September 8, 2014

Matthew Sunseri, Chair
PWR Materials Management Program
Electric Power Research Institute
3420 Hillview Avenue
Palo Alto, CA 94304

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION RELATED ELECTRIC POWER RESEARCH INSTITUTE MRP-335, REVISION 1, “TOPICAL REPORT FOR PRIMARY WATER STRESS CORROSION CRACKING MITIGATION BY SURFACE STRESS IMPROVEMENT [PEENING]” (TAC NO. MF2429)

Dear Mr. Sunseri:

By letter dated May 1, 2013 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML13126A009), the Electric Power Research Institute (EPRI) submitted for U.S. Nuclear Regulatory Commission (NRC) staff review MRP-335, Revision 1, “Topical Report for Primary Water Stress Corrosion Cracking Mitigation by Surface Stress Improvement.”

Upon review of the information provided, the NRC staff has determined that additional information is needed to complete the review. The additional information needed is detailed in the enclosed Request for Additional Information (RAI) questions.

In an email exchange dated August 1, 2014, Mr. Paul Crocker, representing EPRI, agreed that the NRC staff will receive your response to the enclosed RAI questions, approximately September 30, 2014, possibly sooner. If you have any questions regarding the enclosed RAIs, please contact me at (301) 415-7297.

Sincerely,

/RA/

Joseph J. Holonich, Senior Project Manager
Licensing Processes Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Project No. 669

Enclosure:
RAI questions

Matthew Sunseri, Chair
PWR Materials Management Program
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REQUEST FOR ADDITIONAL INFORMATION

THE U.S. NUCLEAR REGULATORY COMMISSION (NRC) REVIEW OF MRP-335, TOPICAL REPORT FOR PRIMARY WATER STRESS CORROSION CRACKING MITIGATION BY SURFACE STRESS IMPROVEMENT

ELECTRIC POWER RESEARCH INSTITUTE (EPRI)

By letter dated May 1, 2013 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML13126A009), the EPRI submitted to the NRC the "Topical Report for Primary Water Stress Corrosion Cracking Mitigation by Surface Stress Improvement" (MRP-335, Revision 1) for review. The NRC staff has initiated its review of the document, and finds EPRI has provided sufficient information to demonstrate that the peening process, if properly implemented, is an effective mitigation to address primary water stress corrosion cracking. Due to the shallow depth of penetration of the peening technique, the NRC staff has concerns for the implementation process controls to ensure an effective mitigation is provided for all in-service surface conditions for which application is proposed. As such, the NRC staff provides the following requests for additional information to complete the review.

General Comments

The NRC staff believes that the peening process should be treated as a controlled process similar to welding to ensure consistent application across the US nuclear fleet in order to justify generic regulatory relief from the current inspection requirements. Without a general standard for peening application, the NRC staff is concerned with the reliance on each individual owner to develop a technical justification document as the only implementation control at an individual plant. Further, the NRC staff is concerned about the range of implementation parameters that will be used across the fleet, if a general standard is not developed or available for independent owner use. Therefore, the NRC staff has determined that our primary request from EPRI will be for the identification of essential variables for each peening process. Additionally, the NRC staff requests that the range of each of these essential variables is identified. As part of a validation program, the NRC staff will request EPRI to facilitate the peening of several materials using the minimum range of each of the essential variables. The NRC, through Pacific Northwest National Laboratory, will then perform non-destructive evaluation, weld residual stress measurements and crack initiation testing on the peened specimens to verify the effective implementation of each peening process within the range of identified essential variables.
Specific Questions on MRP-335, Revision 1

Section 1.0

1-1 Table 1.1 states the following under Quality Assurance Considerations, "…since peening is a special process, it shall be controlled in a manner consistent with Criterion IX, "Control of Special Processes," of Appendix B and any applicable plant specific commitments. As stated in that criterion, this requires that the personnel and procedures involved need to be appropriately qualified. Since there are no industry standards that apply to peening, these qualifications shall be done to vendor requirements developed and documented per their 10 CFR [Part] 50 [Title 10 of the *Code of Federal Regulations*] Appendix B quality assurance program and to utility requirements and commitments applicable at the plant site...."

