April 7, 2008

Mr. James H. Riley, Director
Engineering
Nuclear Energy Institute
Suite 400
1776 I Street, NW
Washington, DC 20006-3708

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION RE: NUCLEAR ENERGY INSTITUTE TOPICAL REPORT MATERIAL RELIABILITY PROGRAM (MRP): TECHNICAL BASIS FOR PREEMPTIVE WELD OVERLAYS FOR ALLOY 82/182 BUTT WELDS IN PRESSURIZED WATER REACTORS (MRP-169) (TAC NO. MD 8005)

Dear Mr. Riley:

By letter dated September 7, 2005 (Agencywide Documents and Access Management System (ADAMS) Accession No. ML052520325), the Nuclear Energy Institute (NEI) submitted for U.S. Nuclear Regulatory Commission (NRC) staff review Topical Report (TR) Material Reliability Program (MRP): Technical Basis For Preemptive Weld Overlays For Alloy 82/182 Butt Welds In Pressurized Water Reactors (MRP-169). By letter dated August 3, 2006, the NRC issued a request for additional information (RAI) (ADAMS Accession No. ML062050337). By letter dated January 9, 2008, the NEI provided its response to the RAI (ADAMS Accession Nos. ML080780299 and ML080780301). Upon review of the information provided, the NRC staff has determined that additional information is needed to complete the review.

Additional draft RAI questions were electronically forwarded to the NEI to facilitate the discussion of TR MRP-169 in the public meeting held on February 21, 2008 (ADAMS Accession No. ML080870372). The purpose of this letter is to formally transmit and request the NEI's written response to the enclosed RAI questions. The industry plans to use TR MRP-169 for the weld overlay of dissimilar metal welds in the fall 2008 refueling outage. To meet this schedule, on April 1, 2008, Mike Melton, Senior Project manager, and I agreed that the NRC staff will receive your response to the enclosed RAI questions by April 30, 2008. If you have any questions regarding the enclosed RAI questions, please contact me at 301-415-3610.

Sincerely,

**/RA/**

Tanya M. Mensah, Senior Project Manager
Special Projects Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Project Nos. 669 and 689

Enclosure: RAI questions

cc w/encl: See next page

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REQUEST FOR ADDITIONAL INFORMATION

BY THE OFFICE OF NUCLEAR REACTOR REGULATION

TOPICAL REPORT MATERIAL RELIABILITY PROGRAM (MRP): TECHNICAL BASIS FOR

PREEMPTIVE WELD OVERLAYS FOR ALLOY 82/182 BUTT WELDS IN PRESSURIZED

WATER REACTORS (MRP-169)

NUCLEAR ENERGY INSTITUTE (NEI)

PROJECT NO. 689

The U.S. Nuclear regulatory Commission (NRC) staff generated the following comments and questions after its review of "MRP Letter 2007-053, NRC RAI Response" and the proposed revision to TR MRP-169, which are enclosed in the NEI letter dated January 9, 2008 (Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML080780299 and ML080780301). All section, page, table, or figure numbers cited in the questions below refer to items in TR MRP-169, unless specified otherwise. Questions, such as Response to General Questions 2, refer to items in "MRP Letter 2007-053."

Questions from NRC Staff

1. Response to General Question 2. Table 1 (the same as Table 4-1 in TR MRP-169) summarizes requirements for the design, inspection, and crack growth calculations of the weld overlay (WOL).

(A) Discuss whether licensees must follow these requirements or if they are guidance that licensees may or may not follow.
(B) Discuss whether licensees are allowed to use some, but not all requirements (i.e., is cherry picking the requirements allowed?).
(C) Licensees have relied on the American Society of Mechanical Engineers (ASME) Code Case N-740, "Dissimilar Metal Weld Overlay for Repair of Class 1, 2, and 3 Items, Section XI, Division 1," in relief requests for NRC approval to install WOLs without using TR MRP-169. Discuss how TR MRP-169 will be used in weld overlay relief requests. Discuss how code cases will be used in conjunction with TR MRP-169 in performing weld overlay activities.

2. Response to Inspection Question 7. The NEI stated that inservice inspection (ISI) of the weld overlay includes a weld volume of ½ inch from each dissimilar metal weld toe. Figure 7-3 on page 56 shows a sketch of the WOL ISI volume. Figure 7-3 should clarify the ½ inch extension on both sides of the weld toe with a footnote (similar to the footnote in Code Case N-740-1 or Appendix Q, "Weld Overlay Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping Weldments" to the ASME Code, Section XI, "Rules for Inservice inspection of Nuclear Power Plant Components." The footnote should clarify whether butter and heat affected zone, if applicable, will be included in the examination volume.

