UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

September 11, 2009

Site Vice President
Entergy Nuclear Operations, Inc.
Pilgrim Nuclear Power Station
600 Rocky Hill Road
Plymouth, MA 02360-5508

SUBJECT: RELIEF REQUEST (PRR)-19, INSTALL A WELD OVERLAY ON JET PUMP INSTRUMENTATION NOZZLE WELD RPV-N9A-1 - PILGRIM NUCLEAR POWER STATION (TAC NO. ME1151)

Dear Sir or Madam:

By letter dated May 1, 2009 (Agencywide Document and Management System (ADAMS) Accession No. ML091270162), as supplemented by letter dated May 7, 2009 (ML091320656), Entergy Nuclear Operations, Inc. (the licensee) requested Nuclear Regulatory Commission (NRC) staff review and approval of Pilgrim Relief Request (PRR)-19 to the requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI for the Pilgrim Nuclear Power Station (Pilgrim) to utilize ASME Code Cases N-638-1, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW 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. Pilgrim Relief Request (PRR)-19 would permit the installation of a weld overlay on the RPV-N9A-1 Jet Pump Instrumentation Nozzle Weld at Pilgrim. The results of the NRC staff's review are provided in the enclosed safety evaluation.

If you have any questions regarding this approval, please contact the Pilgrim Project Manager, James Kim, at 301-415-4125.

Sincerely,

Douglas V Pickett for

Nancy L. Salgado, Chief
Plant Licensing Branch 1-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-293

Enclosure:
As stated

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

REQUEST FOR RELIEF (PRR)-19

ENTERGY NUCLEAR OPERATIONS, INC.

PILGRIM NUCLEAR POWER STATION

DOCKET NO. 50-293

1.0 INTRODUCTION

By letter dated May 1, 2009, as supplemented by letter dated May 7, 2009, Entergy Operations, Inc. (Entergy, the licensee), requested relief from certain American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) requirements at Pilgrim Nuclear Power Station (PNPS). As an alternative to the ASME Code requirements, the licensee proposes to implement a weld overlay (WOL) repair in accordance with ASME Code Cases N-638-1, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW [Gas Tungsten Arc Welding] 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 alternatives proposed in Relief Request (PRR)-19, would be used to perform a WOL on the Jet Pump Instrumentation Nozzle Weld, RPV-N9A-1 at Pilgrim. The Nuclear Regulatory Commission (NRC) verbally authorized the licensee's requested alternative in a teleconference on May 11, 2009. This safety evaluation (SE) documents the basis for the NRC staff's verbal authorization and is written consistent with the information available at the time the verbal authorization was given.

2.0 REGULATORY REQUIREMENTS

Pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR), paragraph 50.55a(g)(4), ASME Code Class 1, 2, and 3 components (including supports) must meet the requirements, except the design and access provisions and the preservice examination requirements, set forth in the ASME Code, Section XI, "Rules for Inservice Inspection (ISI) of Nuclear Power Plant Components," to the extent practical within the limitations of design, geometry, and materials of construction of the components. The regulations require that inservice examination of components and system pressure tests conducted during the first 10-year interval and subsequent intervals comply with the requirements in the latest edition and addenda of Section XI of the ASME Code incorporated by reference in 10 CFR 50.55a(b) 12 months prior to the start of the 120-month interval, subject to the limitations and modifications listed therein. The code of record for the current fourth PNPS ISI interval is the 1998 Edition with 2000 Addenda of the ASME Code, Section XI.

Pursuant to 10 CFR 50.55a(a)(3) alternatives to requirements may be authorized by the NRC if the licensee demonstrates that: (i) the proposed alternatives provide an acceptable level of quality and safety, or (ii) compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety. The licensee submitted the subject relief request, pursuant to 10 CFR 50.55a(a)(3)(i), which proposed an alternative to the implementation of the ASME Code, Section XI requirements based on ASME Code Cases N-638-1 and N-504-3 as modified by the licensee for the deposition of a WOL for the remaining service life of the identified component. Regulatory Guide (RG) 1.147, "Inservice Inspection Code Case Acceptability, ASME Code, Section XI, Division 1," lists the code cases that are acceptable to the NRC for application in licensees' ASME Code, Section XI ISI programs. A licensee may use a code case specified in the RG without prior approval by the NRC if it meets the conditions specified for the code case.

3.0 LICENSEE'S PROPOSED ALTERNATIVE

3.1 Background

During Refueling Outage (RFO)-17, the WOL for the Jet Pump Instrumentation Nozzle N-9A was scheduled for ultrasonic (UT) examination to comply with the inspection requirements of Boiling Water Reactor Vessels and Internal Project (BWRVIP)-75-A: BWR Vessel and Internals Project, "Technical Basis for Revisions to Generic Letter 88-01 Inspection Schedules," October 2005, for Category "E"1 welds. The N-9A nozzle WOL was originally installed in September 1984 to repair detected flaws discovered in the 304 stainless steel safe-end base material. The flaws (two) were located in the heat affected zone (HAZ) of the stainless steel safe end base material adjacent to the nozzle N-9A dissimilar metal weld (DMW). The WOL was designed to provide full structural reinforcement of the flawed material assuming a postulated 360° through-wall crack while maintaining ASME Code safety margins. The WOL was installed with Alloy 82 (ERNiCr-3) weld metal.