The NRC staff is concerned that no generic industry standards are available for the various peening techniques to be applied. To ensure consistent and effective application, the NRC requests the following:

A. Submit reference document MRP-336, "Materials Reliability Program: Specification Guideline for Primary Water Stress Corrosion Cracking Mitigation by Surface Stress Improvement."

B. Identify all essential variables and associated ranges for each peening method. Identify any additional limitations for various surface conditions or access limitations of the proposed components.

1-2 The NRC staff has the option to include lower reactor vessel penetration nozzles (i.e., reactor vessel bottom mounted instrumentation nozzles) and associated welds in the validation testing. However, these areas have not been identified for potential relief from current inspection requirements. Please verify that the NRC does not need to validate the peening of the bottom mounted instrumentation nozzles to support the review of MRP-335.

<u>Section 2.0</u>

2-1 Section 2.0 of MRP-267, Revision 1, "Materials Reliability Program: Technical Basis for Primary Water Stress Corrosion Cracking Mitigation by Surface Stress Improvement," provides essential variables for the three peening processes (described below) and these variables affect the mechanical properties of the peened weld surface. The peening processes include; Water jet peening, Laser shock peening, and Fiber laser peening.

The NRC staff believes that in addition to the essential variables identified by EPRI, the following variables would be important in affecting the quality of the peened surface. Therefore, the staff requests that the MRP address each and determine whether to include these variables in the procedure qualifications.

(a) type of machine (e.g., model) used for any given process.
(b) type of base metal and the thickness.
(c) number of peening layers.

<u>Section 3.0</u>

3-1 Pages 3-2 and 3-4 in Section 3.2.1 of MRP-335, Revision 1, describe that –

"Alloy 600 base material with good access (large radius or flat surface)

ULP (Toshiba): Surface stress -450 to -900 MPa (-65 to -130 ksi), compressive to depths of more than 1.0 mm.
WJP (MHI): Surface stress ranging from -267 to -411 MPa (-39 to -60ksi), compressive to depths of more than 1.0 mm.
ALP (MIC): Shallow surface layer with tensile stress of about +400 MPa, dropping to zero at a depth of about 20 μm and decreasing to -400 to -660 MPa (-58 to -96 ksi) at depths of about 35 to 70 μm stress remains compressive to depths of more than 1.5 mm. In this regard, it is expected that the ALP process parameters selected for use at RPVHPN [reactor pressure vessel head penetration nozzle] J-groove welds will result in compressive stress fields to depths of more than 3 mm.

Alloy 82/182 weld metal with good access

ULP (Toshiba): Surface stress ranging from -500 to -1000 MPa (-73 to -145 ksi), compressive to > 1.0 mm.
WJP (MHI): Surface stress ranging from -293 to -414 MPa (-42 to -60 ksi), compressive to > 1.0 mm.
ALP (MIC): No data available for the stress depth profile for Alloy 82/182 welds; assumed to be similar to data for Alloy 600 given above. This assumption is justified by the capability of ALP to produce compressive residual stress depth as great as 8 mm depending on the treated material and chosen process parameters.

Alloy 600 base material at ID [inside diameter] of small diameter tube

ULP (Toshiba): Surface stress ranging from -300 to -500 MPa (-44 to-73 ksi), compressive to > 1.0 mm (after peening both ID and OD).
WJP (MHI): Surface stress of -210 to -470 MPa (-30 to -68 ksi), compressive to -0.5 mm.
WJP (Hitachi-GE): Surface stress of -500 to -670 MPa (-73 to -97 ksi), compressive to -0.5 mm."

While the information provided by EPRI in support of MRP-335 clearly shows compressive stresses are provided, it is not clear to the NRC staff that these results are bounding for the full range of essential variables that could be implemented at an individual plant. The NRC staff believes that additional information is needed to show the effectiveness of maintaining uniform levels of compressive stresses from peening (adjusted for temperature and load cycling induced relaxations) with the following considerations; surface condition, cold worked condition, and limited access areas.

Provide information, either new results or clarify existing testing, to show that uniform levels of compressive stresses from peening (adjusted for temperature and load cycling induced relaxations) are maintained along the region of concern in these nozzles and welds at the surfaces that are susceptible to primary water stress corrosion cracking (PWSCC) and are being treated. This information, including analysis, should consider application of peening that meets the minimum generic qualification requirements. Further, the analysis should consider and include surfaces that are cold worked (up to 15%), as welded weld surfaces, limited access to surfaces and other potential surfaces found as the surface condition for in-service components.