ENCLOSURE

3. Stress Analysis Question 1. TR MRP-169 requires calculations be performed for primary water stress corrosion cracking (PWSCC) and fatigue. Describe the calculation methodology in detail.

4. Section 4.0. The NEI revised certain sections of TR MRP-169, Revision 0, in particular as Section 4, 5, 7, 9, and 10. Please discuss whether any other sections of TR MRP-169 will be changed as a result of the RAI responses.

5. On page 33, Section 4.0, NEI states that the minimum WOL thickness is 1/3 of the pipe thickness.

(A) Discuss whether there is a limit for the maximum WOL thickness beyond which the WOL will cause detrimental effect on the pipe. Discuss whether this upper bound in WOL thickness will be specified in TR MRP-169 to avoid over-design of the WOL thickness.
(B) The NRC staff has concerns if a WOL is installed on a degraded WOL. Explain the TR MRP-169 position on the use of WOL for more than one time application to any specific degraded dissimilar metal weld (DMW).

6. On page 34, the NEI stated that "…There are cases in which the original DMW configuration does not permit full coverage of the pre-overlay exam volume by qualified techniques (i.e., due to cast stainless steel or geometric limitations), or where flaw indications greater than 50% (but less than 75%) through-wall are detected. An optimized weld overlay (OWOL) may still be applied in such situations, subject to a plant-specific, nozzle specific technical justification demonstrating that the observed or postulated worst-case flaw will not violate the OWOL design basis…."

Clarify how the OWOL design can be carried out under either of the conditions noted above (i.e., less that complete coverage with a qualified examination or a flaw greater than 50 percent but less than 75 percent through wall).

7. On page 34, last sentence, NEI states that the $0.75\sqrt{Rt}$ recommendation [for the axial length of the overlay] is only a rule of thumb, and that shorter lengths may be used if justified by stress analysis of the specific preemptive weld overlay (PWOL) configuration, to demonstrate that adequate load transfer and stress attenuation are achieved. In relief requests, the NRC staff would need to review use of shorter lengths than $0.75\sqrt{Rt}$ and would so state in any safety assessment report on MRP-169. Justify the use of a weld overlay axial length that is shorter than $0.75\sqrt{Rt}$.

8. On page 36, first paragraph, the NEI states that if the inside surface stresses are less than 10 ksi tensile, then PWSCC cracks will not be able to initiate. There has not been any evidence of a threshold value of stress intensity factor (K) for PWSCC growth. If we are operating on the basis that there is no threshold value of K for growth, it appears that this may be in contradiction with a premise that cracks can not initiate at stresses less than 10 ksi. Please address the basis for your statement on crack initiation.

9. Section 5.0. Please submit a proprietary and non-proprietary version of the TR MRP-208, "Development of Preemptive Weld Overlay (PWOL) for Alloy 600 PWSCC Mitigation" report.

10. Section 7.2 does not appear to have a successive inspection requirement for the case when a new indication or growth of existing indications is observed in either the weld overlay or in the original weld. ASME Code Case N-740-1 provides acceptable inspection strategy for successive examinations. Please address actions to be taken when a new indication or growth of existing indications is observed in either the WOL or in the original weld.

11. Discuss how users of TR MPR-169 would inspect cast austenitic stainless steel (CASS) components and how to analyze the CASS components (e.g., postulated flaw size) when the WOL is installed on a CASS component.

12. In the recent WOL installations, licensees have been applying a sacrificial layer made of austenitic stainless steel weld metal on the austenitic stainless steel pipe prior to installing the Alloy 52M WOL to prevent potential cracking. Licensees have included this information in their relief requests. Discuss whether this information needs to be included in TR MRP-169, Revision 1.

13. The ASME Section XI code cases related to WOLs (e.g., N-740) provide requirements in the following areas that may not be addressed in TR MRP-169 to the same level of detail: (a) acceptance, preservice, and inservice examinations of the weld overlay, (b) crack growth calculations, (c) identification of applicable base and weld metal, (d) acceptance criteria for laminar flaws in the weld overlay, and (e) allowable Chromium content in the weld overlay. Please address how the requirements in these areas are addressed by TR MRP-169 or a user of TR MRP-169.

