February 25, 2005

Mr. Michael R. Kansler, President
Entergy Nuclear Operations, Inc.
440 Hamilton Avenue
White Plains, NY 10601

SUBJECT: PILGRIM NUCLEAR POWER STATION - PILGRIM RELIEF REQUEST PRR-36 ALTERNATIVE REPAIR PLAN FOR GENERIC LETTER 88-01, REACTOR PRESSURE VESSEL NOZZLE-TO-CAP WELD IN THE CONTROL ROD DRIVE RETURN LINE (TAC NO. MC0921)

Dear Mr. Kansler:

By letters dated October 1, 3, and 8, 2003, as supplemented by letter dated July 12, 2004, Entergy Nuclear Operations (ENO) requested relief from certain American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) requirements pertaining to flaw removal, and nondestructive examinations at Pilgrim Nuclear Power Station (Pilgrim). Specifically, ENO proposed a modification of ASME Code Case N-504-2, "Alternative Rules for Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping," to perform a weld overlay repair of the reactor pressure vessel (RPV) control rod drive return line nozzle-to-cap weld in penetration N10. The letter dated October 8, 2003, superseded the letter dated October 1, 2003.

The Nuclear Regulatory Commission (NRC) staff reviewed the proposed alternative, and on October 9, 2003, granted verbal authorization to use the alternative repair method described in your relief request. The results of this review are provided in the enclosed safety evaluation. The NRC staff has concluded that the proposed alternative to ASME Code requirements provided in subject relief request provides reasonable assurance of structural integrity, and an acceptable level of quality and safety. Therefore, pursuant to Title 10 of the *Code of Federal Regulations*, Section 50.55a(a)(3)(i), the NRC staff authorizes the use of ASME Code Case N-504-2, as modified, and the use of ultrasonic testing in lieu of radiographic testing, to perform a weld overlay repair of the CRD return line nozzle-to-cap weld (N10) at Pilgrim for the third 10-year inservice inspection interval.

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.

If you have any questions regarding this approval, please contact the Pilgrim Project Manager, John Boska, at 301-415-2901.

Sincerely,

/RA/

Darrell J. Roberts, Chief, Section 2
Project Directorate I
Division of Licensing Project Management
Office of Reactor Regulation

Docket No. 50-293

Enclosure: Safety Evaluation

cc w/encl: See next page

If you have any questions regarding this approval, please contact the Pilgrim Project Manager, John Boska, at 301-415-2901.

Sincerely,

/RA/

Darrell J. Roberts, Chief, Section 2
Project Directorate I
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Enclosure: Safety Evaluation

cc w/encl: See next page

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

PILGRIM STATION RELIEF REQUEST NO. 36, ALTERNATE REPAIR OF

REACTOR PRESSURE VESSEL NOZZLE-TO-CAP WELD

ENTERGY NUCLEAR OPERATIONS, INC.

PILGRIM NUCLEAR POWER STATION

DOCKET NO. 50-293

1.0 INTRODUCTION

By letters dated October 1, 3, and 8, 2003, as supplemented by letter dated July 12, 2004, Entergy Nuclear Operations (ENO or the licensee) requested relief from certain American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) requirements pertaining to flaw removal, and nondestructive examinations (NDE) at Pilgrim Nuclear Power Station (Pilgrim). Specifically, the licensee proposed a modification of ASME Code Case N-504-2, "Alternative Rules for Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping," to perform a weld overlay repair of the reactor pressure vessel (RPV) control rod drive (CRD) return line nozzle-to-cap weld in penetration N10. The letter dated October 8, 2003, superseded the letter dated October 1, 2003.

2.0 REGULATORY EVALUATION

2.1 Applicable Requirements

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

Pursuant to 10 CFR 50.55a(g)(4), ASME Code Class 1, 2, and 3 components (including supports) shall 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

Enclosure

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 Pilgrim's third 10-year ISI interval, which began on July 1, 1995 and ends June 30, 2005, is the 1989 Edition of Section XI of the ASME Code. The components (including supports) may meet the requirements set forth in subsequent editions and addenda of the ASME Code incorporated by reference in 10 CFR 50.55a(b) subject to the limitations and modifications listed therein and subject to the Commission's approval.

3.0 TECHNICAL EVALUATION

3.1 Component For Which Relief is Requested

The component affected by the request for relief is the RPV capped N10 nozzle austenitic to ferritic weld.

3.2 Code Repair Requirements

The ASME Code, Section XI, applicable to Pilgrim is the 1989 Edition with no addenda. Article IWA-4000, "Repair Procedures," of the subject Section XI ASME Code Edition provides rules and requirements for repair of the pressure retaining boundary for Class 1 components and their supports. To perform an ASME Code repair, Sub-article IWA-4310 "Procedure" requires that defects be removed or reduced from the degraded components prior to performing a repair by welding.