3-2 Page 3-4 in Section 3.3.1 of MRP-335 states that:

"…Based on extensive previous weld residual stress FEA [finite element analyses] work performed by the authors for CRDM/CEDM nozzles in many PWRs (see, e.g. [12]), the peak applied stresses at the ID [inner diameter] surfaces of RPVHPNs are relatively low, between 15 and 25 ksi (103-172 MPa) or less. The expected initial surface compressive stresses generated by peening are at least about 300 MPa (44 ksi), but can decrease to about 200 MPa (29 ksi) as a result of temperature and load cycle effects. The total stress at the surface thus will be below zero. Thus, crack initiation is prevented...."
and

"…Based on extensive previous weld residual stress FEA work performed by the authors for CRDM/CEDM [control rod drive mechanism/control element drive mechanism] nozzles in many PWRs (see, e.g. [12]), the peak applied stresses at the OD [outer diameter] surfaces of RPVHPNs, at either the weld or base material, are relatively low, less than 5 ksi (35 MPa) or less. The expected initial surface stresses generated by ALP (without an ablative layer) are about +450 MPa (65 ksi), but with compressive stresses developing just below the surface at about -450 MPa (-65 ksi), i.e. zero stress at 15 μm and -450 MPa at 35 μm. The high tensile surface stresses could result in local initiation of very shallow cracks but the high subsurface compressive stresses limit their growth to less than about 20 or 30 μm according to a stress-intensity-factor based crack growth calculation. Thus, the initiation of cracks with depths that are of engineering significance is prevented. Similarly, the use of ULP or WJP on the OD surfaces of RPVHPNs would preclude future PWSCC initiation at this location...."

Ref. [12] of MRP-335-Rev-1 (Page 7.2): D. Rudland, J. Broussard, et al., "Comparison of Welding Residual Stress Solutions for Control Rod Drive Mechanism Nozzles," Proceedings of the ASME 2007 Pressure Vessels & Piping Division Conference: PVP2007-26045, July 2007.

The FEAs presented in Ref. [12] by the two independent organizations gave considerably different results for the peak stresses (hoop and axial) at the inside diameter (Figures 12 and 14, respectively) along the triple point – welding residual stress only comparison and in Figure 7 (hoop stress along the tube OD- operating loads only) and also in Figure 8 (axial stress along the tube ID – operating loads only) for the CRDM analysis models. The NRC staff believes that other plant-specific analyses show a range of values for use as the peak applied stresses at the ID and the OD surfaces than presented in the Section 3.3.1.

Therefore NRC staff requests EPRI to:–

A. Provide a survey of ranges of peak applied stress values determined with use of in-service material properties.

B. Clarify or submit additional supporting justification to assume that all subsurface stresses under the conditions discussed here would not permit flaw propagation. NRC staff disagrees with the assessment made in the statement, "the peak applied stresses at the ID surfaces of RPVHPNs are relatively low, between 15 and 25 ksi". Many sources, including MRP-95R1, "Generic Evaluation of Examination Coverage Requirements for Reactor Pressure Vessel Head Penetration Nozzles, Revision 1," have found inside diameter stresses in excess of 60 ksi. NRC staff is also concerned about heavily cold worked surfaces and craze cracking on surfaces. Therefore, a process that may only generate 29 ksi of compression may not result in surface stresses below zero ksi.

C. Evaluate the effectiveness of each peening technique considering the effect of peening at the minimum range of the essential variables for each technique. If not, provide justification.

Section 4.0

4-1 Page 4-3, Footnote number 4 (the same as Table 4-1 footnote number 2) states that "…The pre-mitigation examination may be delayed to after the mitigation outage provided that the inspection requirements for unmitigated component apply until the examination is performed and PWSCC must not be detected during the delayed examination for the relaxed inspection requirements to apply…."

(a) The NRC staff assumes that the mitigation outage referenced above is the outage during which peening will be performed. In this case, clarify how and why an examination performed after peening is applied to a component (i.e., after a mitigation outage) may be considered as a pre-mitigation examination. How can a pre-mitigation examination be completed after the mitigation has been applied, especially in light of the fact that flaws detected prior to peening shall be removed.

