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

August 17, 2012

Vice President, Operations
Entergy Operations, Inc.
Grand Gulf Nuclear Station
P.O. Box 756
Port Gibson, MS 39150

SUBJECT: GRAND GULF NUCLEAR STATION, UNIT 1 – RELIEF REQUEST ISI-17 RE: USE OF ASME CODE CASES N-638-4 AND N-504-4 FOR THE THIRD 10-YEAR INSERVICE INSPECTION INTERVAL (TAC NO. ME8525)

Dear Sir or Madam:

By letter dated May 2, 2012, as supplemented by letter dated May 9, 2012 (Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML12124A245 and ML12131A408, respectively), Entergy Operations, Inc. (Entergy, the licensee), requested relief from certain requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) at Grand Gulf Nuclear Station, Unit 1 (GGNS), to utilize ASME Code Cases N-638-4, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW [Gas Tungsten Arc Welding] Temper Bead Technique, Section XI, Division 1," and N-504-4, "Alternative Rules for Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping, Section XI, Division 1," as modified by the licensee. GGNS Relief Request ISI-17 would permit the installation of a weld overlay on the Low Pressure Core Injection "C" Nozzle to Safe End Weld N06B-KB at GGNS. Entergy had requested U.S. Nuclear Regulatory Commission (NRC) approval of Relief Request ISI-17 by May 15, 2012, as this flaw was discovered during the current outage inspections and needed to be repaired to allow GGNS to restart from the current outage.

The NRC staff has completed its review of the licensee's request and on May 10, 2012, pursuant 50.55a(a)(3)(i) of Title 10 of the *Code of Federal Regulations*, the NRC staff verbally authorized the use of relief request ISI-17 for use during refueling outage RF-18 in the spring of 2012. This verbal request was documented by memorandum dated May 22, 2012 (ADAMS Accession No. ML121380483). The repair performed using this relief request will be applicable for the remainder of the third 10-year inservice inspection interval for GGNS, which began on May 31, 2008, and ends in June 2017. The enclosed safety evaluation documents the technical basis for the staff's verbal authorization.

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

If you have any questions, please contact Alan Wang at 301-415-1445 or via e-mail at alan.wang@nrc.gov.

Sincerely,

CF Lyon for

Michael T. Markley, Chief
Plant Licensing Branch IV
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-416

Enclosure:
As stated

cc w/encl: Distribution via Listserv

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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELIEF REQUEST ISI-17

THIRD 10-YEAR INSERVICE INSPECTION INTERVAL

ENTERGY OPERATIONS, INC.

GRAND GULF NUCLEAR STATION, UNIT 1

DOCKET NO. 50-416

1.0 INTRODUCTION

By letter dated May 2, 2012, as supplemented by letter dated May 9, 2012 (Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML12124A245 and ML12131A408, respectively), Entergy Operations, Inc. (Entergy, the licensee), requested relief from certain requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) at Grand Gulf Nuclear Station, Unit 1 (GGNS). As an alternative to the ASME Code requirements, the licensee proposes to implement a structural weld overlay (WOL) repair in accordance with ASME Code Cases N-638-4, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW [Gas Tungsten Arc Welding] Temper Bead Technique, Section XI, Division 1," and N-504-4, "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 ISI-17 would be used to perform a WOL on the Low Pressure Core Injection (LPCI) "C" Nozzle to Safe End Weld N06B-KB at GGNS. Entergy had requested U.S. Nuclear Regulatory Commission (NRC) approval of Relief Request ISI-17 by May 15, 2012, as this flaw was discovered during the current outage inspections and needed to be repaired to allow GGNS restart from the current outage.

The NRC staff completed its review of the licensee's request and, on May 10, 2012, pursuant 50.55a(a)(3)(i) of Title 10 of the *Code of Federal Regulations* (10 CFR), the NRC staff verbally authorized the use of relief request ISI-17 for use during the unit's refueling outage RF-18 in the spring of 2012. This verbal request was documented by memorandum dated May 22, 2012 (ADAMS Accession No. ML121380483). The repair performed using this relief request is applicable for the remainder of the third 10-year inservice inspection (ISI) interval for GGNS, which began on May 31, 2008, and ends in June 2017.

