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10 CFR 50.55a

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

Three Mile Island, Unit 1
Operating License No. DPR-50
NRC Docket No. 50-289

Subject: Additional Information Concerning a Proposed Alternative Associated with the Use of a Weld Overlay

Reference: Letter from Michael P. Gallagher (AmerGen Energy Company, LLC), to U. S. Nuclear Regulatory Commission, dated November 3, 2003

In the Referenced letter, AmerGen Energy Company (AmerGen) requested a proposed alternative in accordance with 10 CFR 50.55a, "Codes and standards," paragraph (a)(3)(i). This proposed alternative would permit the use of a full structural weld overlay repair for an indication identified in the steam generator "A" hot leg surge line nozzle-to-safe end weld. In response to a conference call between AmerGen and the U. S. Nuclear Regulatory Commission staff dated November 5, 2003, attached are responses to several questions discussed during the call.

If you have any questions, please contact us.

Very truly yours,

Michael P. Gallagher

Michael P. Gallagher
Director, Licensing and Regulatory Affairs
AmerGen Energy Company, LLC

Attachment – Response to Additional Questions

cc: H. J. Miller, Administrator, Region I, USNRC
D. M. Kerns, USNRC Senior Resident Inspector, TMI
D. M. Skay, USNRC Senior Project Manager
File No. 01086

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RESPONSE TO ADDITIONAL QUESTIONS REGARDING ALTERNATIVE REPAIR FOR SURGE NOZZLE-TO-SAFE END WELD

Reference: Letter from Michael P. Gallagher (AmerGen Energy Company, LLC), to U. S. Nuclear Regulatory Commission, dated November 3, 2003

Question:

1. The ISI Code of record is the 1995 Edition with 1996 Addenda. Is this the edition/addenda that will be used for the repair and replacement inspection? If not, what will be used.

Response:

The Three Mile Island, Unit 1 (TMI) Third Ten-Year Interval Inservice Inspection (ISI) Program complies with the requirements of the 1995 Edition through 1996 Addenda, of the ASME, Section XI Code (ISI Code). Paragraph IWA-4150(b) of the ISI Code requires the Edition and Addenda of Section XI used for the Repair/Replacement Program correspond with the Edition and Addenda identified in the ISI Program applicable to the inspection interval.

Paragraph IWA-4410(a) of the ISI Code also requires repair/replacement activities, including but not limited to defect removal, welding, heat treatment, inspection and testing, meet the requirements of the original Construction Code of the component or system. The Construction Code of record for the surge line nozzle-to-safe end weld, SR0010BM, is USAS B31.7, draft 1968 Edition including June 1968 Errata (Construction Code).

Question:

2.0 On page 3 in the degradation mechanism section of the submittal, the thermal fatigue mechanism is identified as being oriented circumferentially, being single faceted, and not confined to the nickel weld metal. Thermal fatigue cracks have acoustic responses with characteristics ranging from single-to-multi faceted, and they can be of various orientations (see the pictures in NUREG-0619). Since the depth of the flaw is not known, the conclusion that the crack is confined to the weld material may be incorrect. Instead, the crack may not have grown sufficiently to extend past the weld.

2a. Because the UT is inconclusive in identifying the failure mechanism, provide a discussion on the growth rate of the axial crack for a postulated PWSCC and for a postulated thermal fatigue crack.

Response:

Evidence suggests that the axial flaw is due to PWSCC. We are conservatively addressing both PWSCC and fatigue in the flaw evaluation for crack growth for the weld overlayed condition. PWSCC crack growth is unlikely, because the stress field will be compressive at the crack tip. However, for conservatism, the crack growth rate of 1 mil per year, or approximately 1 KSI square root inch, will be used in the PWSCC for crack growth assessment. The 1 mil per year value is consistent with the current position of the MRP expert panel on PWSCC.

The fatigue crack growth rate will be determined based on the methodology and information provided in NUREG/CR-6721.

The basis for our conclusion that PWSCC is the operative mechanism is contained in the paragraphs below.

The surge line weld (SR-0010BM) has one axial flaw. The axial flaw was detected using a qualified manual technique for detection. This axial flaw was verified through the use of a PDI qualified automated system which also provided depth sizing of the axial flaw. The single flaw detected was axially oriented with a depth of 0.48".