(b) The NRC staff interpreted the intent of the phrase, "…the inspection requirements for unmitigated component apply until the examination is performed….," as that the inspection requirements for the unmitigated component in Code Case N-770-1 will be applied to the candidate component that has not yet been peened. Discuss whether this is the correct interpretation.

(c) Clarify the phrase: "…PWSCC must not be detected during the delayed examination for the relaxed inspection requirements to apply…." The NRC staff understands that if PWSCC is detected, then the relaxed inspection requirements will not be applied. The NRC staff assumes that the relaxed inspection requirements are those requirements for the mitigated components as specified in Code Case N-770-1. However, if PWSCC is detected during the pre-mitigation examination, discuss whether the peening is permitted to be applied to the candidate component.

(d) Revise Footnote number 4 on page 4-3 (and footnote 2 in Table 4-1) in its entirety for clarification.

4-2 Page 4-4, first paragraph states that “a post-mitigation inspection (a.k.a. pre-service inspection) **may be** performed just after the application of peening and before the unit begins to operate.” If a licensee wishes to take credit for the peening so that the inspection interval of Alloy 600/82/182 components in accordance with ASME Code Case N-770-1 could be extended, the licensee needs to follow the pre-service inspection requirements of the ASME Code, Sections III and XI. The NRC staff finds that the pre-service inspection (i.e., post-mitigation inspection) is a requirement of the ASME Code Sections III and XI, and therefore should be performed before the peened component can be placed in service. The NRC staff notes that a UT, eddy current and liquid penetrant testing should be performed after peening is applied and before the component is placed in service. (a) Justify why the pre-service inspection “may be performed” instead of "must be performed." (b) Discuss the examination techniques that will be used in the pre-service inspection.

4-3 Page 4-4, third paragraph states that the extent of the required surface to be peened in the case of RPVHPN is defined by the examination volume/area of Figure 2 of ASME Code Case N-729-1. Footnotes of figure 2 in Code Case N-729-1 may allow licensees to only peen to the boundary of the J-groove weld which the NRC staff finds insufficient. For clarity, include a figure in MRP-335 that is similar to Figure 2 of Code Case N-729-1 and eliminate any potential footnotes that may allow a reduction in surface area application. The figure should identify and therefore define the maximum surfaces of the RPVHPNs including the J-groove weld surface that are qualified and permitted to be peened based on the calculations and/or mockups and the surfaces that are to be examined as part of the peening effort.

4-4. Page 4-4, fourth paragraph states that “…An evaluation shall be performed prior to water jet peening to identify susceptibility of adjacent areas to flow induced vibration. A post-mitigation visual examination (VT-1 or VT-3) shall be performed if the evaluation shows susceptibility to damage from the peening process. Such evaluations need to consider the experience of the extensive peening performed in Japan, the specific peening process performed, and whether there is any potential for inadvertent damage to components adjacent to the target peening area….”

(a) Describe the details of the evaluation to identify susceptibility of adjacent areas to flow induced vibration.

(b) Discuss the experience and any lessons learned from the Japanese peening experience that could be adopted and included as guidance for the domestic nuclear plants in MRP-335.

(c) The NRC staff finds that a post-mitigation ultrasonic testing, penetrant testing and eddy current testing must be performed on the peened component regardless the outcome of the evaluation of susceptibility to flow induced vibration. The visual examination will not have the capability of detecting embedded flaws. As such, discuss why a visual examination is sufficient to determine whether a peened component is acceptable for service.

(d) Discuss why peening is permitted for a component that is susceptible to flow induced vibration.

(e) The NRC assumes that the evaluation to identify susceptibility of adjacent areas to flow induced vibration is based on analyses. The NRC staff has reservations about the adequacy of using analyses in this regard. The NRC staff believes that a mockup could also be used to identify susceptibility of adjacent areas to flow induced vibration. Discuss whether a mockup will be used to identify susceptibility of adjacent areas to flow induced vibration and to demonstrate that peening will not affect structural integrity of the candidate component. Discuss the acceptance criteria that determine susceptibility of flow induced vibration. If not, discuss why an analytical evaluation by itself is adequate.

(f) It is not clear to the NRC staff whether the concern on page 4-4 is regarding the susceptibility of adjacent areas (surrounding the peened region) to the flow induced vibration in the component itself (e.g., vibration caused by the fluid flow inside the pipe during the peening process), or susceptibility of adjacent areas to the mechanical vibration of the candidate component during the peening process (i.e., generation of the harmonic excitation of the candidate component during the peening). Clarify what is meant by the flow induced vibration.