Enclosure

2.0 REGULATORY EVALUATION

Pursuant to 10 CFR 50.55a(g)(4), ASME Code Class 1, 2, and 3 components (including supports) must meet the requirements, except the design and access provisions and the preservice examination requirements, set forth in the ASME Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," to the extent practical within the limitations of design, geometry, and materials of construction of the components. The 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 third 10-year ISI interval at GGNS is the 2001 Edition with 2003 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-638-4 and N-504-4 as modified by the licensee for the deposition of a WOL for the remaining service life of the identified component. NRC Regulatory Guide (RG) 1.147, Revision 16, "Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1," October 2010 (ADAMS Accession No. ML101800536), 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 TECHNICAL EVALUATION

3.1 Relief Request ISI-17

During refueling outage RF-18, ultrasonic (UT) examination was performed on the WOL for the LPCI "C" Nozzle to Safe End Weld N06B-KB at GGNS. The UT examination was performed to comply with the inspection requirements of Electric Power Research Institute (EPRI) proprietary BWRVIP-75-A: BWR [Boiling-Water Reactor] Vessel and Internals Project, "Technical Basis for Revisions to Generic Letter 88-01 Inspection Schedules," October 2005, for Category "C" welds. The UT examination performed in accordance with Appendix VIII of the ASME Code, Section XI and Supplement 11, "Qualification Requirements for Full Structural Overlaid Wrought Austenitic Piping Welds," which requires performance demonstration initiative (PDI) and a flaw was detected during this examination. The subject weld was previously examined in 2002 with a UT technique that did not comply with Appendix VIII criteria and no flaws were found during that examination.

The licensee proposed to install a WOL on the LPCI "C" Nozzle to Safe End Weld N06B-KB at GGNS using ASME Code, Section XI Code Cases N-504-4 and N-638-4. The flaw identified during RF-18 was located in the Inconel weld and the Inconel weld butter on the Nozzle "C", with a depth of 0.47 inch, and 0.9-inch long. The flaw is located 8.1 inches from the top-dead-center looking into the vessel (clockwise). The WOL was designed to provide full structural reinforcement of the flawed material assuming a 360 degree through-wall crack while maintaining ASME Code safety margins. The WOL was installed with Alloy 52M (ERNiCrFe-7A) weld metal followed by a PDI qualified UT examination consistent with the ASME Code, Section XI, Appendix VIII, Supplement 11 requirements.

GGNS performs repair/replacement activities in accordance with the 2001 Edition with 2003 Addenda of ASME Code, Section XI. This edition of ASME Code, Section XI does not include requirements for application of full structural WOLs on dissimilar metal welds (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 or addenda of ASME Code, Section XI (including Code Cases) approved by the NRC. However, the NRC staff has conditionally approved Code Case N-638-4 and N-504-4 in RG 1.147, Revision 16, for installation of WOLs on austenitic stainless steel materials.

3.2 ASME Code Component Affected

LPCI "C" Nozzle to Safe End Weld N06B-KB.

3.3 ASME Code Requirements

ASME Code, Section XI, Subarticle IWA-4411 and Subparagraph IWA-4500 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-4411 (a) and (b) 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-4420 specifies the requirements for performing defect removal and the associated non destructive examinations for repairs performed with or without welding. IWA-4600(b) provides alternative welding methods such as temper bead welding when the requirements of the Construction Code cannot be met. 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.

In its letter dated May 2, 2012, the licensee stated, in part, that,

> As an alternative to the above, ASME Code, Section XI, Code Cases N-504-4 and N-638-4 specify requirements for performing the following:
>
> - Code Case N-504-4 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 Regulatory Guide 1.147 with the following condition:
>
>   "The provisions of Section XI, Nonmandatory Appendix Q, "*Weld Overlay Repair of Class 1, 2, and 3 Austenitic Stainless Steel*

Piping Weldments," must also be met. In addition, the following conditions shall be met: (a) the total laminar flaw area shall not exceed 10% of the weld surface area, and no linear dimension of the laminar flaw area shall exceed the greater of 3 inches or 10% of the pipe circumference; (b) the finished overlay surface shall be 250 micro-in (6.3 micrometers) root mean square or smoother; (c) the surface flatness shall be adequate for ultrasonic examination; and (d) radiography shall not be used to detect planar flaws under or masked by laminar flaws. "

- Code Case N-638-4 establishes requirements for performing ambient temperature temper bead welding as an alternative to the preheat and postweld heat treat (PWHT) requirements of the Construction Code. The NRC has conditionally approved this [Code] Case in Regulatory Guide 1.147 with the following conditions:

  "(1) Demonstration for ultrasonic examination of the repaired volume is required using representative samples which contain construction type flaws.