The axial flaw has been determined to be in a region that was previously repaired during original fabrication of the dissimilar metal weld. This is consistent with other PWSCC cracks observed in the V. C. Summer hot leg and the Tsuruga pressurizer nozzle. In addition, Ringhals 3 and 4 also found axial cracks determined to be PWSCC. Local ID repairs result in residual stresses that tend to drive axial crack into the pipe wall. The normal operating temperature in the location of the TMI axial flaw is approximately 602 degrees F, which makes it a highly susceptible location to PWSCC.

The NDE inspection results indicated that the axial flaw does not extend into the carbon steel (A 105 Grade 2) material or the austenitic stainless steel material on either side of the Alloy 182/82 weld. This is consistent with previously mentioned PWSCC cracks; they are confined to the Alloy 182/82 weld and butter material. In addition, during the scanning, NDE personnel skewed the transducer, which showed a response of a faceted crack typical of a branched PWSCC crack.

Therefore, the TMI flaw is consistent with PWSCC based on our field inspections and since it is also consistent with industry experience with confirmed PWSCC cracks.

<u>Question</u>:

3.0 On pages 1 and 2 of the submittal, the section on "Applicable Code Requirement" states code requirements. On page 5 of the submittal, the section on "Reason for Request" also states code requirements. The Section on "Proposed Alternative and Basis for Use" does not address any of the Code paragraphs but instead proceeds to propose changes to code cases. The spreading of what appears to be requirements throughout the submittal is confusing. The staff gives relief to specific Code requirements, which should be identified, in a section of Code requirements for which relief is being requested. The justification should be explicitly linked to the Code requirement for which relief is being requested.

3a. Is this request specifically for "the complete removal of a flaw" requirement in the paragraphs referenced in the section on page 5 "Reason for Request."

<u>Response</u>:

Refer to Table 1. Reference to the complete removal of the flaw has been included.

Question:

3b. On page 5 in the section on the "Proposed Alternative and Basis for Use", the first sentence states that a full structural weld overlay repair is proposed. Does this sentence mean that the weld overlay would satisfy all the structural design requirements of the pipe if the pipe were not there?

Response:

A full structural overlay is designed by postulating a fully circumferential through-original pipe wall flaw. This assumption does not take any credit for the remaining ligament when a circumferential flaw is present (only an axial flaw exists).

A full structural weld overlay repair will return the surge line in its currently degraded condition conforming with all aspects of the current licensing basis, including codes, standards, design criteria, and commitments. The weld shall be of a sufficient size as to accept, transmit and react to all design basis loads and load combinations under limiting design load conditions.

In addition, the ASME Code Section XI requirements that no flaw be greater than 75% of wall must also be assured. Note that in this case, the 75% of wall is the governing requirement and thus the safety margins are larger than required based on stress.

Question:

4.0 The Code Case N-504-2 is endorsed in RG 1.147. The proposed modifications to the code cases do not provide technical justification for expanding the code case for dissimilar metal welds, Provide a technical justification discussion.

4a. The weld metal is high in chromium and nickel and the carbon base material is high in carbon. As a result of diffusion, a new alloy is formed in the first layer of weld overlay on carbon steel. This new alloy has less chromium and nickel and more iron and carbon than a weld made with Inco Alloy 52/152 weld wire (Alloy N06690). What are the estimated crack growth and corrosion characteristics of this new alloy? How resistant is this new alloy to PWSCC? Provide technical data that the new alloy is not detrimental to the design criteria for the weld overlay.

Response:

The initial weld layer, and in fact the initial two weld layers, will have an intermediate composition lying between that of the SA 105 carbon steel nozzle and the Alloy 52 weld metal compositions due to dilution. The bead composition is dependent upon various welding variables, such as heat input, wire feed, travel speed, and consequently, the diluted first layer or second layer alloy composition cannot be predicted with great confidence. This item was addressed in 1986 when the first temper-bead weld overlay was applied to a core spray nozzle to safe end weld at Vermont Yankee. During that qualification project, a weld overlay mockup was fabricated depositing an Alloy 82 weld overlay on an SA 508 Class 2 low alloy steel nozzle using the temper-bead weld parameters to be used in the field application. The results of that investigation are provided in EPRI Report NP-7085-D, Section 6. The mockup was sectioned after the overlay application and the composition of each layer was determined. It is noteworthy that the composition did not approach that of Alloy 82 until the third layer was deposited. It is also noteworthy that that overlay (at Vermont Yankee) is still in service, with no crack extension observed.