The UT examination procedure and personnel were qualified in accordance with ASME Code, Section XI, Appendix VIII, Supplement 11 as implemented by the Performance Demonstration Initiative (PDI). However, prior to performing the UT examination, PNPS determined that the subject WOL could not be appropriately examined due to its present configuration. The ISI weld number for the subject WOL is RPV-N9A-1.

Entergy has initiated this request to propose an alternative to the ASME Code, Section XI. PNPS intends to use Code Cases N-504-3 and N-638-1 to modify the existing WOL of the Jet Pump Instrumentation Nozzle N-9A (ISI Weld RPV-9A-1). The modification will be performed using Alloy 52M (ERNiCrFe-7A) filler metal to facilitate performance of the required ASME Code, Section XI, Appendix VIII, Supplement 11 UT examination.

PNPS performs repair/replacement activities in accordance with the 1998 Edition/2000 Addenda of ASME Code, Section XI. This Edition of ASME Code, Section XI does not include requirements for application of full structural WOLs on DMWs and non-austenitic stainless steels. Moreover, requirements for installing full structural WOLs on DMWs and non-austenitic stainless steels are not presently included in any edition/addenda of ASME Code, Section XI (including Code Cases) approved by the NRC. However, the NRC has conditionally approved Code Case N-504-3 in RG 1.147 for installation of WOLs on austenitic stainless steel materials.

3.2 ASME Code Component Affected

ISI Weld RPV-N9A-1 Jet Pump Instrumentation Nozzle "N-9A"

3.3 ASME Code Requirements

ASME Code, Section XI, Subparagraph IWA-4421(a) and Subsubarticle IWA-4520 require that repair/replacement activities be performed and examined in accordance with the Owner's Requirements and the original Construction Code of the component or system. Alternatively, IWA-4421(b) and (c) allow use of later editions/addenda of the Construction Code (or a later different Construction Code such as ASME Code, Section III) and revised Owner Requirements. IWA-4430 and IWA-4600(b) provide alternative welding methods such as temper bead welding when the requirements of Paragraph IWA-4421 cannot be met. IWA-4520 requires that welds and weld repairs be performed in accordance with the Construction Code identified in the Repair/Replacement Plan. IWA-4530(a) requires the performance of pre-service examinations based on Subarticle IWB-2200 for Class 1 components. Table IWB-2500 prescribes ISI requirements for Class 1 butt welds in piping.

As an alternative to the above, ASME Code, Section XI Code Cases N-504-3 and N-638-1 specify requirements for performing the following:

Code Case N-504-3 provides alternative requirements to reduce a defect to a flaw of acceptable size in austenitic stainless steel materials by deposition of a structural WOL on the outside surface of the pipe or component. The NRC has conditionally approved this code case in RG 1.147 with the following condition: "The provisions of [ASME Code,] Section XI, Nonmandatory Appendix Q, Weld Overlay Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping Weldments, must be met."

Code Case N-638-1 establishes requirements for performing ambient temperature temper bead welding as an alternative to the preheat and post-weld heat treat (PWHT) requirements of the Construction Code. The NRC has conditionally approved this code case in RG 1.147 with the following condition: "UT volumetric examinations shall be performed with personnel and procedures qualified for the repaired volume and qualified by demonstration using representative samples which contain construction type flaws. The acceptance criteria of NB-5330 in the 1998 Edition through 2000 Addenda of [ASME Code,] Section III apply to all flaws identified within the repaired volume."

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

3.4 Duration of the Alternative

The repair performed using this relief request is applicable to the fourth 10-Year ISI interval for PNPS which began July 1, 2005, and will end June 30, 2015. The licensee implemented the request during the unit's spring 2009 refueling outage (RFO-17).

3.5 Licensee's Proposed Alternatives for ASME Code Case N-504-3

3.5.1 Code Case N-504-3 and ASME Code, Section XI Appendix Q apply strictly to austenitic stainless steel piping and weldments. As an alternative, Entergy proposes to use Code

Cases N-504-3 and ASME Code, Section XI Appendix Q to perform WOL welding on SA-508, Class 2 low alloy steel, Alloy 82 welds, and austenitic stainless steel using Alloy 52M (ERNiCrFe7A) filler metals.

3.5.2 Code Case N-504-3, paragraph (b) and ASME Code, Section XI Appendix Q, Subparagraph Q-2000(a) require that weld metal used to fabricate WOLs be low carbon steel (0.035%) austenitic stainless steel. As an alternative, Entergy proposes to perform WOL welding using Alloy 52M (ERNiCrFe-7A).

3.5.3 Code Case N-504-3, paragraph (e) and ASME Code, Section XI Appendix Q, Subparagraph Q-2000(d) require that as-deposited austenitic weld metal used to fabricate WOLs have a delta ferrite content of at least 7.5 FN or 5 FN under certain conditions. As an alternative, Entergy proposes to perform WOL welding using Alloy 52M (ERNiCrFe-7A) which is purely austenitic. Therefore, this delta ferrite requirement does not apply.

