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Acting Director
Nuclear Safety & Licensing

CNRO-2006-00009

February 24, 2006

U. S. Nuclear Regulatory Commission
Attn.: Document Control Desk
Washington, DC 20555-0001

SUBJECT: Request for Alternative W3-R&R-005
Proposed Alternative to ASME Requirements for Evaluating Postulated Flaw Remnants

Waterford Steam Electric Station, Unit 3
Docket No. 50-382
License No. NPF-38

REFERENCE: NRC letter to Arizona Public Service Company, "Palo Verde Nuclear Generating Station, Units 1, 2, and 3 – Relief Request No. 29 RE: Remnant Sleeve(s) Flaw Evaluation (TAC Nos. MC3606, MC3607, and MC3608)," dated November 5, 2004.

Dear Sir or Madam:

Pursuant to 10 CFR 50.55(a)(3)(i), Entergy Operations, Inc. (Entergy) proposes alternatives to the flaw evaluation methodology and acceptance criteria basis requirements of ASME Section XI IWB-3610. As documented in Request for Alternative W3-R&R-005 (see Enclosure 1), Entergy proposes to use these alternatives to support our efforts to ensure that the pressurizer at Waterford Steam Electric Station, Unit 3 (Waterford 3) remains within Code allowable values if subjected to the recently-identified insurge/outsurge transient loading conditions.

The NRC staff approved a similar request for Palo Verde Nuclear Generating Station, as documented in the referenced letter.

Entergy requests NRC approval by November 1, 2006 in order to support startup activities from Waterford 3's upcoming fall 2006 refueling outage (RF-14). Should you have any questions regarding this submittal, please contact Guy Davant at (601) 368-5756.

A047

This letter contains commitments as identified in Enclosure 2.

Very truly yours,

FGB/GHD/baa

Enclosures: 1. Request for Alternative W3-R&R-005
2. Licensee-Identified Commitments

cc: Mr. W. A. Eaton (ECH)
Mr. J. E. Venable (W3)

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ENCLOSURE 1

CNRO-2006-00009

REQUEST FOR ALTERNATIVE
W3-R&R-005

ENTERGY OPERATIONS, INC.
WATERFORD STEAM ELECTRIC STATION, UNIT 3
REQUEST FOR ALTERNATIVE
W3-R&R-005

I. COMPONENTS

Component/Number: Pressurizer RC-MPZR-0001

Description: Pressurizer Heater Sleeves, Pressurizer Instrument Nozzles

Code Class: 1

References:

1. ASME Section XI, 1992 Edition with portions of the 1993 Addenda as listed in Reference 8
2. ASME Section XI, 2004 Edition, 2005 Addenda
3. ASME Section III, 1965 Edition, Summer 1967 Addenda
4. ASME Section III, 1968 Edition, Summer 1970 Addenda
5. ASME Section III, Subsection NB, 1971 Edition, Summer 1971 Addenda
6. ASME Section III, Subsection NB, 1971 Edition, Summer 1972 Addenda
7. ASME Section III, Subsection NB, 1989 Edition
8. CEP-ISI-001, *Waterford 3 Steam Electric Station Inservice Inspection Plan*
9. W. H. Bamford, G. L. Stevens, T. J. Griesbach, and S. N. Malik, *Technical Basis for Revised P-T Limit Curve Methodology*, ASME Pressure Vessel and Piping, Codes and Standards, 2000, Vol. 407, pp. 169-178
10. NRC letter to Arizona Public Service Company, *Palo Verde Nuclear Generating Station, Units 1, 2, and 3 – Relief Request No. 29 RE: Remnant Sleeve(s) Flaw Evaluation (TAC Nos. MC3606, MC3607, and MC3608)*, dated November 5, 2004
11. NRC letter to Entergy Operations, Inc., *Arkansas Nuclear One, Unit No. 1 – RE: Proposed Alternatives to Weld Repair and Examination Requirements for Repairs of Reactor Vessel Head Penetration Nozzles (TAC No. MB9660)*, dated September 29, 2004

Unit / Inspection Interval: Waterford Steam Electric Station, Unit 3 (Waterford 3) / Second (2^{nd}) 10-Year Interval

II. CODE REQUIREMENTS

The ASME Section XI code of record for Waterford 3 is the 1992 Edition with portions of the 1993 Addenda as identified in the Waterford 3 Inservice Inspection Plan (Reference 8). Sub-article IWB-3610 specifies: (1) that flaws in ferritic steel components be evaluated by analyses described in Section XI Appendix A; and (2) the acceptance criteria for the flaw evaluation. Section XI Appendix A provides a procedure for determining the acceptability of flaws based on linear elastic fracture mechanics (LEFM) methodology.