Based upon the Vermont Yankee study, and the concern about dilution and the undefined nature of the alloy produced in that diluted layer, it was decided that the weld overlay repair for the surge nozzle at TMI would not take credit for the initial two overlay layers as PWSCC resistant. It is recognized that the initial two layers can be alloy rich or base metal rich in composition, depending on the welding parameters used. In addition, we are taking steps during welding with bead placement to minimize dilution by overlapping beads.

This application of dissimilar metal welding to low alloy steel nozzles is not new to this weld overlay application. Every nozzle buttered with Alloy 182 prior to performing the butt weld contains a similar dilution zone. Many of the OD weld pad repairs to Combustion Engineering nuclear power plant pressurizer instrument or heater penetrations were fabricated from Alloy 82 or 52 and involved a similar dilution zone as the pad was welded onto the pressurizer shell. These welds have likely been exposed to the PWR environment and there has been no reported incident of PWSCC. Note that several BWRs have also had weld overlays applied at dissimilar metal locations and have operated without reported incidents utilizing 52 filler metal.

In summary, the concern regarding the composition of the dilution layer(s) when welding Alloy 52 over carbon steel is acknowledged. To address this issue, the initial two weld layers have been not counted as part of the thickness of the structural weld overlay for PWSCC considerations for the TMI surge nozzle repair. It is noted, however, that dissimilar metal welds of this type have been performed in the PWR industry since initial plant fabrication. Furthermore, many of the PWSCC repair concepts currently in use, including the OD weld pad buildup used extensively in repairs to pressurizer penetrations, have employed this type of dissimilar metal weld repair without reported incidents.

Question:

4b. Page 7 states that the ASME Section XI Code requirements or alternatives approved by the NRC for pressure testing will be used in lieu of Paragraph (h). Identify the specific code (paragraph or code case) that will be applied in lieu of Paragraph (h).

Response:

The discussion on pressure testing requirements is a point of clarification and not the basis for a request for alternative. In following the Code Case N-504-2 methodology and Construction Code reconciliation, both stipulate the performance of a hydrostatic pressure test, which denotes the performance of an elevated pressure test at some multiple of the system design pressure. This requirements for this repair/replacement activity, i.e. pressure testing, are determined by the station ASME Section XI repair/replacement Program, which stipulates the performance of a system leakage test at normal operating pressure. See Table 1 for details.

Question:

5.0 Page 7 of the submittal discusses the band around the area of at least one and one-half time the component thickness .... be examined using UT and PT. For this repair, what is the distance for the band around the area that is required to be examined? On page 10, Figure 1, the proposed preservice inspection stops at the edges of the overlay, and on page 8, Table 2, it states that the preservice examination of the completed weld overlay and examination of the "band" 2-inches outward from the toe of the weld around the entire circumference of the nozzle after 48 hours. Discuss the differences between the proposed alternative and Code/code case requirements?

Response:

The surge line nozzle-to-safe end weld overlay repair has been designed to eliminate the addition of a stress riser on the nozzle side OD and to increase its UT inspectability and as such, is larger than would be required by design loading considerations only. The effects of this larger design on the PSI and ISI examination requirements is discussed in Table 1.

Question:

6.0 The submittal proposes using N-504-2 and N-638 with changes. Are the changes part of this relief request? If so, Identify in the section on "Reason for Request" the specific part(s) or paragraph(s) in Code from which the licensee will need relief. Provide a technical justification in the "Basis for the Relief ".

Response:

As discussed previously, the surge line nozzle-to-safe end weld overlay repair requests approval for alternatives to the Construction Code requirements. No changes to Code Case N-504-2 and N-638 requirements are being requested. The Code Cases provide the guidance for making weld overlay repairs using ASME and NRC approved methodology. They provide support to the technical basis for approving the proposed alternatives to the Construction Code requirements.

Question:

7.0 The Code Case N-638 is endorsed in RG 1.147. Page 6 in the submittal discussed using a SMAW procedure for weld repair and seal welding if needed. N-638 is applicable for the automated GTAW process not SMAW. Does the request for relief include using SMAW in lieu of the automated GTAW process endorsed in N-638? Is this part of the request for relief?

Response:

No, all requirements of N-638 will be complied with when welding on the P1 carbon steel material for the required temper bead thickness of the overlay. Exceptions to the methodology of N-638 were identified in the proposed alternative.