3.5.4 Code Case N-504-3, paragraph (f)(1) and ASME Code, Section XI Appendix Q, Subparagraph Q-3000(b)(2) require that the end transition slope of the WOL "not exceed 45°". As an alternative, Entergy proposes to allow the end transition slope to exceed 45° provided the following two conditions are met: (1.) a physical restriction along the Jet Pump Instrument Penetration Seal Assembly prevents the WOL end transition slope from being 45° or less and (2.) the as-built configuration of the WOL is analyzed by Finite Element Analysis to demonstrate compliance with the applicable stress limits of the Construction Code.

3.5.5 Code Case N-504-3, paragraph (h) requires that a system hydrostatic test be performed in accordance with IWA-5000. As an alternative, Entergy proposes to perform a system leakage test in accordance with IWA-5000.

3.6 Licensee's Basis for Alternatives to Code Case N-504-3

Paragraphs 3.5.1, 3.5.2, and 3.5.3 above all relate to the same topic, i.e., application of Code Case N-504-3 and ASME Code, Section XI Appendix Q to SA508, Class 2 low alloy steel, Alloy 82 welds, and austenitic stainless steel using Alloy 52M (ERNiCrFe-7A) filler metals instead of strictly austenitic stainless steel piping and weldments. Therefore, the NRC staff has combined the bases for these three items below.

3.6.1 These proposals are acceptable because the WOL design, fabrication, examination, and preservice/inservice inspection requirements of Code Case N-504-3 and ASME Code, Section XI Appendix Q may also be applied to nickel alloy WOLs of non-austenitic steels such as low alloy steels and nickel alloys. While some material requirements in Code Case N-504-3 and ASME Code, Section XI Appendix Q may only apply to austenitic stainless steels, Entergy has identified these requirements and proposed alternatives to appropriately address them.

3.6.2 The requirement to use low carbon steel (0.035%) austenitic stainless-steel was included in Code Case N-504-3 and ASME Code, Section XI Appendix Q to reduce the sensitization potential of the austenitic stainless steel WOL, thereby reducing its susceptibility to intergranular stress-corrosion cracking (IGSCC). As an alternative, Entergy has proposed to perform WOL welding using Alloy 52M (ERNiCrFe-7A) weld metal. While carbon content is not a critical factor in assessing resistance of nickel alloys

to IGSCC, the chromium content is. This point has been clearly documented in Section 2.2 of Electric Power Research Institute (EPRI) Technical Report MRP-115. "The only well explored effect of the compositional differences among the weld alloys on IGSCC is the influence of chromium. Business, et al. evaluated the IGSCC resistance of nickel-based weld metals with various chromium contents ranging from about 15% to 30% chromium. Testing was performed in doped steam and primary water. Alloy 182, with about 14.5% chromium, was the most susceptible. Alloy 82 with 18-20% chromium took three or four times longer to crack. For chromium contents between 21 and 22%, no stress corrosion crack initiation was observed..." To conclude, Alloy 52M weld metal has high chromium content (28 - 31.5%); therefore, it has excellent resistance to IGSCC.

3.6.3 The requirement to have a delta ferrite content of at least 7.5 FN was included in Code Case N-504-3 and ASME Code, Section XI Appendix Q to reduce the sensitization potential of the austenitic stainless steel WOL, thereby reducing its susceptibility to IGSCC. As an alternative, Entergy has proposed to perform WOL welding using Alloy 52M (ERNiCrFe-7A) weld metal which has a purely austenitic microstructure. Therefore, the requirement to measure delta ferrite does not apply in this application. The susceptibility of nickel alloys to IGSCC is dependant on its chromium content as explained above. Furthermore, the chromium content of the first layer of Alloy 52M weld metal could be reduced due to dilution with the underlying base and weld materials. Because this is the case, Entergy has self-imposed the following restriction on the first layer of the WOL: "The first layer of Alloy 52M weld metal deposited may not be credited toward the required thickness. Alternatively, a diluted layer may be credited toward the required thickness, provided the portion of the layer over the austenitic base material, austenitic weld, and the associated dilution zone from an adjacent ferritic base material contains at least 20% chromium. The chromium content of the deposited weld metal may be determined by chemical analysis of the production weld or from a representative coupon taken from a mockup prepared in accordance with the [welding procedure specification] WPS (or a representative WPS) for the production weld."

3.6.4 Code Case N-504-3, paragraph (f)(1) and ASME Code, Section XI Appendix Q, Subparagraph Q-3000(b)(2) require that the end transition slope of the WOL "not exceed 45°." It is Entergy's intent to comply with this requirement. However, the close proximity of the WOL to the instrument lines of the Jet Pump Instrument Penetration Seal Assembly limits Entergy's ability to lengthen the WOL along the penetration seal assembly. This interference could necessitate the design and installation of an end transition slope that exceeds 45°. Should this condition exist, Entergy will analyze the as-built configuration of the WOL using Finite Element Analysis to demonstrate compliance with the applicable stress limits of the Construction Code or ASME Code, Section III.