  "(2) The provisions of 3(e)(2) or 3(e)(3) may only be used when it is impractical to use the interpass temperature measurement methods described in 3(e)(1), such as in situations where the weldment area is inaccessible (e.g., internal bore welding) or when there are extenuating radiological conditions."

- ASME Code, Section XI, Appendix VIII, Supplement 11, "Qualification Requirements for Full Structural Overlaid Wrought Austenitic Piping Welds," specifies PDI requirements for UT examinations of weld overlays.

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

The repair performed using this relief request is applicable to the third 10-year ISI interval for GGNS which began May 31, 2008, and ends in June 2017. The licensee implemented the request during the unit's refueling outage RF-18 in the spring of 2012.

3.5 <u>Licensee's Proposed Alternatives for ASME Code Case N-504-4</u>
(as stated by the licensee)

1. Code Case N-504-4 and Appendix Q apply strictly to austenitic stainless steel piping and weldments. As an alternative, Entergy proposes to use Code Cases N-504-4 and Appendix Q to install a WOL on SA-508, Class 2 low alloy steel, Alloy 182/82 weld, and an SB-166, Alloy 600 nickel alloy safe-end using ERNiCrFe-7A (Alloy 52M) filler metal.

2. Code Case N-504-4, paragraph (b) and Appendix Q, paragraph 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 ERNiCrFe-7A (Alloy 52M). Therefore, this requirement does not apply.

3. Code Case N-504-4, paragraph (e) and Appendix Q, paragraph Q-2000(d) require that the WOL consist of at least two austenitic stainless steel weld layers, each layer having an as-deposited delta ferrite content of at least 7.5 FN [ferrite number] or 5 FN under certain conditions. As an alternative, Entergy proposes to perform WOL welding using ERNiCrFe-7A (Alloy 52M) which is purely austenitic. Therefore, this delta ferrite requirement does not apply.

4. Code Case N-504-4, 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.

5. Appendix Q, paragraph Q-4000 specifies that procedures and personnel for examining weld overlays be qualified in accordance with Appendix VIII (Supplement 11) of ASME Section XI. As an alternative, Entergy proposes to UT examine the WOL in accordance with Appendix VIII, Supplement 11 except as modified by the PDI Program. The proposed PDI alternatives to Appendix VIII, Supplement 11 are specified in Attachment 2 [of the licensee's letter dated May 2, 2012].

3.6 Licensee's Basis for Alternatives to Code Case N-504-4

Paragraphs 1, 2, and 3 of Section 3.5 of this safety evaluation (SE) all relate to the same topic (i.e., application of Code Case N-504-4 and ASME Code, Section XI, Appendix Q to welding on SA-508, Class 2 low alloy steel, Alloy 82/182 welds, and SB-166, Nickel Alloy 600 safe end using Alloy 52M (ERNiCrFe-7A) filler metals). Therefore, the NRC staff has combined the bases for these three items below.

While some material requirements in Code Case N-504-4 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.

The requirement to use low carbon steel (0.035 percent) austenitic stainless steel was included in Code Case N-504-4 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 is documented in Section 2.2 of Electric Power Research Institute (EPRI) technical report "Materials Reliability Program, Crack Growth Rates for Evaluating Primary Water Stress Corrosion Cracking (PWSCC) of Alloy 82, 182, and 132 Welds (MRP-115)," November 2004 (nonproprietary version, designated as MRP-115NP, is available at ADAMS Accession No. ML051450555) which states, in part, that

> The only well explored effect of the compositional differences among the weld alloys on PWSCC is the influence of chromium. Buisine, et al. evaluated the PWSCC resistance of nickel-based weld metals with various chromium contents ranging from about 15% to 30% chromium [1]. 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 percent); therefore, it has excellent resistance to IGSCC.

The requirement to have a delta ferrite content of at least 7.5 FN was included in Code Case N-504-4 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 dependent 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. In its letter dated May 2, 2012, Entergy stated, in part, that because of this consideration, 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.