4-5 Page 4-4, fourth paragraph states that "…It is not necessary that volumetric or surface examinations be performed post-peening as the peening process does not introduce any significant geometrical changes of the treated component, and because flaws detected prior to peening shall be removed, repaired, or mitigated prior to or after peening…" The NRC staff notes that operating experience has shown that ultrasonic examinations missed detecting service-induced flaws. The NRC staff finds that a post-peening examination using ultrasonic and eddy current testing techniques must be performed to verify that no new flaws are introduced and flaws undetected during the pre-peening examination have not grown as a result of the peening. Justify why volumetric and eddy current examinations are not necessary after peening is applied.

4-6 Page 4-5, Section 4.2.1 states that for piping, a pre-peening ultrasonic examination shall be performed of the dissimilar metal weld using a technique that has been qualified to the performance demonstration requirements of Appendix VIII of Section XI of the ASME Code.

(a) ASME Code, Section XI, Appendix VIII, Supplement 10 limits flaw depths in qualification mockups to the range of 10 - 100% of wall thickness. Please clarify how the existing qualification mockups and thus qualifications may be applied to the pre-peening ultrasonic examination, especially for very shallow flaws.

(b) Specify whether the pre-peening ultrasonic examination will be performed from the outer diameter or inner diameter of the pipe.

(c) Include in MRP-335 report examination diagrams of the pipe components that peening will be applied. The diagrams should indicate the exact volumes and surface areas of the pipe that are required to be examined. For example, a diagram similar to Figure IWB-2500-8 of the ASME Code, Section XI should be included in MRP-335 to clearly show the required examination volume and surfaces. The peened surface should also be shown in the diagrams as a reference.

(d) Some of the Alloy 82/182 welds join components that are fabricated with cast austenitic stainless steel (e.g., pipe, safe end, and pump nozzles). Ultrasonic testing (UT) of cast austenitic stainless steel has not been qualified by the ASME Code, Section XI. Some of the Alloy 82/182 welds are situated with nearby obstructions such as small bore branch lines. As a result, pre-peening UT of the weld could not achieve essentially 100 percent examination coverage. As such, flaws located in the unexamined volume of the weld may not be detected. Discuss for these two situations (i.e., cast stainless steel and obstructions) whether peening could be applied to the Alloy 82/182 weld of the pipe. If yes, justify why peening could be applied to a component that UT or ET could not achieve essentially 100 percent examination coverage.

(e) The NRC staff finds that pre-peening UT must achieve 100 percent examination coverage (not essentially 100 percent) of the surface that will be peened and the volume that will be affected by peening. Also, the pre-peening surface examination must achieve 100 percent coverage (not essentially 100 percent) of the surfaces that will be affected by peening. The pre-peening and post-peening UT and surface examination must cover ½ inch on the either side of the peened surface. The ½ inch is a buffer zone that will not be peened but should be inspected with UT, eddy current testing and liquid penetrant testing before and after peening to ensure that peening would not adversely affect the buffer zone. Discuss whether these criteria could be included in MRP-335 as a requirement. If not, provide justification.

(f) If pre-peening examination detects a flaw in an Alloy 82/182 weld, MRP-335 stated that the flaw will be removed and the weld will be repaired before peening will be applied. (1) Discuss the maximum size (depth and length) of the flaw that will be removed and repaired before peening can be applied (i.e., specify the maximum flaw size beyond which the peening will not be applied). (2) Discuss whether some ligament of the flaw will remain in the component while peening is applied. If yes, discuss the maximum flaw size that can be remain in the component and peening can still be applied (e.g., flaw size, location with respect to the peened surface). For example, if peening is applied to the ID surface of a pipe weld and if the flaw is located near the outside diameter surface, would the flaw be permitted to remain inservice? If yes, what size of the flaw will be permitted?

(g) Discuss whether the ultrasonic testing (UT) and eddy current testing (ET) are qualified to perform examination on the peened surface. If yes, discuss the industry codes and standards by which the UT and ET are qualified and provide qualification requirements for the UT and ET.