3.6.5 Code Case N-504-3, paragraph (h) requires that a system hydrostatic test be performed in accordance with IWA-5000 when a flaw penetrates the full thickness of the pressure boundary. For non-through-wall flaw conditions, Code Case N-504-3 allows performance of a system leakage test. Pressure testing is not addressed by ASME Code, Section XI Appendix Q. As an alternative, Entergy proposes to perform a system leakage test in accordance with IWA-5000. This proposal is consistent with the pressure testing requirements of IWA-4540 and Code Case N-416-3, except that the NDE requirements of IWA-4540 and Code Case N-416-3 would not apply to a WOL. The WOL acceptance examination will include both liquid penetrant and UT examinations. Liquid penetrant examinations will be performed in accordance with ASME Code, Section III while the UT

examination will be performed in accordance with ASME Code, Section XI Appendix VIII, Supplement 11 as implemented by PDI. The UT acceptance standards are as specified in Tables IWB-3514-2 and 3.

3.7 Staff Evaluation of Alternatives to Code Case N-504-3

Under the rules of ASME Code, Section XI, IWA-4421, repairs shall be performed in accordance with the Owner's Requirements 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 ASME Code Cases may be used. Code Case N-504-3, as modified by the identified alternatives, will be used by the licensee for installation of a weld overlay on the RPV-N9A-1 Jet Pump Instrumentation Nozzle Weld. 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.

The requests for alternative shown in paragraphs 3.5.1, 3.5.2, and 3.5.3 above all relate to the same topic, i.e., application of Code Case N-504-3 and ASME Code, Section XI, Appendix Q to SA508, Class 2 low alloy steel, Alloy 82 welds, and austenitic stainless steel using Alloy 52M (ERNiCrFe-7A) filler metals instead of strictly austenitic stainless steel piping and weldments. Therefore, the NRC staff has combined the bases for these three items below.

The licensee's proposed implementation of ASME Code, Section XI, Appendix Q for the ISI and subsequent additional examinations of the WOL is acceptable since RG 1.147, Revision 15 requires this condition to be met when using ASME Code Case N-504-3. ASME Code, Section XI, Appendix Q, provides an alternative to the requirements of IWA-4420, IWA-4520, IWA-4530, and IWA-4600 for making repairs to, and the examination of, Class 1, 2, and 3 austenitic stainless steel pipe weldments by deposition of a weld overlay on the outside surface of the pipe.

3.7.1, 3.7.2 & 3.7.3

The first and second proposed modifications to the Code Case N-504-3 and ASME Code, Section XI, Appendix Q, provisions involve the use of a nickel-based alloy weld material rather than austenitic stainless steel. The licensee stated that Paragraph (b) of Code Case N-504-3 requires that the reinforcement weld material shall be low carbon (0.035% maximum) austenitic stainless steel and ASME Code, Section XI, Appendix Q is for Weld Overlay Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping Weldments. In lieu of the stainless steel weld material, Alloy 52M, a consumable welding wire, which is highly resistant to stress-corrosion cracking (SCC), was proposed for the overlay weld material. The NRC staff notes that the use of Alloy 52M material is consistent with weld materials used to perform similar WOLs at other operating boiling-water reactor (BWR) facilities. The NRC staff also notes that the licensee is performing the subject WOL on dissimilar metal welds made of Alloy 82/182 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 this weld joint configuration. Alloy 52M contains about 30% chromium which would provide excellent resistance to SCC if exposed to the reactor coolant environment. This material is identified as F-No. 43 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 WOL as a modification to the requirements of Code Case N-504-3, Paragraph (b) and ASME Code, Section XI, Appendix Q is acceptable as it will provide an acceptable level of quality and safety.

The third proposed modification is to Code Case N-504-3 Paragraph (e) and ASME Code, Section XI, Appendix Q which require as-deposited delta ferrite measurements of at least 7.5 FN for the weld reinforcement. The licensee proposed that delta ferrite measurements will 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 and ASME Code, Section XI, Appendix Q are designed for WOL 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), and ASME Code, Section XI, Appendix Q apply only to an austenitic stainless steel WOL material to ensure its resistance to SCC. These requirements are not applicable to Alloy 52M, a nickel-based material which would be used for the WOL. Therefore, the NRC staff finds that the requested alternative will provide an acceptable level of quality and safety.

3.7.4 The fourth proposed modification is to Code Case N-504-3, paragraph (f)(1) and ASME Code, Section XI, Appendix Q, Subparagraph Q-3000(b)(2) which require that the end transition slope of the WOL "not exceed 45°." The licensee intends to comply with this requirement. However, the primary purpose of this weld overlay is to make the weld configuration able to be UT inspected, but due to the geometry of the configuration of the weldment and interferences from other equipment the licensee may not be able to comply with this requirement. The licensee will demonstrate compliance with the applicable stress limits of the Construction Code or ASME Code, Section III on this weld configuration. Therefore, since the weld configuration will meet the applicable stress limits of the original Construction Code or ASME Code, Section III, the NRC staff finds that the requested alternative will provide an acceptable level of quality and safety

3.7.5 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. Use of a leak test at normal operating temperature and pressure in lieu of a hydrostatic test has been incorporated in ASME Code, Section XI beginning in the 1998 Edition with the 1999 Addenda. PNPS is currently in its fourth 10-year ISI interval and the ISI Code of Record for the fourth 10-year ISI interval is the 1998 Edition with 2000 Addenda of the ASME Code, Section XI. As the licensee's alternative is consistent with the current practice, the NRC staff accepts the licensee's basis for this alternative.