---

1 D. Buisine, et al., "PWSCC Resistance of Nickel Based Weld Metals with Various Chromium Contents," *Proceedings: 1994 EPRI Workshop on PWSCC of Alloy 600 in PWRs,* EPRI, Palo Alto, CA: 1995. TR-105406, Paper D5.

Code Case N-504-4, 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-504-4 allows performance of a system leakage test. Pressure testing is not addressed by ASME Code, Section XI, Appendix Q. In its letter dated May 2, 2012, the licensee stated, in part, that:

> 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-416-4, except that, the [non-destructive examination (NDE)] requirements of IWA-4540/N-416-4 would not apply to a WOL. The WOL acceptance examination will include both liquid penetrant (PT) and UT examinations. PT 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 IWB-3514-3].

Appendix Q, paragraph Q-4000 of the ASME Code, Section XI specifies that procedures and personnel for examining weld overlays be qualified in accordance with Appendix VIII of ASME Code, Section XI. In its letter dated May 2, 2012, the licensee stated, in part, that

> Appendix VIII, Supplement 11 of the 2001 Edition of ASME [Code,] Section XI specifies requirements for performance demonstration of ultrasonic examination procedures, equipment, and personnel used to detect and size flaws in full structural overlays of wrought austenitic piping welds.

In lieu of meeting certain qualification requirements in Appendix VIII, Supplement 11, Entergy proposed alternatives based on the PDI Program as indicated in Attachment 2 of the relief request because the industry currently cannot meet certain requirements of Appendix VIII, Supplement 11. Therefore, the PDI program as described in Attachment 2 will be used for qualification of UT examinations used to detect and size flaws in the preemptive full structural weld overlays of this request.

3.7 <u>NRC Staff Evaluation of Alternatives to Code Case N-504-4</u>

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-504-4, as modified by the identified alternatives, will be used by the licensee for installation of a weld overlay on the LPCI "C" Nozzle to Safe End Weld N06B-KB. Code Case N-504-4 was conditionally approved by the staff for use under RG 1.147, Revision 16. Therefore, the use of Code Case N-504-4 as an alternative to the mandatory ASME Code repair provisions is acceptable to the NRC staff, when all conditions and provisions specified in RG 1.147, Revision 16, are complied with.

The requests for alternative shown in paragraphs 1, 2, and 3 of SE Section 3.5 all relate to the same topic (i.e., application of Code Case N-504-4 and ASME Code, Section XI, Appendix Q to

SA-508, Class 2 low alloy steel, Alloy 82/182 welds, and SB-166, Nickel Alloy 600 safe end 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 16, requires this condition to be met when using ASME Code Case N-504-4. 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. As discussed above, Appendix Q requires the UT be performed in accordance with Appendix VIII of the ASME Code, Section XI. However, the current industry UT cannot satisfy the requirements of Appendix VIII. The industry initiated a PDI program managed by EPRI as an alternative to satisfy the requirements of Appendix VIII. Entergy proposed to use the same PDI program to examine the WOL.

The first and second proposed modifications to the Code Case N-504-4 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-504-4 requires that the reinforcement weld material shall be low carbon (0.035 percent 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 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 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 percent 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 second proposed modification is evaluated above along with the first proposed modification.

The third proposed modification is related to Code Case N-504-4 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 percent austenitic and contains no delta ferrite due to the high nickel composition (approximately 60 percent nickel). Code Case N-504-4 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-504-4, 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 that would be used for the WOL. Therefore, the NRC staff finds that the requested alternative will provide an acceptable level of quality and safety.

The licensee's proposed modification to paragraph (h) of Code Case N-504-4 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. GGNS is currently in its third 10-year ISI interval and the ISI Code of record for the fourth 10-year ISI interval is the 2001 Edition with 2003 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.

As stated above, the licensee proposed to use PDI program to perform UT of the weld overlay. 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, in the NRC letter dated July 3, 1984 (ADAMS Legacy 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 dated January 15, 2002, to the PDI Chairman (ADAMS Accession No. ML020160532).

The PDI program is routinely assessed by the NRC staff for consistency with the current ASME Code requirements, operating experience, and proposed changes. The PDI program does not fully comport with the existing requirements of Supplement 11. PDI presented the differences at public meetings on January 31-February 2, 2002, and June 12-14, 2001 (meetings summaries dated March 22, 2002, and November 29, 2001 (ADAMS Accession Nos. ML010940402 and ML013330156, respectively)), in which the NRC participated. Based on the discussions at these public meetings, the NRC staff determined that the PDI program provides an acceptable level of quality and safety.