The licensee uses the 1992 Edition of Section III of the ASME Code for NDE and acceptance criteria. Paragraph NB-5221 requires that "Category B welded joints in vessels shall be examined by the radiographic and either the liquid penetrant or magnetic particle method."

3.3 Proposed Alternative

In lieu of removing or reducing the defect in accordance with ASME Code, Section XI, IWA-4000 requirements, the licensee proposes to perform a local repair using ASME Code Case N-504-2, "Alternative Rules for Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping," modified for austenitic weld overlay made with Alloy 52 or Alloy 152.

In addition, the licensee proposes to use ultrasonic testing (UT) that is qualified according to ASME Code, Section XI, Appendix VIII, Supplement 11, as administered by the Electric Power Research Institute - Performance Demonstration Initiative (PDI) in lieu of radiographic testing (RT). By letter dated February 26, 2004, the NRC staff authorized Supplement 11 as administered by PDI for use at Pilgrim (Pilgrim Relief Request No. 38).

3.4 Licensee's Bases for the Proposed Alternative

In its letter dated October 1, 2003, ENO stated that it would experience “unusual difficulty” in meeting ASME Code requirements to remove the flaw prior to repairing the N10 nozzle cap weld. The licensee further stated that:

> Replacement of the cap would require draining down the vessel to a level below the affected nozzle to allow the following:
>
> - Machining of the nozzle to remove the Inconel 182 weld butter and ID [inside diameter] cladding.
> - Preheat of the nozzle prior to welding.
> - Actual welding of the replacement cap to the CRD vessel nozzle.
> - Final Post weld heat treatment.
>
> [ ]If the vessel is drained, the radiation dose rates in the nozzle would increase significantly, resulting in increased personnel exposure [to radiation]. Therefore, consistent with [as low as reasonably achievable] ALARA practices and prudent outage scheduling and utilization of outage personnel, there is no vessel drain down planned for the overlay, although sealing of the flaw may be performed without water water backing. The weld overlay will be completed with water on the inside surface of the nozzle and end cap. This approach (i.e., no vessel drain down) reduces radiation exposure to personnel.

Prompted by these “unusual difficulties,” ENO proposed an alternative repair method in accordance with 10 CFR 50.55a(a)(3)(i) on the basis that the proposed alternative provides an acceptable level of quality and safety. The licensee's basis for the proposed alternative is summarized below:

(1) The subject weldment is austenitic. The weldment is designed to be highly resistant to interdendritic stress corrosion cracking (IDSCC) and is compatible with the existing weldment and base metal materials.

(2) A consumable welding wire highly resistant to IDSCC was selected for the overlay material. This material, commonly referred to as Alloy 52, will be applied using the gas tungsten arc welding (GTAW) process. Alloy 52 contains approximately 30 percent chromium which imparts stress corrosion cracking resistance to this material. By comparison, Alloy 82 is identified as an IDSCC resistant material in NUREG-0313, Revision 2 and contains approximately 18 to 22 percent chromium while Alloy 182 has approximately 13 to 17 percent. The high chromium content (30 percent) in Alloy 52 provides a high level of resistance to IDSCC.

(3) In lieu of hydrostatic pressure test requirements defined in ASME Code Case N-504-2, the required pressure test shall be performed in accordance with the third interval ISI program and plan and ASME Code Case N-416-2, with the exception that the volumetric

examination performed shall be an ultrasonic examination of the weld overlay. This alternative is sufficient to demonstrate that the weld overlay is of adequate quality to ensure the pressure boundary integrity.

(4) ASME Code Case N-638 was developed for temper bead applications to similar and dissimilar metals. It permits the use of machine GTAW at ambient temperature without the use of preheat or postweld heat treatment (PWHT) on Class 1, 2, and 3 components. Temper bead welding methodology is not new. Numerous applications over the past decade have demonstrated the acceptability of temper bead technology in nuclear environments. Temper bead welding achieves heat affected zone (HAZ) tempering and grain refinement without subsequent PWHT. Excellent HAZ toughness and ductility are produced. Use of ASME Code Case N-638 has been accepted in Regulatory Guide (RG) 1.147, Revision 13.