3.8 Licensee's Proposed Alternatives to Code Case N-638-1

3.8.1 ASME Code Case N-638-1, Paragraph 1.0(a) limits the maximum area of an individual weld to 100 square inches. As an alternative, Entergy proposes to limit the surface area on the ferritic base material to 500 square inches.

3.8.2 ASME Code Code Case N-638-1, paragraph 2.1(j) specifies that the "average values of the three HAZ [heat affected zone] impact tests shall be equal to or greater than the average values of the three unaffected base metal tests." This requirement applies to acceptance criteria for Charpy V-notch HAZ tests of the welding procedure qualification test coupon. As an alternative, Entergy proposes to use the following acceptance criteria: "The average lateral expansion value of the three HAZ impact test specimens shall be equal to or greater than the average lateral expansion value of the three unaffected base metal test specimens."

3.8.3 Code Case N-638-1, paragraph 3.0(c) requires the deposition and removal of at least one weld reinforcement layer for "similar materials" (i.e., ferritic materials). As an alternative, Entergy proposes to exclude this requirement because it does not apply to austenitic weld filler metals.

3.8.4 Code Case N-638-1, Section 3.0 does not specifically address verification or monitoring of welding preheat and interpass temperatures. As an alternative, Entergy proposes the following: "Preheat and interpass temperatures will be measured using a contact pyrometer. In the first three layers, the interpass temperature will be measured every three to five passes. After the first three layers, interpass temperature measurements will be taken every six to ten passes for the subsequent layers. Contact pyrometers will be calibrated in accordance with approved calibration and control program documents."

3.8.5 Code Case N-638-1, paragraph 4.0(b) requires that the final weld surface and the "band" around the final weld surface be examined using surface examinations and UT methods. The "band" referred to in this requirement is defined in paragraph 1.0(d) of N-638-1 as a dimension equal to "1-1/2 times the component thickness or 5 inches, whichever is less". As an alternative, Entergy proposes the following: (1.) the WOL and adjacent base material that is within 1/2" of the WOL (on each side) shall be examined by the liquid penetrant method and (2.) the WOL examination volume A-B-C-D in Figure Q-4100-1 of ASME Code, Section XI, Appendix Q shall be UT examined.

3.8.6 Code Case N-638-1, paragraph 4.0(b) specifies that surface and volumetric examinations cannot be performed until the completed weld (i.e., WOL) "has been at ambient temperature for at least 48 hours." As an alternative, Entergy proposes that the surface and ultrasonic examinations cannot be performed until at least 48 hours after completion of the third temper bead layer of the WOL.

3.8.7 Code Case N-638-1, paragraphs 4.0(b) and (e) state that the UT examination shall be performed in accordance with Appendix I of ASME Code, Section XI and meet the acceptance criteria of IWB-3000. Regarding this UT examination, RG 1.147 includes the following condition: "UT volumetric examinations shall be performed with personnel and procedures qualified for the repaired volume and qualified by demonstration using representative samples which contain construction type flaws. The acceptance criteria of NB-5330 in the 1998 Edition through 2000 Addenda of [ASME Code,] Section III apply to all flaws identified within the repaired volume. As an alternative, Entergy proposes to perform this UT acceptance examination in accordance with the requirements and acceptance criteria of ASME Code, Section XI Appendix Q, Section Q-4000.

3.9 <u>Licensee's Basis for Alternatives to Code Case N-638-1</u>

3.9.1 Code Case N-638-1, Paragraph 1.0(a) specifies that the maximum area of finished surface of the weld shall be limited to 100 square inches. As an alternative, the licensee states that the surface area will be limited to 500 square inches over the ferritic material. They state that Code Case N-638-3 has been approved by the ASME and that residual stress analyses performed in support of Code Case N-638-3 show that stresses for 100 square inch through 500 square inch surface area overlays are very similar. The licensee indicated that there is extensive field experience with temper bead weld overlays on ferritic material. Several overlays have been applied with low alloy steel coverage significantly greater than the 100 square inches. These overlays have been examined

with Performance Demonstration Initiative (PDI) qualified techniques, in some cases multiple times, and none have shown any signs of new cracking or growth of existing cracks.

3.9.2 Code Case N-638-1, paragraph 2.1(j) specifies that the "average values of the three HAZ impact tests shall be equal to or greater than the average values of the three unaffected base metal tests." As an alternative, Entergy proposes to use the following alternative acceptance criteria: "The average lateral expansion value of the three HAZ impact test specimens shall be equal to or greater than the average lateral expansion value of the three unaffected base metal test specimens." The acceptance criteria for Charpy V-notch HAZ testing in Code Case N-638-1 is misleading and inconsistent with the specified acceptance criteria in ASME Code, Section XI applicable to other Class 1 components, since it implies that all three parameters: lateral expansion, absorbed energy, and percent shear fracture must be equal to or exceed the base material values. Code Case N-638-2 corrected paragraph 2.1(j) to state that Charpy V-notch acceptance criteria is based on the "average lateral expansion values" rather than the average of all three values. This change clarified the intent of the code case and aligned its acceptance criteria with NB-4330 of ASME Code, Section III and IWA-4620 and IWA-4630 of ASME Code, Section XI.