Question:

8.0 On page 7 under number 1, the statement is made that the repair area may exceed 100 sq. inches and be greater than 1/2 the base metal thickness. What will these dimensions be? How large in area and thickness will the weld be? A technical justification is needed for these deviations from the code case. Will there be excessive distortion of the weldment? Will there be cracking due to weld contraction stresses?

Response:

The repair area on the nozzle is estimated to be approximately 163 in^2. The overlay thickness on the nozzle will be 0.51" plus two layers (on the order of 0.15" to 0.2") to compensate for dilution.

Several similar weld overlays have been applied to operating BWRs (Nine Mile Point 2, Perry, Duane Arnold) with similar geometry and overlay dimensions. In addition, a nozzle weld build-up was applied to V. C. Summer using the 30 Cr Ni based weld metal (Alloy 52/152) well in excess of the 100 in^2 limit. Studies have been performed by EPRI in qualifying weld overlays for application to BWRs and in these instances have shown no issue with shrinkage stress, or weld contraction stresses, etc. The TMI overlay design is generally similar to that design applied many times in feedwater, core spray, and recirculation nozzles in BWRs. Note that weld shrinkage caused by the overlay application will be measured and the impact on the system determined consistent with ASME Code Case N-504-2.

The 1/2 base metal thickness applies only to excavations and repairs, and is not applicable to the TMI case.

A technical justification evaluated the effect of exceeding the 100 in^2 area on a nozzle (see Attachment 1). Results of this evaluation show that based on a comparison of the residual stress results for the >100 in^2 case and the 100 in^2 case, there is no detrimental effect caused by the added welding in excess of the 100 sq. inch limit.

TABLE 1
COMPARISON OF CODE REQUIRMENTS

Section XI Requirements	Related Construction Code, B31.7, Requirements	Proposed Alternatives & Basis
IWA-4410(a) states in part – "Repair/replacement activities shall be performed in accordance with the Owner's Requirements and the Original Construction Code of the components or system, ..."	1-727.7 states in part – "All defects in welds requiring repair shall be removed by grinding, chipping, arc, or flame gouging, or machining. ..."	Alternative to Code: A full structural weld overlay repair, which extends around the full circumference of the nozzle-to-safe end weldment, is proposed in lieu of repair by defect removal. The weld overlay will be structurally designed using the methodology of Code Case N-504-2 and will account for PWSCC and fatigue crack growth. Basis: The weld overlay will be designed consistent with the methodology of ASME Code Case N-504-2. The as-left PWSCC defect will be completely covered with Alloy 52 that is highly resistant to PWSCC.
	1-731.2.1(a) states in part – "P-number 1 materials shall be preheated to a temperature of 175° for material that has both a specified maximum carbon content in excess of 0.30% and a thickness in excess of 1 in. ..." 1-731.3.1(a) states in part – ".... Except as otherwise specifically provided in the notes of Table 1-731.3.1, all welds shall be given a post-weld heat treatment at a temperature not less than that specified in Table 1-731.3.1.	Alternative to Code: Temper bead welding approach will be used following the methodology of Code Case N-638, which provides for machine gas tungsten-arc welding (GTAW) temper bead welding to P-No.1 nozzle material at ambient temperature. Temper bead welding supplants the requirement for the preheat and post weld heat treatment of the heat-affected zones in welded carbon steel material. Welding will be performed with water backing. The maximum welded area on the P-No.1 material will be approximately 163 in^2.

Section XI Requirements	Related Construction Code, B31.7, Requirements	Proposed Alternatives & Basis
	Table 1-731.3.1 and associated Footnote 4 require a post-weld heat treatment at 1100°F at minimum hold time of 1 hr/in of weld thickness.	A nickel-based alloy weld filler material, commonly referred to as Alloy 52, will be used. Basis: Temper bead welding technique produces excellent toughness and ductility in heat affected zones of welded carbon steel materials, and, in this case also result in compressive residual stresses on the inside surface, which helps inhibit PWSCC. The size of the weld overlay is based on engineering analysis. Alloy 52 contains about 30% chromium that imparts excellent corrosion resistance to PWSCC. This filler material is more suitable for welding over the carbon steel nozzle, Alloy 182/82 weld, and stainless steel safe-end.
IWA-4520(a) states – "Welding or brazing areas and welded joints made for installation of items shall be examined in accordance with the Construction Code identified in the Repair/Replacement Plan."	1-727.4.2(e).1 states – "All girth butt welds shall be examined 100% by radiography in accordance with the method set forth in Appendix B-1 and shall meet the acceptance criteria of Appendix B-1."	Alternative to Code: The complete weld overlay will be examined by surface examination and ultrasonic testing methods after a 48-hours post weld hold period. PDI qualified procedure and personnel will be used to perform the UT examination. The required examination surface area and volume are identified in Table 2 and Figure 1 of the referenced submittal. Post weld/preservice surface examination of the base materials will be limited to a 2" band around the entire circumference of the P-No. 1 nozzle material. The 2" band is measured outward from the toe of the weld overlay on the nozzle side.