By letter dated July 12, 2004, the licensee responded to a request for additional information regarding its conclusion that it is acceptable to leave the flaw in place on the CRD return line nozzle-to-cap weld. The licensee stated:

> ASME [Code] Section XI allows a repair to be performed by either removing a flaw or reducing it to an acceptable size, as documented for instance in [ASME] Code Case N-504-2. The weld overlay approach does the latter. The allowable flaw size is defined in Table IWB-3641-1 (since Normal/Upset loads govern). The initial flaw is assumed to be entirely through wall and to extend entirely around the circumference of the repair location (through wall x 360 degrees around). The weld overlay approach applies additional thickness to the flawed location, such that the resulting as-repaired component meets the requirements of IWB-3640. This approach has been extensively used since the mid-1980s in repair of BWR [boiling water reactor] piping.[...]

3.5 NRC Staff's Evaluation

The repair area is a weld holding a cap to CRD vessel nozzle N10. The function of the cap is to permanently seal the nozzle. The leakage is an IDSCC flaw (term used for austenitic nickel based material which is similar to intergranular stress corrosion cracking (IGSCC) for austenitic iron based material). The industry has experience in repairing IGSCC in a manner that minimizes radiation exposure to personnel. ASME Code Cases N-504-2 and N-638 were developed to minimize radiation exposure by leaving water in the system and using automated equipment to build up the wall thickness to ASME Code-required thicknesses. The ASME Code repair dictates lowering the water in the vessel for the duration of the repair; however, this would expose personnel in the area to unnecessary radiation exposure and is not consistent with ALARA practices. By leaving water in the vessel during the overlay welding process, the licensee is able to maintain exposure to a level ALARA.

Evaluation of Modifications to Code Case N-504-2

The licensee discovered the leaking nozzle-to-cap weld (penetration N-10) during the 2003 fall refueling outage. Based on an evaluation of the NDE inspection results, the flaw appeared to initiate at the ID of the weld in the area of a weld repair. The through-wall location appears to be close to the weld centerline. For the repair, the licensee’s proposed alternative to the ASME Code, Section XI is based on a modification to ASME Code Case N-504-2 and the application of ASME Code Case N-638. Both code cases were endorsed for use in RG 1.147, Revision 13, dated June 2003.

The licensee's first modification to ASME Code Case N-504-2 extends the application of ASME Code Case N-504-2 to a weld repair using Alloy 52/152 on the low-alloy carbon steel rather than using stainless steel for the weld overlay. By letter dated July 12, 2004, the licensee responded to a request for additional information regarding the use of Alloy 52/152 instead of stainless steel for the weld overlay repair. The licensee stated that:

> Alloys 52/152 are also austenitic materials that exhibit very high toughness, similar to that of austenitic stainless steels. As a result, the use of net section collapse methodology as detailed in Appendix C of ASME [Code] Section XI is appropriate for the evaluation of allowable flaw size and repair design.
>
> The particular material property significant to this analysis is the allowable stress intensity[,] Sm[,] of the repair material. This property is significantly higher for the nickel-based alloys used in the repair, compared to the property value for austenitic stainless steels such as Type 304. The Sm value enters into the determination of the applied primary stress ratio (applied stresses divided by the allowable stress intensity), which is used to enter the Tables contained in IWB-3640 to determine allowable flaw size and thus required repair thickness. It is the Sm of the repair material that determines repair thickness, and not the Sm of the underlying base material, since the design basis of the repair is that the underlying flaw extends entirely through the original component thickness and entirely around the circumference of the component, such that no strength credit is taken for any remaining base material. This design assumption corresponds to the "Standard Weld Overlay" design as defined in NUREG-0313 Revision 2, Section 4.0. This approach has been used for repair of more than 1000 IGSCC flaws in BWR piping.
>
> For conservatism in the Pilgrim design, the Sm value of 23.3 ksi was used (corresponding to Alloy 600 values) rather than the higher Sm of about 30 ksi applicable to the Alloy 690 class materials such as Alloy 52/152.

The NRC staff finds this modification acceptable since the licensee used conservative material properties during consideration of the weld repair. The staff approved a similar weld overlay repair performed on a CRD return line nozzle-to-cap weld at James A. Fitzpatrick (Fitzpatrick) Nuclear Power Plant using a previous version of this ASME Code Case (Code Case N-504-1).

The licensee's second modification to ASME Code Case N-504-2 is to remove the delta ferrite requirement in the ASME Code Case. Delta ferrite (formed at high temperatures) measurement requirements were developed for stainless steel welds to minimize hot cracking or micro-fissuring as the weld metal cools down. Stainless steel is an iron-based metal with major additions of chromium and nickel and less amounts of other additives to achieve its corrosion resistance properties. As an iron-based alloy, the chemistry can be adjusted to assure that sufficient data ferrite is available to suppress hot cracking in the weld. Alloy 52 is a nickel-based alloy with additions of chromium and iron (less than 5 percent), and lesser amounts of other additives. The iron content is insufficient to form ferrite. Therefore, the NRC staff concludes there is no ferrite number for Alloy 52.