3.9.3 Code Case N-638-1, paragraph 3.0(c) requires the deposition and removal of at least one weld reinforcement layer for "similar materials" (i.e., ferritic materials). As an alternative, Entergy proposes to exclude this requirement because it does not apply to austenitic weld materials. This requirement only applies when welding is performed using ferritic weld metal. When temper bead welding is performed with ferritic weld metal, each ferritic weld layer must be tempered by the heat supplied from a subsequent weld layer. Because the final layer of a completed weld or weld repair would be untempered, paragraph 3.0(c) requires the deposition and removal of an additional layer (weld reinforcement) to ensure that the final layer of the completed weld is tempered. Since only austenitic weld metal (i.e., Alloy 52M) will be used to fabricate the proposed WOL, deposition and removal of a weld reinforcement layer is not required.

3.9.4 Code Case N-638-1, Section 3.0 does not specifically address verification or monitoring of welding preheat or interpass temperatures. Therefore, Entergy has proposed the following controls: "The preheat and interpass temperatures will be measured using a contact pyrometer. In the first three layers, the interpass temperature will be measured every three to five passes. After the first three layers, interpass temperature measurements will be taken every, six to ten passes for the subsequent layers. Contact pyrometers will be calibrated in accordance with approved calibration and control program documents." The proposed preheat and interpass temperature controls are based on field experience with depositing WOLs. Interpass temperatures beyond the third layer have no impact on the metallurgical properties of the low alloy steel heat affected zone.

3.9.5 Code Case N-638-1, paragraph 4.0(b) requires that the final weld surface and the band around the weld area (1.5T or 5", whichever is less) shall be examined using surface examinations and UT methods. Entergy has proposed the following as an alternative: (1) the WOL and adjacent base material within ½" of the WOL shall be examined by the liquid penetrant method and (2) the WOL examination volume A-B-C-D in Figure Q-4100-1 of ASME Code, Section XI, Appendix Q shall be ultrasonically examined. The

requirement in Code Case N-638-1, paragraph 4.0(b) to nondestructively examine the entire 1.5T band was established to address hydrogen cracking concerns. While the code case requirement is conservative, the proposed alternative is more than capable of detecting hydrogen cracking in ferritic materials. First of all, if hydrogen cracking were to occur, it would occur in the HAZ of the ferritic base material either below or immediately adjacent to the WOL. Therefore, it is unnecessary to examine the entire 1.5T band. Hydrogen cracking is not a concern in austenitic materials. If it occurs in the ferritic base material below the WOL, it will be detected by the UT which will interrogate the entire WOL including the interface and HAZ beneath the WOL. If it occurs in the ferritic base material immediately adjacent to the WOL, it will be detected by the liquid penetrant examination which is performed at least 1/2 inch on each side of the WOL.

3.9.6 Code Case N-638-1, paragraph 4.0(b) specifies that surface and volumetric examinations cannot be performed until the completed weld (i.e. WOL) "has been at ambient temperature for at least 48 hours." As an alternative, Entergy proposes that surface examinations and UT cannot be performed until at least 48 hours after completion of the third temper bead layer of the WOL. The 48-hour hold is specified to allow sufficient time for hydrogen cracking to occur (if it is to occur) in the HAZ of ferritic materials prior to performing final Non-Destructive Examination (NDE). However, based on extensive research and industry experience, EPRI has provided a technical basis for starting the 48-hour hold after completing the third temper bead weld layer rather than waiting for the weld overlay to cool to ambient temperature (weld layers beyond the third layer are not designed to provide tempering to the ferritic HAZ when performing ambient temperature temper bead welding). EPRI has documented their technical basis in Technical Report 1013558, "Temper Bead Welding Applications - 48 Hour Hold Requirements for Ambient Temperature Temper Bead Welding." The technical data provided by EPRI in their report is based on testing performed on SA-508, Class 2 low alloy steels and other P-Number 3, Group 3 materials. This point is important because the PNPS N-9A nozzle was manufactured from SA-508, Class 2 steel. After evaluating the issues relevant to hydrogen cracking such as microstructure of susceptible materials, availability of hydrogen, applied stresses, temperature, and diffusivity and solubility of hydrogen in steels, EPRI concluded the following: "There appears to be no technical basis for waiting 48 hours after cooling to ambient temperature before beginning the NDE of the completed weld. There should be no hydrogen present, and even if it were present, the temper bead welded component should be very tolerant of the moisture." The report also notes that over 20 weld overlays and 100 repairs have been performed using temper bead techniques on low alloy steel components over the last 20 years. During this time, there has never been an indication of hydrogen cracking by the NDE performed after the 48-hour hold or by subsequent inservice inspection.