III. PROPOSED ALTERNATIVE

A. Background

The Waterford 3 pressurizer contains 30 heater sleeves, four top-mounted instrument nozzles, one side-mounted instrument nozzle, and two bottom-mounted instrument nozzles. The original sleeves and instrument nozzles were made from Alloy 600 material, a nickel-based alloy that has been found to be susceptible to primary water stress corrosion cracking (PWSCC). The attachment weld to the inside surface of the pressurizer is made with an Alloy 82/182 filler material that is a nickel-based alloy that is also susceptible to PWSCC. The pressurizer is manufactured from SA-533, Grade B, Class 1 low alloy steel. There is an Alloy 600 overlay on the inside surface of the pressurizer bottom head at the intersection of the heater sleeve and bottom mounted instrument nozzle penetrations that reinforces the pressurizer bottom head. There is stainless steel cladding on the inside surface of the pressurizer shell at the intersection of the side mounted temperature nozzle.

To address the industry problems encountered with Alloy 600, Entergy took actions to remove all Alloy 600 nozzles used in the Waterford 3 pressurizer and replace them with PWSCC-resistant Alloy 690 material. In all cases, remnant Alloy 600 material was left in place, although serving no pressure boundary function.

In 2003, Westinghouse Electric Company identified a potential new pressurizer insurge/outsurge transient for which Westinghouse and Combustion Engineering designed plants were not originally analyzed. During this postulated event, cooler reactor coolant may surge into the pressurizer introducing substantial thermal transients in the lower regions of the pressurizer.

Evaluations performed by Westinghouse have shown that some earlier thermal and structural analyses did not adequately capture the severity and frequency of these transients on the pressurizer. Consequently, previous evaluations performed in accordance with IWB-3610 do not meet the specified criteria when using the LEFM methodology.

B. Proposed Alternative

Pursuant to 10 CFR 50.55a(a)(3)(i), Entergy proposes alternatives to the flaw evaluation methodology and acceptance criteria basis requirements of IWB-3610 and Section XI Appendix A in order to analyze the effects of the insurge/outsurge transient on the Waterford 3 pressurizer. The alternatives are as follows:

1. <u>Use of Elastic-Plastic Fracture Mechanics</u>

As stated in Section III.A above, remnant Alloy 600 nozzle material was left in place when Entergy removed Alloy 600 nozzles from the Waterford 3 pressurizer. This material may contain pre-existing cracks or may develop cracks in the future. In order to properly analyze the effects of an insurge/outsurge transient on the pressurizer, Entergy proposes an alternative evaluation procedure based on elastic-plastic fracture mechanics (EPFM) techniques for portions of the flaw evaluation rather than using LEFM techniques as specified in Section XI Appendix A. EPFM will be used for loading conditions at plant operating temperature and, therefore, in the Charpy V-Notch upper shelf regime for the low alloy steel pressurizer material. LEFM analysis will be used for transient loading conditions at low temperatures.

2. <u>Use of Stress Intensity Factor $K_{1c}/\sqrt{2}$</u>

The acceptance criterion for the structural analysis required by IWB-3610 is specified in IWB-3613. The IWB-3613 acceptance criterion for flaws is $K_{1a}/\sqrt{2}$ where the temperature is above RT_{NDT} + 60° F and the pressure is below 20% of the design pressure. The calculated stress intensity factor (SIF) for the postulated flaw size may be near the allowable flaw size when the allowable value is $K_{1a}/\sqrt{2}$. Entergy requests that an allowable SIF of $K_{1c}/\sqrt{2}$ rather than $K_{1a}/\sqrt{2}$ be approved, where the temperature is above RT_{NDT} + 60°F and the pressure is below 20% of the design pressure.

IV. BASIS FOR PROPOSED ALTERNATIVE

Entergy will perform LEFM and EPFM analyses of a postulated flaw in the Alloy 600 remnant nozzle and associated remnant J-groove weld material for the Waterford 3 pressurizer. These analyses will demonstrate that a flaw will not affect the integrity of the pressurizer lower head. These analyses will be similar to those performed for the Palo Verde Nuclear Generating Station, Units 1 and 3, as approved by the NRC (Reference 10). In addition to Palo Verde, the NRC staff approved the use of EPFM techniques for evaluating flaws left in reactor pressure vessel head penetration nozzles at Entergy's Arkansas Nuclear One, Unit 1 (see Reference 11).

The Palo Verde pressurizer analyses showed that the worst-case flaw in the Alloy 600 remnant nozzle and weld material will remain acceptable in accordance with ASME Section XI for the 40-year plant life and a 20-year life extension. Similar results are expected for the Waterford 3 analyses. Below is a discussion of the EPFM analysis used in the Palo Verde analysis and in the proposed change to the Waterford 3 analysis, and the basis for each.

A. Use of EPFM

The Palo Verde evaluation was based on EPFM for portions of the evaluation. EPFM was used for loading conditions that are at plant operating temperature and, therefore, in the Charpy V-notch upper shelf regime for the low alloy steel pressurizer material. Application of LEFM techniques, such as ASME Section XI Appendix A to materials in this regime, is overly conservative. Section XI contains several alternative procedures for flaw evaluation of ductile materials, such as:

- Appendix C, *Flaws in Austenitic Piping*
- Appendix H, *Flaws in Ferritic Piping*
- Appendix K, *Assessment of RPVs with Low Upper Shelf Toughness*

These procedures utilize EPFM techniques and provide for different safety factors for primary (load-controlled) versus secondary (strain-controlled) loading conditions. They also permit EPFM-based crack stability analysis to allow for the higher ductility of these materials.