The NRC staff evaluated the differences between the PDI program and Supplement 11 and the associated justification for the differences as documented in Attachment 2 of Relief Request ISI-17. Based on the above, the NRC staff concludes that the justifications for the differences are reasonable and the PDI program provides an acceptable level of quality and safety for the examination of the WOL. Therefore, the proposed PDI program is acceptable to be used to satisfy Supplement 11 of Appendix VIII to the ASME Code, Section XI.

3.8 Licensee's Proposed Alternatives to Code Case N-638-4
(as stated by the licensee)

1. Code Case N-638-4, paragraphs 3(e) and 3(e)(1) state that the interpass temperature during welding shall be determined by temperature measurement (e.g., pyrometers, temperature indicating crayons,

thermocouples). In monitoring preheat and interpass temperatures during WOL welding, Entergy proposes the following alternative:

> "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."

2. Code Case N-638-4, paragraphs 4.0(a), 4.0(a)(2), and 4.0(a)(4) state that all welds (including repair welds) shall be volumetrically examined in accordance with the requirements and acceptance criteria of the Construction Code or ASME Section III. As an alternative, Entergy proposes to volumetrically examine the WOL using the UT method in accordance with the requirements and acceptance criteria of paragraph Q-4100 of ASME Section XI, Appendix Q.

3.9 Licensee's Basis for Alternatives to Code Case N-638-4

In its letter dated May 2, 2012, the licensee has provided the following basis for the suitability of the proposed alternatives:

(a) Code Case N-638-4, paragraphs 3(e) and 3(e)(1) state that the interpass temperature during welding shall be determined by temperature measurement (e.g., pyrometers, temperature indicating crayons, thermocouples). In monitoring preheat and interpass temperatures during WOL welding, Entergy proposes the following:

> "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.... "

The proposed preheat and interpass temperature controls are based on field experience with depositing WOLs and have been successfully used throughout the industry. Interpass temperatures beyond the third layer have no impact on the metallurgical properties of the low alloy steel heat affected zone.

(b) Code Case N-638-4, paragraphs 4.0(a), 4.0(a)(2), and 4.0(a)(4) state that all welds (including repair welds) shall be volumetrically examined in accordance with the requirements and acceptance criteria of the Construction Code or ASME [Code,] Section III. As an alternative, Entergy proposes to volumetrically examine the WOL using the UT method in accordance with the requirements and acceptance criteria of Appendix Q, Section Q-4100 of ASME [Code,] Section XI. The UT examination requirements and acceptance standards in Appendix Q, paragraph Q-4100 were developed specifically for WOLs unlike those in Code Case N-638-4. According to Article Q-4000, UT examination procedures and personnel shall be qualified in accordance with Appendix VIII of ASME [Code,] Section XI. Supplement 11 of Appendix VIII specially addresses qualification requirements for WOLs. When UT examinations are performed in accordance with 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. Appendix Q, Article Q-4100 also establishes UT acceptance standards for WOL examinations. Similar to NB-5330 [of the ASME Code, Section III], the UT examination must assure adequate fusion with the base material and detection of flaws related to welding 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 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. The conditions in Regulatory Guide 1.147 applicable to Appendix Q will also be met.

3.10 NRC Staff Evaluation of Modifications to Code Case N-638-4

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-638-4. The NRC endorsed Code Case N-638-4 in RG 1.147, Revision 16. The temper bead technique carefully controls heat input and bead placement which allows subsequent welding passes to stress relieve and temper the heat affected zone 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-638-4.

Code Case N-638-4, 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 stated that 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 degrees Fahrenheit (°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.

The NRC staff concludes that the licensee will follow ASME Code, Section XI, Appendix Q, Section Q-4000 in lieu of Code Case N-638-4, paragraphs 4.0(a), 4.0(a)(2) and 4.0(a)(4). The NRC staff concludes that the use of the ASME Code, Section XI, Appendix Q, Section Q-4000 to examine the weld overlay with UT technique is acceptable as it is permitted by the condition imposed on Code Case N-504-3 in RG 1.147, Revision 16.