14. For full structural WOL repair without pre-WOL inspection as shown in Table 4-1, TR MRP-169 states that for crack growth calculation, the assumed 75 percent flaw shall not exceed the design basis flaw size in next inspection interval. In its relief request reviews, the NRC staff has asked licensees to address a larger initial crack should a flaw be detected in the outer 25 percent region of the pipe wall. That is, if a flaw is detected in the outer 25 percent pipe thickness region, the as-found flaw should be added to the assumed 75 percent through wall flaw in the crack growth calculation. Discuss how TR MRP-169 addresses the initial flaw size when the post overlay inspection identifies a flaw in the outer 25 percent of the original pipe wall.

15. TR MRP-169 states that the required examination volume for the OWOL includes the weld overlay thickness and outer 50 percent of the pipe thickness. However, the ASME Code, Section XI, Appendix VIII, "Performance Demonstration for Ultrasonic Examination Systems" has not issued a supplement to address the inspection of OWOL (i.e., weld overlay thickness and the outer 50 percent pipe wall). Please address how the level of inspection qualification for OWOL equivalent to full structural WOLs to be demonstrated and implemented through ASME or other requirements.

16. The Proposed Response to Inspection Question 7 notes that ASME Code Case N-460, "Alternative Examination Coverage for Class 1 and 2 Welds, Section XI, Division 1" coverage requirements apply to overlay preservice and inservice inspections. ASME Code Case N-460 was not written to address the situation where an active degradation mechanism exists and where the results of the inspection are to be relied upon for design and flaw evaluation. The NRC staff does not agree to this limitation in N-460 in the context of WOL relief requests.

17. Table 1 on page 2 of the response uses the expression, “WOL + outer 25% of Code DMW exam volume.” The NRC staff understands that the aforementioned requirement is based on the examination figures on page 56. However, the DMW examination volume per ASME Code, Section XI does not include the outer 25 percent of the examination volume. Please correct this discrepancy.

18. The first paragraph of the proposed response to Inspection Question 1 states that “…an optimized weld overlay may be used either preemptively or as a repair for observed flaw indications up to 50% through wall, as long as the crack growth analysis demonstrates that the observed flaw would not violate the OWOL design basis in the normal ASME Section XI inspection interval of ten years ….”

The NRC staff recommends that the above statement be revised to read “…an optimized weld overlay may be used either preemptively or as a repair for observed flaw indications up to 50% through wall, as long as the crack growth analysis demonstrates that the observed flaw would not violate the OWOL design basis in the normal ASME Section XI inspection interval of ten years and the WOL + 50% of the outer pipe wall is inspectable with Appendix VIII qualified personnel and procedures.”

19. This question relates to question 15 above. The responses to the RAI questions on inspection contain a high level discussion of criteria and mockup samples being developed for qualification of OWOL inspection. The status of the development of OWOL criteria and mockups is not clear. It is not clear whether TR MRP-169 plans to rely on demonstration as opposed to qualification. Since OWOL inspection requirements have not been developed (or at least NRC staff has not seen any proposed requirements from the industry), clarify what MRP perceives as the regulatory approach for obtaining NRC staff approval of inspection qualification, in so far as it would apply to review and approval of MRP-169.

20. The Proposed Response to Stress Analysis Question 2 is vague and not particularly informative. Please clarify.

21. The Proposed Response to Fatigue Question 1 indicates that the cumulative usage factor (CUF) = 0.2 criterion is based primarily on engineering judgment. The NRC staff finds this justification inadequate and insufficient. TR MRP-169 assumes that there will be no significant differences in the stress distribution under the same plant thermal transients before and after the PWOL. This should be verified by bounding fatigue calculations, which may form an adequate basis for making this judgment. Justify the use of the “CUF = 0.2” criterion.

22. Section 5 of TR MRP-169 pertains to verification of weld overlay effectiveness. Figures 5-14 and 5-15 on pages 51 and 52 show comparisons of measured and analytically calculated axial and hoop residual stresses on the inside surface of the mock-up nozzle, both pre- and post-overlay. The results do not indicate good agreement between measured and calculated values. The pre-overlay measurements indicate that both the hoop and the axial stresses are not uniformly distributed around the circumference for the pipe and, therefore, the assumption of axisymmetry in the calculation does not appear to be valid. The pre-overlay diagram in Figure 5-14 shows significant measured compressive inside diameter (ID) hoop stresses around the circumference and along the length of the pipe, whereas the calculated ID hoop stresses are all tensile. The largest measured compressive hoop stress is about 70 ksi.