4-7 Page 4-5 Section 4.2.1 states that "…[prior to peening] an eddy current (ET) or liquid penetrant (PT) inspection shall also be performed of the weld ID [for RPV head penetration nozzles]. The ET or PT technique need not be qualified using formal performance demonstration techniques, but shall have been demonstrated by the inspection vendor per current practices (e.g., per ASME Section V)…"

(a) The NRC staff believes that for the pre-peening examination, the ET or due to access limitations PT must be used. The eddy current technique must be qualified to detect flaws both on the surface and near surface volume that will be affected by peening to provide reasonable assurance of detecting flaws. The NRC staff does not consider the low rigor qualifications of Article 14 of ASME Code, Section V practices rigorous enough for this application. However, under some circumstances the NRC staff would entertain qualification demonstrations that meet the requirements outlined in Section V, Article 14, Intermediate Rigor. Please clarify what is meant by "demonstrated by the inspection vendor per current practices" and justify why the ET technique need not be qualified using formal performance demonstration techniques.

(b) MRP-335 states that the peening will be effective for 1 millimeter (mm) in depth into the component. The NRC staff finds that the pre- and post-peening ET should be capable of detecting a flaw within the 1 mm distance and beyond the 1 mm distance with certain margins so as to include the detection error and measurement uncertainty. ET should be qualified to that wall thickness (distance) with the margin. (1) Discuss the maximum wall thickness (distance) that ET can detect a flaw in a unmitigated component and in a peened component. (2) Discuss the wall thickness ET is qualified to detect in an unmitigated component and in a peened component with the margin. (3) Discuss whether ET's capability would change when examining a unmitigated component vs. a peened component. (4) Discuss the margin in terms of wall thickness. (5) How will surface condition affect ET performance? (6) Should there be a minimum surface roughness condition to ensure effective ET and peening coverage?

4-9 Table 4-1, under the Follow-Up Exams column, specifies that volumetric and visual examinations be performed for the peened Alloy 600 reactor vessel heads and Alloy 82/182 butt welds. The NRC staff notes that visual examination is not adequate to detect flaws embedded in the wall thickness which may be affected by peening. The NRC staff believes that volumetric, ET or PT should be performed as part of the follow-up examination. The NRC staff understands that PT may not be applicable to examining piping because in the follow-up examination, inside of piping would be filled with coolant. However, PT should be applicable to the reactor vessel head nozzle penetrations and J-groove welds. Discuss why ET or PT will not be performed in the follow-up inspections.

4-10 (a) For the ISI examinations, discuss why ET is not needed for the Alloy 82/182 butt welds in piping.

(b) Table 4-1 provides examination requirements for the Alloy 82/182 hot and cold legs and reactor vessel head only. Discuss whether peening will be applied to bottom mounted instrumentation nozzles of the reactor vessel, piping other than the hot and cold legs (e.g., surge lines), and relief and safety valve nozzles and heater sleeve nozzles at pressurizer. If yes, discuss why Table 4-1 does not provide examination requirements for these components.

4-11 The NRC staff notes that Section 4 and Table 4-1 do not provide guidance for the event when the follow-up and ISI examinations detect a new flaw or growth of an existing flaw in the peened component (assuming an existing flaw was permitted to remain in the component before peening).

(a) Discuss how new flaws or growth of an existing flaw in the peened component would be dispositioned (e.g., what are the acceptance criteria).
(b) Discuss under what criteria the peened component would be re-classified as the unmitigated component in accordance with ASME Code Case N-770-1 and Table 4-1.

(c) Discuss whether peening can be re-applied to the peened component in which new flaws or growth of existing flaws has occurred.

4-12 (a) NRC imposed additional conditions on Code Cases N-729-1 and N-770-1 in 10 CFR 50.55a. Table 4-1 should include a footnote to reference 10 CFR 50.55a for completeness.

(b) Clarify why Table 4-1 specifies Code Cases N-729 and N-770 instead of N-729-1 and N-770-1 as required in 10 CFR 50.55a.

(c) 10 CFR 50.55a also imposed conditions on Code Case N-722-1 which is related to visual inspections of Alloy 600/82/182 components. Discuss why Code Case N-722-1 is not discussed in Section 4 and Table 4-1.

(d) ASME will likely to publish revisions to Code Cases N-722, N-729 or N-770 in the future. The NRC may approve the revisions. Include in Section 4 or Table 4-1 how the NRC-approved code case revisions will be used.