When performing UT per Appendix Q to the ASME Code, Section XI, the licensee will use the PDI program in lieu of Appendix VIII of the ASME Code, Section XI. The NRC staff concludes that the PDI program is acceptable as discussed in SE Section 3.7. Therefore, the NRC staff concludes 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, provides an acceptable level of quality and safety.

3.11 Licensee's Proposal for WOL Design and Verification

In its letter dated May 2, 2012, the licensee stated, in part, that

> The fundamental design basis for full structural WOLs is to maintain the original design margins with no credit taken for the underlying IGSCC-susceptible weldments. The assumed design basis flaw for the purpose of structural sizing of the WOL is a flaw completely around the circumference (360°) and 100% through the original wall thickness of the dissimilar metal weld. Regarding the crack growth analysis, the detected axial flaw described in Section III, above [of Relief Request ISI-17], will be analyzed. The specific analyses and verifications to be performed are summarized as follows:
>
> - A nozzle-specific stress analysis will be performed to establish a residual stress profile in the WOL and the underlying weld and base materials. A severe internal diameter weld repair will be assumed in this analysis that effectively bounds any actual weld repairs that may have occurred. The analysis will then simulate application of the WOL to determine the final residual stress profile. Post-WOL residual stresses at normal operating conditions will be shown to result in beneficial compressive stresses on the inside surface of the underlying weld and base materials, assuring that further crack initiation in susceptible materials due to IGSCC is highly unlikely.
>
> - Fracture mechanics analyses will also be performed to predict crack growth of the detected flaw. Crack growth due to IGSCC and fatigue will be analyzed. The crack growth analyses will consider all design loads and transients, plus the post-WOL and through-wall residual stress

distributions. The analyses will demonstrate that postulated flaws will not degrade the design basis for the WOL.

- The analyses will demonstrate that applying the WOL does not impact the conclusions of the existing nozzle stress reports. The ASME Code, Section III primary stress criteria will continue to be met.

- Shrinkage will be measured during the WOL application. Shrinkage stresses at other locations in the piping systems arising from the WOL will be demonstrated not to have an adverse effect on the systems. Clearances of affected supports and restraints will be checked after the overlay repair and will be reset within the design ranges if required.

- The added weight on the piping systems due to the WOL will be evaluated for potential impact on piping system stresses and dynamic characteristics.

- The as-built dimensions of the WOL will be measured and evaluated to demonstrate that they meet or exceed the minimum design dimensions of the WOL.

3.12 NRC Staff Evaluation of WOL Design and Modification

By e-mail dated May 8, 2012 (ADAMS Accession No. ML121290617), the NRC staff requested that the licensee provide (1) the nominal diameter of the pipe and pipe wall thickness and, (2) a more detailed design drawing of the weld overlay, nozzle, safe-end and pipe.

In response to the NRC staff's request for additional information (RAI), by letter dated May 9, 2012, Entergy submitted a sketch which provides dimensions of the nozzle, safe -end, weld overlay and nozzle configuration. Entergy noted that Figures 1 and 2 in the original relief request were based on NDE data, and provided a preliminary overlay design thickness that was selected to optimize the future examination coverage. The sketch provided in the licensee's RAI response reflects nominal design values and variable dimensions that are dependent on the final contour of the overlay deposit. The outside diameter of the nozzle to safe-end transition varies; therefore, the wall thickness and the overlay thickness will vary depending on the axial location. To avoid confusion, it should also be recognized that Figures 1 and 2 in the original relief request show the nozzle on the right-hand side with the safe-end on the left-hand side of the sketch, while the sketch provided in the RAI response shows the nozzle on the left-hand side with the safe-end on the right-hand side of the sketch.

The NRC staff asked the licensee to discuss the crack-growth rate of the IGSCC that will be used for the crack-growth calculation and provide the reference, the fracture mechanics analyses, and the acceptance criteria for the results of the fracture mechanics analyses. By letter dated May 9, 2012, Entergy proposed to use the IGSCC crack-growth rate for normal water chemistry provided in Figure A-21 of EPRI's proprietary topical report BWRVIP-59-A, "BWR Vessel and Internals Project: Evaluation of Crack Growth in BWR Nickel Based

Austenitic Alloys in RPV [Reactor Pressure Vessel] Internals," May 2007 (no public version available). As stated in Attachment 2 of the licensee's RAI response dated May 9, 2012:

> Although the Grand Gulf Nuclear Station employs both hydrogen water chemistry (HWC) and on-line noble chemistry (OLNC) as a global IGSCC mitigation technique against the initiation and propagation of IGSCC and these BWR water chemistry practices have been shown to be effective in preventing the initiation and propagation of IGSCC of most reactor pressure vessel (RPV) nozzles, for this particular LPCI nozzle location, it appears that no significant benefit is achieved... Accordingly, the more conservative normal water chemistry crack growth rates will be used.