An EPFM technique was used for Palo Verde in lieu of the Section XI Appendix A LEFM technique to evaluate assumed cracks in the existing Alloy 600 heater sleeves and weldments that potentially propagate into the low alloy pressurizer base material when at upper shelf temperatures.

The above EPFM techniques and criteria will be used for the Waterford 3 analyses.

B. Use of SIF $K_{1c}/\sqrt{2}$

As was done for Palo Verde, LEFM analysis will be used for loading conditions that are below plant operating temperatures and below the Charpy V-notch upper shelf regime for the low alloy steel pressurizer material. However, Entergy is requesting relief from the acceptance criterion for these analyses, stated in Section XI, IWB-3613. Entergy proposes that in lieu of the $K_{1a}/\sqrt{2}$ acceptance criterion for flaws where the temperature is above RT_{NDT} + 60° F and pressure is below 20% of the design pressure, the acceptance criterion be $K_{1c}/\sqrt{2}$. The basis for the use of K_{1c} rather than K_{1a} for the above case is the precedent set in ASME Section XI for use of K_{1c} rather than K_{1a} in reactor vessel P-T limit curve methodology in Code Case N-640 and now incorporated into ASME Section XI Appendix G. The arguments for the use of K_{1c} rather than K_{1a} in Appendix G were based on reasons that are summarized in the Technical Basis Document for the changes made to Code Case N-640 and Appendix G (Reference 9). These same reasons are applicable to the pressurizer heater sleeve remnant evaluations and are summarized as follows:

- Specific to Pressurizer Application - Use of the static lower bound fracture toughness, K_{1c}, reflects a more accurate fracture toughness value of the pressurizer than use of dynamic/arrest fracture toughness, K_{1a}. This is because the heatup and cooldown processes in operating nuclear plants are very slow-changing processes. The fastest heatup/cooldown rate allowed is typically 100°F/hour. For this rate of change, the rate of change of pressure and temperature is often constant, so the resulting stresses are essentially constant. Therefore, both the heatup and cooldown processes, as well as pressure test conditions that have little or no thermal stress, are essentially static processes. In fact, with regard to fracture toughness, all operating transients (levels A, B, C, and D) correspond to static loading conditions.

- Large Margin - Use of the historically large margin of K_{1a} is no longer necessary because of the availability of significantly more information about the uncertainties (e.g., flaw size and fracture toughness) and postulated (but unqualified) effects (e.g., local brittle zones) that were covered by the use of the more conservative K_{1a}.

- Fracture Toughness - Since the original formulation of the K_{1a} and K_{1c} fracture toughness curves in 1972, the fracture toughness database has increased by more than an order of magnitude; both K_{1a} and K_{1c} remain lower bound curves. In addition, the temperature range over which the data have been obtained has been extended to both higher and lower temperatures than the original database.

- Local Brittle Zones - Experience has shown that the postulated local brittle zones in the weld or heat-affected-zone of the base material that could have justified the use of K_{1a} to account for a dynamically moving cleavage crack, do not exist in operation or experimentally at a level that would justify the use of the more conservative K_{1a} to account for this postulated condition.

- Code Change - A Code change has been incorporated into Section XI to change the acceptance criteria used in Paragraphs IWB-3612 and IWB-3613 from the use of K_{1a} to K_{1c} (Reference 2).

V. CONCLUSION

10CFR50.55a(a)(3) states:

"Proposed alternatives to the requirements of (c), (d), (e), (f), (g), and (h) of this section or portions thereof may be used when authorized by the Director of the Office of Nuclear Reactor Regulation. The applicant shall demonstrate that:

(i) The proposed alternatives would provide an acceptable level of quality and safety, or

(ii) Compliance with the specified requirements of this section would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety."

Entergy believes that the proposed alternative to use the EPFM analysis technique and SIF value of K_{1c} rather than K_{1a}, both discussed in Section IV, provides an acceptable level of quality and safety. Entergy will augment existing LEFM flaw evaluations utilizing the EPFM technique and K_{1c} to demonstrate compliance with ASME Section XI criteria for the life of the plant, including a 20-year life extension. Therefore, Entergy requests that the NRC staff approve the proposed alternative pursuant to 10 CFR 50.55a(a)(3)(i).

ENCLOSURE 2

CNRO-2006-00009

LICENSEE-IDENITIFIED COMMITMENTS

LICENSEE-IDENTIFIED COMMITMENTS

COMMITMENT	TYPE (Check one)		SCHEDULED COMPLETION DATE
	ONE-TIME ACTION	CONTINUING COMPLIANCE	
1. Entergy will perform LEFM and EPFM analyses of a postulated flaw in the Alloy 600 remnant nozzle and associated remnant J-groove weld material for the Waterford 3 pressurizer. These analyses will demonstrate that a flaw will not affect the integrity of the pressurizer lower head. These analyses will be similar to those performed for the Palo Verde Nuclear Generating Station, Units 1 and 3.	✓		
2. LEFM analysis will be used for loading conditions that are below plant operating temperatures and below the Charpy V-notch upper shelf regime for the low alloy steel pressurizer material.	✓		