3.9.7 Code Case N-638-1, paragraphs 4.0(b) and (e) state that the UT shall be performed in accordance with Appendix I of ASME Code, Section XI and meet the acceptance criteria of IWB-3000. Regarding this UT examination, RG 1.147 includes the following condition: "UT volumetric examinations shall be performed with personnel and procedures qualified for the repaired volume and qualified by demonstration using representative samples which contain construction type flaws. The acceptance criteria of NB-5330 in the 1998 Edition through 2000 Addenda of [ASME Code,] Section III apply to all flaws identified within the repaired volume." As an alternative, Entergy has proposed to perform the UT acceptance examination in accordance with the requirements and acceptance criteria of ASME Code, Section XI, Appendix Q, Article Q-4000. The UT examination requirements

and acceptance standards in ASME Code, Section XI, Appendix Q, Article Q-4000 were developed specifically for WOLs unlike those in Code Case N-638-1. According to Article Q-4000, UT examination procedures and personnel are qualified in accordance with Appendix VIII of ASME Code, Section XI. Supplement 11 of Appendix VIII specifically addresses qualification requirements for WOLs. When UT examinations are performed in accordance with ASME Code, Section XI, Appendix VIII, Supplement 11 (as implemented through PDI), the examinations are considered more sensitive for detecting fabrication and service-induced flaws than traditional radiographic and ultrasonic examination methods. Furthermore, construction-type flaws have been included in the PDI qualification sample sets for evaluating procedures and personnel. ASME Code, Section XI, Appendix Q, Article Q-4100 also establishes UT acceptance standards for WOL examinations. Similar to NB-5330, the UT examination must assure adequate fusion with the base material and detect welding flaws such as interbead lack of fusion, inclusions, and cracks. Detected planar and laminar flaws are required to meet the acceptance standards of Tables IWB-3514-2 and IWB-3514-3, respectively. Paragraph Q-4100(c) also limits the reduction in coverage due to a laminar flaw to less than 10% while uninspectable volumes are assumed to contain the largest radial planar flaw that could exist within the volume. Therefore, the Article Q-4100 qualification requirements and acceptance standards are equivalent or more conservative than those specified in RG 1.147.

3.10 Staff Evaluation of Modifications to Code Case N-638-1

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 15. The temper bead technique carefully controls heat input and bead placement which allows subsequent welding passes to stress relieve and temper the HAZ of the low alloy or carbon steel 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 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.

3.10.1 Code Case N-638-1, Paragraph 1.0(a) requires that the maximum area of an individual weld, based on the finished surface, will be limited to 100-square inches and the depth of the weld will not exceed one-half of the ferritic base metal thickness. This condition will not be met because the design for the weld overlay covers an area up to approximately 500-square inches on the ferritic component, which exceeds the limitations of Code Case N-638-1. 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. Results of industry analyses and testing performed to date have indicated that there is no direct correlation between the amount of surface area repaired and residual stresses generated using temper bead welding. Residual stresses associated with larger area repairs (>100 square inches) remain compressive at an acceptable level. Based on the preceding discussion, the NRC staff concludes that the modification to increase the weld overlay to as much as 500-square inches provides an acceptable level of quality and safety.

3.10.2 The licensee has adequately demonstrated that Paragraph 2.1(j) of Code Case N-638-1 clearly intended that the Charpy V-notch test acceptance criteria in Code Case N-638-1 be based on the average lateral expansion value rather than the average of all three values (lateral expansion, absorbed energy, and percent shear fracture). They have shown that all of the governing documents, i.e., ASME Code, Section III, NB-4330, "Impact Test Requirements," ASME Code, Section XI, IWA-4620, "Temperbead Welding of Similar Materials," and ASME Code, Section XI, IWA-4630, "Temperbead Welding of Dissimilar Materials" and Code Case N-638-2 all use the average lateral expansion value criterion. Therefore, the licensee's proposed alternative to use the average lateral expansion value criterion for Charpy V-notch test acceptance criteria provides an acceptable level of quality and safety.

3.10.3 Code Case N-638-1, Paragraph 3.0(c) requires the deposition and removal of at least one weld reinforcement layer for "similar materials" (i.e., ferritic materials). Since this weld is a dissimilar metal weld with an austenitic filler metal (i.e., Alloy 52M) for the proposed weld overlays, depositing and removing a weld reinforcement layer is not required.

3.10.4 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 states that thermocouples will not be used. Instead, preheat and interpass temperatures will be monitored by contact pyrometers. These temperature sensing devices will be used to verify preheat temperature and interpass temperature every three to five passes in the first three layers. After the first three layers, interpass temperature measurements will be taken every six to ten passes for the subsequent layers. Contact pyrometers will be calibrated in accordance with approved calibration and control program documents. The NRC staff agrees that this method of temperature measurement acceptable for the measurement of preheat and interpass temperature in the temperature range of 50 °F to 350 °F. Therefore, the NRC staff concludes that this type of monitoring of the interpass temperature provides an acceptable level of quality and safety.