The licensee assumed a full circumferential crack in a cylinder with t/R (thickness/radius) = 0.2 is used with the axial stresses, and a model of a semi-elliptical longitudinal crack in a cylinder (with $0.1 < t/R < 1.0$) is used with the hoop stresses.

The fatigue crack growth law for Alloy 600 in high purity BWR water containing 300 parts per billion (ppb) dissolved oxygen, is obtained from NUREG/CR-6721, "Effects of Alloy Chemistry, Cold Work, and Water Chemistry on Corrosion Fatigue and Stress Corrosion Cracking of Nickel Alloys and Welds," April 2001 (ADAMS Accession No. ML011170079).

As stated in Attachment 2 of the licensee's RAI response dated May 9, 2012:

> The applicable fatigue cycles for the thermal transient events are distributed evenly over 40 years. For conservatism, the thermal and pressure ranges are assumed the full fluctuation from zero to maximum stress. The full piping moment is conservatively added to the maximum K value for all cycles. An initial crack depth as reported in the examination results is used in the fatigue crack growth calculation. Fatigue crack growth threshold is assumed to be zero.
>
> In addition to fatigue crack growth, IGSCC must be considered when the steady-state normal operating stress intensity factors are shown to be tensile for some flaw depths. Sustained steady-state normal operating stresses are the only stresses that need to be considered for the SCC [stress corrosion cracking] growth analysis. The sustained stress intensity factors due to residual stress (at normal operating temperature and pressure) and full piping loads, conservatively including deadweight and seismic loading, are used in the SCC growth analysis.
>
> [...] A 10-year inspection interval is assumed, based on EPRI BWRVIP-59-A...; however, a 40-year crack growth period is conservatively evaluated for both fatigue crack growth and IGSCC growth (for tensile stress regions in the DMW). No IGSCC crack growth is assumed for compressive stress intensity factor regions in the DMW. The initial crack shall not grow to exceed the design basis of the weld overlay during the inspection period. The acceptance criteria are in accordance with ASME Code, Section XI, IWB-3600 rules.

The NRC staff notes that it is difficult to determine which IGSCC crack growth rate is conservative because of various test conditions such as water chemistry and applied stresses. However, the licensee is required to examine the weld overlay periodically. Any potential crack growth will be detected and compared to the analytical solutions. Therefore, the NRC staff concludes that the proposed crack growth rate is acceptable because the licensee will monitor the growth rate using inspection results. The NRC staff concludes the licensee will use an acceptable crack model and will follow the requirements of IWB-3600 of the ASME Code, Section XI.

On page 7 of the relief request, item (d) states that the PT (penetrant test) examination will be performed in accordance with the ASME Code, Section III. The NRC staff asked the licensee to confirm that the acceptance criteria for the PT results (indications detected) will be based on the ASME Code, Section III, NB-5000. By letter dated May 9, 2012, Entergy stated, in part, that

> The PT examination acceptance criteria of the weld overlay will comply with NB-5000 of the 1992 Edition of ASME [Code,] Section III. However, the PT acceptance criteria of the base material adjacent to the weld overlay will comply with NB-2500 of ASME [Code,] Section III. This PT acceptance criterion is specified in Appendix Q, paragraph Q-4100(b) of the 2004 Edition/2005 Addenda of ASME [Code,] Section XI for acceptance of the weld overlay... To comply with preservice examination requirements of N-504-4, paragraph (i), the PT examination will also comply with the acceptance standards of IWB-3514-2.

The NRC staff concludes that the licensee will follow the acceptance criteria in NB-2500 and NB-5000 of the ASME Code, Section III to disposition the PT results.

