16-01	reducer to safe end	R1.11
Relief	1PZR-01-SE-06	R1.15	6"	1RC-35-01	safe end to cut 45 deg elbow	R1.20
Safety A	1PZR-01-SE-02	R1.15	6"	1RC-32-01	safe end to cut 90 deg elbow	R1.20
Safety B	1PZR-01-SE-03	R1.15	6"	1RC-32-07	safe end to cut 90 deg elbow	R1.20
Safety C	1PZR-01-SE-04	R1.15	6"	1RC-32-13	safe end to cut 90 deg elbow	R1.20
For Unit 2 Pressurizer 2 RY01S						
Surge	2PZR-01-SE-01	R1.11 R1.15	14"	2RC-05-01	Safe end to pipe	R1.11
Spray	2PZR-01-SE-05	R1.11 R1.15	4"	2RC-16-01	reducer to safe end	R1.11
Relief	2PZR-01-SE-06	R1.15	6"	2RC-35-01	safe end to cut 45 deg elbow	R1.20
Safety A	2PZR-01-SE-02	R1.15	6"	2RC-32-01	safe end to cut 90 deg elbow	R1.20
Safety B	2PZR-01-SE-03	R1.15	6"	2RC-32-07	safe end to cut 90 deg elbow	R1.20
Safety C	2PZR-01-SE-04	R1.15	6"	2RC-32-13	safe end to cut 90 deg elbow	R1.20

Note: Item numbers reflect Risk-Informed classification per ASME Code Case N-578-1.
R1.11: Elements Subject to Thermal Fatigue.
R1.15: Elements Subject to Primary Water Stress Corrosion Cracking (PWSCC).
R1.20: Elements not Subject to a Damage Mechanism.
* Existing configurations (prior to SWOL) cannot be fully examined using Appendix VIII or EPRI PDI UT techniques.