4-13 Discuss whether after peening the surface of a component would become rough enough to adversely affect the post-peening UT and ET (e.g., the probe would not have good contact with the component surface). If yes, discuss how the roughness would be eliminated, what would be the final roughness of the surface, and whether the final surface finish would satisfy the surface conditioning requirement of the ASME Code, Section XI, Appendix D.

4-14 To assist in reviewing MRP-335, the NRC staff requests the following references: The NRC staff requests References (a), (b) and (c) because they are the eddy current testing (ET) specification sheets that would provide information to support the capability of ET. Reference (d) provides specific ET and UT technology for the examination of the bottom mounted nozzles in BWRs which will assist the NRC staff to understand the component-specific UT and ET technology.

The NRC staff requests Reference (e) because the article provides information on the examination of Alloy 600 components.

The NRC staff requests Reference (f) because the report will help the NRC staff to understand the guidance and qualification of Alloy 82/182 weld examination. This information will help the NRC staff to review the pre-peening examination of the Alloy 82/182 welds.

(a) EPRI Eddy Current Examination Technique Specification Sheet, ETSS #20510.1, Rev. 7, October 2006 (available from EPRI NDE Center, Charlotte, NC).

(b) EPRI Eddy Current Examination Technique Specification Sheet, ETSS #20501.2, Rev. 4, August 2006 (available from EPRI NDE Center, Charlotte, NC).

(c) EPRI Eddy Current Examination Technique Specification Sheet, ETSS #21503.1, Rev. 4, July 2006 (available from EPRI NDE Center, Charlotte, NC).

(d) Outline of Hitachi-GE GE Nuclear Energy (HGNE)'s ECT and UT technologies for nickel based weld lines of BWR bottom head, Hitachi-GE document E-TY-50521r1, Feb. 1, 2012.

(e) M. Taniguchi and N. Hori, "Maintenance Technology Development for Alloy 600 PWSCC Issue," *Proceedings of ICONE12 12th International Conference on Nuclear Engineering*, April 25–29, 2004, Arlington, Virginia, USA.

(f) Dissimilar Metal Piping *"Weld Examination Guidance and Technical Basis for Qualification."* EPRI, Palo Alto, CA: 2003. 1008007.

4-15 Discuss the minimum pipe size and wall thickness that peening is permitted to be applied. Discuss and cite the calculations that support these limits in pipe size and wall thickness.

<u>Section 5, Appendix A, and Appendix B</u>

5-1 Page A-58, Section A.4, Flaw Detection Model, states that "Hitachi-GE reported the ability to detect flaws with depths greater than 0.5 mm and lengths greater than 3.3 mm of BMNs [bottom mounted nozzles] " The NRC staff needs to understand the technical basis for flaw detection used for certain size flaws.

(a) Confirm that flaw depth greater than 0.5 mm and lengths greater than 3.3 mm of BMN can be detected by either surface or volumetric examination. (b) Provide the document "Outline of Hitachi-GE GE Nuclear Energy (HGNE)'s ECT and UT technologies for nickel based weld lines of BWR bottom head, Hitachi-GE document E-TY-50521rl, Feb. 1, 2012".

5-2 Page 5.3, Section: 5.2.2, Inspection and Detection, states that "…the median UT inspection POD curve used for cracking on DMW component ID is from MRP-262R1. In Section 5.2.2, Inspection and Detection, the second paragraph states that "…because the MRP-262 curve was developed using only circumferential cracks, and a review of the examination data suggests a generally lower POD for axial cracks, the POD predicted by the MRP-262 curve is reduced by 20% for axial cracks…."

Page 43 of Reference 19 of MRP-335 “Materials Reliability Program: Development of Probability of Detection Curve for Ultrasonic Examination of Dissimilar Metal Welds (MRP-262, Revision 1) Typical PWR Leak-Before-Break Line Locations, EPRI, Palo Alto, CA: 2009.1020451” discusses the circumferential crack assessment, but there is no discussion on the axial crack limitation.

While the NRC staff agrees that the POD will be lower for axial flaws due to the greater sound path through weld material and thus more difficult nature of the examination, this approach to determining POD for axial flaws seems to be very arbitrary. (a) Explain the technical basis and justify the applicability of creating POD cures for axial flaws by simply reducing the POD curves for circumferential flaws by 20%. (b) Discuss the accessibility inside the bottom mounted nozzle for peening.