The NRC staff asked the licensee to (1) discuss any surface preparation for the nozzle, safe end, and pipe prior to weld overlay installation, and (2) if the surface configuration of the weld/nozzle is changed by the surface preparation process, to discuss whether the weld would be reexamined following the surface preparation. In its RAI response dated May 9, 2012, the licensee stated, in part, that

> The weld crown was removed to achieve the required flatness prior to performing the Appendix VIII, Supplement 10 volumetric examination that identified the flaw in the dissimilar metal weld. The only additional surface preparation performed was light buffing to achieve a clean surface for performing pre-overlay surface examinations, and to achieve a bright metal surface for welding. The design configuration of the nozzle, weld, and safe end assembly was not changed by the surface preparation.

The NRC staff concludes that the licensee will prepare the weld surface in accordance with the required surface condition per Appendix VIII prior to perform pre-overlay examination.

3.13 Regulatory Commitments

In its letter dated May 2, 2012, Entergy made the following regulatory commitments:

- Weld overlay examination results including a listing of indications detected;
- Disposition of 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; and,
- A discussion of any repairs to the weld overlay material and/or base metal and the reason for the repairs.
- Submit to the NRC a stress analysis summary demonstrating that the nozzle to safe-end DMW, N06B-KB, will perform its intended design function after weld overlay installation.

For the first three commitments, Entergy will submit the above information to the NRC within 14 days from completing the final UT examinations of the completed WOL, and for the last commitment, Entergy will submit this analysis within 90 days of completing GGNS's refueling outage RF-18. The stress analysis report will include results showing that the requirements of NB-3200 and NB-3600 of the ASME Code, Section III are satisfied. The stress analysis will also include results showing that the requirements of Subsection IWB-3000 of the ASME Code, Section XI, are satisfied. The results will show that the detected IGSCC crack, including its growth in the nozzle, will not adversely affect the integrity of the overlay repair. The NRC staff concludes that these commitments are acceptable because the WOL inspection results will demonstrate that the condition of the installed WOL is acceptable. The stress analysis will demonstrate that the WOL satisfies the requirements of the ASME Code, Section III, NB-3200 and NB-3600 and ASME Code, Section XI, IWB-3600.

The NRC staff concludes that reasonable controls for the implementation and for subsequent evaluation of proposed changes pertaining to the above regulatory commitments are best provided by the licensee's administrative processes, including its commitment management program. The above regulatory commitments do not warrant the creation of regulatory requirements (items requiring prior NRC approval of subsequent changes).

4.0 CONCLUSION

Based on the above, the NRC staff concludes that the alternatives proposed in Relief Request ISI-17 to perform a WOL on the LPCI "C" Nozzle to Safe End Weld N06B-KB will provide an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the NRC staff authorizes Relief Request ISI-17 for the installation of a WOL on the LPCI "C" Nozzle to Safe End Weld N06B-KB. This relief request was authorized for use during refueling outage RF-18 in the spring of 2012 at GGNS. The repair performed using this relief request is applicable for the remainder of the third 10-year ISI interval for GGNS which began on May 31, 2008, and ends in June 2017.

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: Ganesh Cheruvenki

Date: August 17, 2012

If you have any questions, please contact Alan Wang at 301-415-1445 or via e-mail at alan.wang@nrc.gov.

Sincerely,

/RA by FLyon for/

Michael T. Markley, Chief
Plant Licensing Branch IV
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-416

Enclosure:
As stated

cc w/encl: Distribution via Listserv

DISTRIBUTION:
PUBLIC
LPLIV r/f
RidsAcrsAcnw_MailCTR Resource
RidsNrrDeEvib Resource
RidsNrrDorlLpl4 Resource
RidsNrrLAJBurkhardt Resource
RidsNrrPMGrandGulf Resource
RidsOgcRp Resource
RidsRgn4MailCenter Resource
GCheruvenki, NRR/DE/EVIB

ADAMS Accession No: ML12214A318 ***SE input dated July 30, 2012**

OFFICE	NRR/LPL4/PM	NRR/LPL4/LA	NRR/DE/EVIB/BC	NRR/LPL4/BC	NRR/LPL4/PM
NAME	AWang	JBurkhardt	SRosenberg JPoehler for *	MMarkley (FLyon for)	AWang
DATE	8/15/12	8/6/12	7/30/12	8/16/12	8/17/12

OFFICIAL AGENCY RECORD