The post-overlay diagram indicates that the largest measured compressive hoop stress is approximately 55 ksi., *smaller* than the pre-overlay stress. As a result of the overlay, the largest measured compressive hoop stress on the ID appears to have actually decreased.

The pre-overlay diagram in Figure 5-15 shows measured ID residual tensile axial stresses in excess of 100 ksi, considerably larger than the largest calculated tensile axial stress and *higher* than the ultimate stress. Likewise, the post-overlay diagram shows a measured compressive axial stress in excess of 100 ksi.

Therefore, either the measurements are unreliable, or the method of calculating the stresses does not reflect the actual pre-overlay and post-overlay stress states, or both. These results cast doubt on the accuracy of the fatigue crack growth calculations, the predictability of the effectively mitigating PWSCC, and on the proposed inspection frequency. Please address these issues.

23. Figures A-1 and A-2 on pages 25 and 26 appear to have an editorial error. Based on the SY and SZ notation, it appears that Figure A-1 compares the hoop stress of the Surge Nozzle Example and the axial stress of PWOL Mockup. A similar error appears to have been made on Figure A-2. Please explain the discrepancy.

24. There are a couple of cases where the proposed responses discuss case specific justification to extend the conditions laid out in TR MRP-169. For example, (a) Proposed Response to Inspection Question 1 discusses configurations that do not permit full coverage of the pre-overlay examination volume by qualified techniques or where flaw indications greater than 50 percent (but less than 75 percent) through-wall may be detected. It also notes that TR MRP-169, Rev. 1 will state that an OWOL may still be applied in such situations, subject to a plant-specific, nozzle specific technical justification. (b) Proposed Response to Inspection Question 3 notes that MRP would like to retain the option of applying an "approved alternative" (i.e., Risk Informed-ISI) to weld overlaid PWR DMWs at some time in the future, pending sufficient experience and technical justification.

For example (a) above, justify why OWOL configurations are allowed for less than full examination coverage or for a degraded weld containing flaws greater than 50 percent through wall. For example (b) above, justify the use of risk-informed ISI to weld overlays when Code Case N-740 provides specific inspection requirements.

25. Submit a proprietary and non-proprietary version of the revised TR MRP-169 (i.e., MRP-169, Revision 1) in its entirety.

<u>Questions from Battelle Columbus Laboratory</u>

1. The second paragraph on page 33 states, "Weld overlay sizing requirements are further defined in Code Case N-504-2...ASME Code Section XI allowable flaw size criteria (IWB-3640 and Appendix C) are used for sizing the weld overlay ...."

ASME Code Case N-504-2, "Alternative Rule for Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping Section XI, Division 1," was developed for stainless steel piping, and as such Appendix C and IWB-3640 of the ASME Code, Section XI would be appropriate. However, these requirements may not apply for DMWs if the crack is near the fusion line of the butter to the ferritic material. There is a very limited set of J-R curves for these DMWs. There is data developed at Battelle Laboratory for the fusion line as part of the Short Cracks program and for the weld metal itself as part of the Large Break LOCA program. Outside of those data the NRC staff is not aware of any other fracture toughness data. It may be premature to universally say that limit load is the governing fracture criteria based on this limited set of data. Using the Dimensionless Plastic Zone Parameter (DPZP) analysis which was developed to distinguish when limit load was valid and when it was not, and using the Short Cracks fusion line fracture toughness data, we saw as part of our review of MRP-140 that for the hot leg geometry the DPZP maximum predicted stress was only about 60 percent of the limit load stress. Please address this comment.

2. In the third paragraph of Section 4.2 on page 35 when discussing the need for weld residual stress analysis for each unique PWOL configuration, the last sentence states, "Several tools exist and have been demonstrated to produce residual stress results that are in agreement with experimental measurements (see Section 5)." The NRC staff is aware that the data has a good deal of scatter. The above statement may be premature until such time as we can better validate these models through the mock-ups both NRC and EPRI are planning on fabricating and testing. Clarify the above statement.

3. The last sentence of the first full paragraph on page 8-2 of TR MRP-169, Revision 0, states, “Since the weld overlay is being applied with Alloy 52 GTAW weld metal, the stress ratio is computed as (Pm + Pb)/Sm, where Sm = 23.3 ksi for Alloy 600 and 690 piping material at 650 degrees F.”