3.10.5 The NRC staff agrees with the licensee that the proposed alternative to use liquid penetrant examination of the WOL and adjacent base metal within 1/2" of the WOL can detect cracking, since if cracking were to occur, it would occur either in or immediately adjacent to the WOL. Therefore, it is unnecessary to examine the entire 1.5T band. If it occurs in the ferritic base material below the WOL, it will be detected by UT which will interrogate the entire WOL including the interface and HAZ beneath the WOL. If it occurs in the ferritic base material immediately adjacent to the WOL, it will be detected by the liquid penetrant examination which is performed at least 1/2 inch on each side of the WOL.

For the UT, the NRC staff notes that the proposed requirement is consistent with Subarticle Q-4300 of the ASME Code, Section XI, Appendix Q and the NRC staff's position. The NRC staff finds these proposals acceptable.

3.10.6 Code Case N-638-1, Paragraph 4.0(b) specifies that the final weld surface shall be examined using surface and UT methods no sooner than 48 hours after the weld reaches ambient temperature. The 48-hour hold is to assure adequate hydrogen removal to avoid hydrogen cracking. Hydrogen cracking is a form of cold cracking. It is produced by internal tensile stresses produced from a localized build up of monatomic hydrogen. Monatomic hydrogen can form when moisture or hydrocarbons interact with the welding

arc and molten weld pool. The monatomic hydrogen can be entrapped during weld solidification and tends to migrate to transformation boundaries or other microstructure defect locations. As concentrations build, the monatomic hydrogen will recombine to form molecular hydrogen, thus generating localized internal stresses at these internal defect locations. If these stresses exceed the fracture toughness of the material, hydrogen-induced cracking will occur. This form of cracking requires the presence of hydrogen and low toughness materials. It is manifested by intergranular cracking of susceptible materials and can occur within 48 hours of welding. EPRI Technical Report 1013558, *Temper bead Welding Applications - 48 Hour Hold Requirement for Ambient Temperature Temper bead 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. Therefore, the licensee's proposed alternative to perform the surface and UT examinations no sooner than 48 hours after the third layer of the weld overlay is installed provides an acceptable level of quality and safety.

3.10.7 The NRC staff agrees with the licensee that the proposed alternative to perform the UT acceptance examination in accordance with the requirements and acceptance criteria of ASME Code, Section XI, Appendix Q, Article Q-4000 is acceptable, since the UT examination requirements and acceptance standards in ASME Code, Section XI, Appendix Q, Article Q-4000 were developed specifically for WOLs. ASME Code, Section XI, Appendix Q is also a condition for acceptance of Code Case N-504-3 in RG 1.147. According to Article Q-4000, UT examination procedures and personnel are qualified in accordance with Appendix VIII of ASME Code, Section XI. Supplement 11 of Appendix VIII specifically addresses qualification requirements for austenitic WOLs. Therefore, the proposed alternative to perform the UT acceptance examination in accordance with the requirements and acceptance criteria of ASME Code, Section XI, Appendix Q, Article Q-4000, provides an acceptable level of quality and safety.

4.0 CONCLUSION

The NRC staff concludes that the alternatives proposed in PNPS Relief Request (PRR)-19 to perform a WOL on the RPV-N9A-1 Jet Pump Instrumentation Nozzle dissimilar metal weld will provide an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the NRC staff authorizes PNPS Relief Request (PRR)-19 for the installation of a WOL on the RPV-N9A-1 Jet Pump Instrumentation Nozzle dissimilar metal weld. This relief request is authorized for use during spring 2009 refueling outage (RFO-17) at PNPS. The repair performed using this relief request is applicable to the fourth 10-Year ISI interval for PNPS which began July 1, 2005, and will end June 30, 2015.

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: Edward Andruszkiewicz

Date: September 11, 2009

September 11, 2009

Site Vice President
Entergy Nuclear Operations, Inc.
Pilgrim Nuclear Power Station
600 Rocky Hill Road
Plymouth, MA 02360-5508

SUBJECT: RELIEF REQUEST (PRR)-19, INSTALL A WELD OVERLAY ON JET PUMP INSTRUMENTATION NOZZLE WELD RPV-N9A-1 - PILGRIM NUCLEAR POWER STATION (TAC NO. ME1151)

Dear Sir or Madam:

By letter dated May 1, 2009 (Agencywide Document and Management System (ADAMS) Accession No. ML091270162), as supplemented by letter dated May 7, 2009 (ML091320656), Entergy Nuclear Operations, Inc. (the licensee) requested Nuclear Regulatory Commission (NRC) staff review and approval of Pilgrim Relief Request (PRR)-19 to the requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI for the Pilgrim Nuclear Power Station (Pilgrim) to utilize ASME Code Cases N-638-1, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW 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. Pilgrim Relief Request (PRR)-19 would permit the installation of a weld overlay on the RPV-N9A-1 Jet Pump Instrumentation Nozzle Weld at Pilgrim. The results of the NRC staff's review are provided in the enclosed safety evaluation.

If you have any questions regarding this approval, please contact the Pilgrim Project Manager, James Kim, at 301-415-4125.

Sincerely,

/RA/

Nancy L. Salgado, Chief
Plant Licensing Branch 1-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-293

Enclosure:
As stated

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Accession No.: ML092370549 *See memo dated 8/13/2009

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