Section XI Requirements	Related Construction Code, B31.7, Requirements	Proposed Alternatives & Basis
		Basis: The alternative examination methods are acceptable examination methods of Code Case N-504-2 and N-638. The upper 25% of the base material thickness (original nozzle, buttering, weld, and safe-end) needs to be examined because the full structural weld overlay is designed such that the full thickness of original base materials is no longer required to carry the applicable loads. A post-weld 2 inch band surface examination needs to be performed on the P-No.1 nozzle because of the potential hydrogen induced cracking. Stainless steel material is not known to be susceptible to hydrogen induced cracking, which is support by field experience at BWR's.
IWA-4530(a) states in part – "When portions of items requiring preservice or inservice inspection are affected by repair/replacement activities, or for items being installed, including welded joints made for installation of items, preservice inspections shall be performed in accordance with IWB-2200, ..." IWB-2200(a) states in part – "Examination required by this Article (with the exception of Examination Category B-P, and the visual VT-3 examination of the internal surfaces of Categories B-L-2 and B-M-2, of Table IWB-2500-1) shall be	N/A	Alternative to the Code: The methodology and requirements for the preservice inspections are provide in Table 2 of the Referenced letter. The insevice inspection requirements are provided in Table 3. Basis: These pre-service requirements follow the guidance of Code Case N-504-2 and N-638. The insevice inspection requirements in Table 3 refer to ASME Section XI and the methodology of Code Case N-504-2 and N-638. Re-inspection frequencies have been established based on historical BWR experience.

Section XI Requirements	Related Construction Code, B31.7, Requirements	Proposed Alternatives & Basis
completed prior to initial plant startup. In addition, these preservice examinations shall be extended to include essentially100% of the pressure retaining welds in all Class 1 components, except in those components exempted from examination by IWB-1220(a), (b), or (c). ..." Examination Category B-J, Item No. B9.11 requires surface and volumetric examination to be performed on the surface area and volume identified in Figure IWB-2500-8.		
N/A	1.737.1.1 states in part – "All piping installed shall be tested by a hydrostatic test prior to initial operation to demonstrate leak tightness. ...."	<u>Alternative to Code</u>: System Leakage test following the weld overlay will be performed. <u>Basis</u>: ASME Code Section XI through the 2000 Addenda permits system leakage tests.

ATTACHMENT 1
SUMMARY OF TECHNICAL EVALUTION

An evaluation was performed to determine the effect of exceeding the 100 in^2 area limitation for temper bead welding onto a low alloy steel nozzle. The nozzle was approximately 12 diameter and 1.5" thickness on the nozzle side of the weld. The actual area on which weld overlay was applied on the nozzle material was 126 in^2.

No clear bases for the 100 in^2 area limitation existed so a comparison was made between two weld overlay cases. The first was for a 100 in^2 area and the second was for a 126 in^2 area. Since the 100 in^2 area is considered acceptable per ASME Code, comparing the results will demonstrate the acceptance of the >100 in^2 case if there is no significant difference.

The analysis was performed using elastic-plastic finite element analysis with non-linear material properties and simulation of the as-welded condition and weld overlayed condition.

Results of these evaluations demonstrate that the stress distributions are similar between the two cases. Both cases show that compressive stress remains on the inside surface near the weld, which supports mitigation of degradation mechanisms. In fact, in some cases, the extended overlay results in higher compressive stress than the 100 in^2 case.

Although the focus of this study was the residual stress, it should be noted that the resulting displacements following the 100 in^2 and extended weld overlay cases were very similar. Thus, there appears to be no significant impact of the extended overlay on the resulting displacements.