This implies that one will use the weld metal strength properties to define the Sm (or strength properties) for the fracture analysis. In all of the work done at Battelle Laboratory over the years in comparing pipe fracture experiments with analytical results, Battelle obtains the best agreement between the experimental results and analytical results when the base metal strength properties and the weld metal fracture toughness properties are used in analyzing experiments where cracks were in the weld metal. In these types of analyses it would be more conservative to use the lower strength base metal properties in these types of fracture analyses. EPRI agreed with this approach during the work on Advanced Finite Element Analysis. Discuss why this approach is not being used herein.

4. The bottom of page 8-2 and the top of page 8-3 of TR MRP-169, Revision 0, state, “The desired result is that post-WOL residual stress on the inside surface of the nozzle, over the entire region of PWSCC susceptible material, in both the axial and circumferential directions, be sufficiently compressive, such that the total stress, when sustained operating loads are added, remain less than 10 ksi tension. This result will inhibit PWSCC initiation in any direction."

Discuss the consequence where there is already PWSCC in the weld and the 10 ksi tension with operating loads is high enough to open the existing crack faces and allow in corrosive liquid which acts on the more highly stressed crack tip. Is this acceptable?

5. Page 8-11 of TR MRP-169, Revision 0, includes the expression, “Phase = base material property.” Is that the carbon steel or stainless steel base properties for the dissimilar metal welds?

6. TR MRP-169, Revision 0, Table 8-9, 4th column, implies that Crack Opening Displacement values are provided but they are not included. Please clarify.

7. TR MRP-169, Revision 0, Figures 8-2 and 8-6 do not show the thermal sleeve on the ID surface that is typically used for this application. Please clarify.

8. For Figure 8-11 of TR MRP-169, Revision 0, if the thickness of the weld is 0.875 inches (Figure 8-1) and the overlay thickness is 0.3 inches (Page 8-5), then the combined thickness is 1.175 inches, but Figure 8-11 shows through thickness stresses out to 1.3+ inches from the inside surface. Similarly for Figure 8-13, if the thickness of the weld is 1.28 inches (Figure 8-2) and the overlay thickness is 0.44 inches (Page 8-6), the combined thickness is 1.72 inches but Figure 8-13 shows through thickness stresses out to almost 2 inches. Please clarify this discrepancy.

9. Regarding Chapter 8 of TR MRP-169, Revision 0, the welding direction was from the safe end side toward the nozzle for the hot leg and surge nozzle. The spray nozzle was done with the opposite progression from the nozzle side to the safe end side. No mention is made of differences in results with different weld pattern direction. This appears to be a very important issue with weld overlays working properly. Please comment.

cc:

Mr. Anthony Pietrangelo, Vice President
Regulatory Affairs
Nuclear Energy Institute
1776 I Street, NW, Suite 400
Washington, DC 20006-3708
arp@nei.org

Mr. Alexander Marion, Executive Director
Nuclear Operations & Engineering
Nuclear Energy Institute
1776 I Street, NW, Suite 400
Washington, DC 20006-3708
am@nei.org

Mr. Jack Roe, Director
Operations Support
Nuclear Energy Institute
1776 I Street, NW, Suite 400
Washington, DC 20006-3708
jwr@nei.org

Mr. John Butler, Director
Safety-Focused Regulation
Nuclear Energy Institute
1776 I Street, NW, Suite 400
Washington, DC 20006-3708
jcb@nei.org

Mr. Charles B. Brinkman
Washington Operations
ABB-Combustion Engineering, Inc.
12300 Twinbrook Parkway, Suite 330
Rockville, MD 20852
brinkmcb@westinghouse.com

Mike Melton, Senior Project Manager
1776 I Street, NW, Suite 400
Washington, DC 20006-3708
man@nei.org

Mr. James Gresham, Manager
Regulatory Compliance and Plant Licensing
Westinghouse Electric Company
P.O. Box 355
Pittsburgh, PA 15230-0355
greshaja@westinghouse.com

Dennis Buschbaum
PWROG Chairman
Comanche Peak Steam Electric Station
6322 North Farm to Marked Rd 56
Mail Code E15
Glen Rose, TX 76043
Dennis.Buschbaum@luminant.com

Ms. Barbara Lewis
Assistant Editor
Platts, Principal Editorial Office
1200 G St., N.W., Suite 1100
Washington, DC 20005
Barbara_lewis@platts.com