The third modification to ASME Code Case N-504-2 is to use ASME Code Case N-416-2 as an alternative to the hydrostatic pressure test. The function of the hydrostatic pressure test is to subject the pipe components to a small increase in pressure over the design pressure and does not present a significant challenge to the pressure boundary integrity. The incremental benefit provided by the hydrostatic pressure test is considered small. The hydrostatic pressure test is primarily a means to enhance leakage detection of the component under pressure. As an alternative to the hydrostatic pressure test, ASME Code Case N-416-2 uses a system pressure test, visual examination, surface examination, and volumetric examination. ASME Code Case N-416-2 was endorsed in RG 1.147, Revision 13 with a condition. The condition is that the hold times for uninsulated components in IWA-5213 of the 1989 Edition of the ASME Code, Section XI must be adhered to prior to the visual leakage test. The hold time for uninsulated components is 10 minutes. The licensee agreed to meet this condition.

ASME Code Case N-416-2 provides an alternative to hydrostatic pressure testing by validating weld integrity with NDE performed according to the 1992 Edition of Section III, which requires surface testing and RT examinations. To apply RT, the licensee would have to drain the vessel and place a radioactive source inside the capped nozzle which would create a hardship. In lieu of RT, the licensee will use UT.

RT and UT examination methods are complimentary. They are not directly comparable or equivalent. Depending on the flaw type and orientation, RT may be superior to UT or vice versa. RT is most effective in detecting changes in material density, such as volumetric (welding) type flaws (i.e., slag and porosity), and planar type flaws with detectable density differences, such as lack-of-fusion and open cracks that are oriented in a plane parallel to the X-ray beam. RT is limited in detecting small changes in density such as tight, irregular planar flaws and non-optimally oriented planar flaws with respect to the X-ray beam. RT is also limited in determining depth characteristics. The flaws that are easiest for RT to detect are 3-dimensional and are associated with the welding process (construction).

In contrast, UT examinations are capable of detecting the features in a component that reflects sound waves. The degree of reflection depends largely on the physical state of matter on the opposite side of the reflective surface and to a lesser extent on specific physical properties of that matter. For instance, sound waves are almost completely reflected at metal-gas interfaces, and partially reflected at metal-to-solid interfaces. Discontinuities that act as metal-gas interfaces, like cracks, laminations, shrinkage cavities, bursts, flakes, pores, and bonding faults are easily detected. These are the types of flaws that generally originate during plant operations and from the welding process. UT is less effective in detecting flaws in a plane parallel to the sound beam because of target size and in detecting volumetric type flaws such as slag, porosity, and other inhomogeneities because of sound dispersion from irregular surfaces. UT may also have difficulty in detecting discontinuities (flaws) that are present in the shallow layer immediately beneath the surface and in separating discontinuities from background noises that are caused by certain metal characteristics like large grains in stainless steel alloys. However, modern UT techniques involving partial reflection of sound waves have successfully detected flaws parallel to the sound beam and volumetric type flaws. Tip diffraction and corner trap UT techniques have successfully characterized these flaws.

In the proposed alternative, the examination volume consists of scanning through the weld overlay and 25 percent through-wall of the base metal. The scans provide assurance that planar flaws, regardless of orientation, will be detected and non-planar, welding flaws will be easier to discern from inhomogeneities. The procedures and personnel will be qualified to Section XI, Appendix VIII, Supplement 11 of the ASME Code as administered by the PDI program which was submitted to the NRC staff as Relief Request No. 38 and authorized by letter dated February 26, 2004. The qualification process assures that the UT procedure contains sufficient detail and the personnel have the necessary skills for detecting various types of flaws. Flaws that are detected will be evaluated in accordance with the 1992 Edition of Section III acceptance criteria.

For leakage to occur, there must be a flow path. Any flow path through the weld repair would be detected with the volumetric and surface examinations. Therefore, the proposed system leakage test in conjunction with the volumetric and surface examinations will provide reasonable assurance of structural and pressure boundary integrity of the weld overlay repair.

4.0 CONCLUSION

Based on its review, the NRC staff concludes that the proposed alternative provides reasonable assurance of structural and pressure boundary integrity of the RPV capped N10 nozzle and, thus, provides an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the NRC staff authorizes the licensee's proposed use of ASME Code Case N-504-2, as modified, and the use of UT in lieu of RT, to perform a weld overlay repair of the CRD return line nozzle-to-cap weld (N10) at Pilgrim for the third 10-year ISI interval.

All other requirements of the ASME Code, Section XI for which relief has not been specifically requested remain applicable, including third party review by the Authorized Nuclear Inservice Inspector.

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Date: February 25, 2005