5-3 Page 5-28, Section 5.2.3.3, Validation Study for the Weight Function Method Stress Intensity Factor Calculation, states that “…Further details to demonstrate sound implementation of the stress intensity factor calculation methodology is withheld here. More rigorous stress intensity factor calculation validation has been performed and is documented internally….” The stress intensity factor calculation provides the technical basis of the peening application. It is not clear to the NRC staff why the stress intensity factor calculation is withheld from the subject report. Submit details on the rigorous stress intensity factor calculation methodology and validation.

5-4 Page A-58, Section A 8.4, Flaw Detection Model, states that “…experience indicates that there exists a minimum crack length below which cracks are very difficult to detect by ET. A deterministic input of 2 mm was selected for this length….” The NRC staff needs to understand the technical justification for the minimum crack length of 2 mm. Also, the NRC is concerned with limitations for detection of a minimum crack length for non-smooth surfaces (i.e. as welded). Provide the technical basis for eddy current testing capability of detecting a crack length of 2 mm (0.08-inches).

5-5 Page 5-31, Section 5.3.2, Reactor Pressure Vessel Head Penetration Nozzles (RPVHPNs), states that “…the program predicted that the cumulative probability of leakage after peening would be reduced by a factor between 9 and 12....” Justify that the cumulative probability of leakage after peening can be reduced by a factor between 9 and 12.

5-6 Page A-58, Section A.4, Flaw Detection Model, states that “For BMN J-weld surfaces, cracks 0.9 mm or deeper were detected (Ref 29).” Reference 29, M. Taniguchi and N. Hori, "Maintenance Technology Development for Alloy 600 PWSCC Issue," Proceedings of ICONE12 1 2nd International Conference on Nuclear Engineering, April 25-29, 2004, Arlington, Virginia, USA, does not appear to provide a discussion on cracks of 0.9 mm in length being detectable. Justify the conclusion that cracks of 0.9 mm in length can be detected.

5-7 Page B-69, Section B.9, Results of probabilistic cases states: “…the magnitudes of the predicted risks for any given case may include a substantial bias error….” Provide details of substantial bias error in calculating the magnitudes of the predicted risks with respect to peening.

5-8 Page B-16 of MRP-335 states that "…a peening compressive residual stress to a depth of at least 3 mm is assumed for the wetted nozzle OD and weld surfaces of the RPVHPN...." Page B-66 states that "…the peening of the penetration nozzle OD and weld location is expected to be performed with ALP [air laser peening]...." It is also stated on Page B-66 that water jet peening (WJP) or underwater laser peening (ULP) was assumed to be applied to the nozzle inside diameter. (a) Clarify why the simulation was conducted with mixed peening processes. (b) Page 2-3 of MRP-335 states that the ALP process in nuclear power plants is not as developed as for WJP and ULP, and there has not been any experience with using this method in PWR or BWR reactor applications. Clarify why the simulation results of Appendix B to MRP-335 rely on this method.

5-9 MRP-262 contains POD curves only for pressurizer surge, reactor pressure vessel nozzle, and steam generator nozzle dissimilar metal welds. No POD curves for the head penetrations were included in the MRP-262 report. As such, where does the POD curve for RPVHPN and outside diameter locations shown in Figure 3 come from? The NRC staff notes that the caption is titled "assumed". What does this mean? What data was used and how was that data used to generate the curve in Figure 3?

5-10 Figure 5-2 on page 5-5 presents linear POD curves for dissimilar metal welds examined from the inside diameter. Please address why the POD curves are linear and are extrapolated to the baseline (even though the Performance Demonstration Initiative (PDI) samples contain no flaws that are less than 10 percent of full wall thickness).

5-11 Page 5-4 states that "…The median ET [eddy current testing] inspection POD curve used for cracking on DMW [dissimilar metal weld] and RPVHPN ID locations is shown in Figure 5-4. In the absence of a rigorous experimental investigation, this curve was derived based on a review of ET POD for various probe types and locations, as detailed in Appendix A.8.4.3…." Please provide all the references listed on page A-58 related to the ET POD curves. Please explain in detail how these curves were generated, especially in light of the lack of "rigorous experimental" data.

5-12 Three conclusion statements are made on page 5-4. Please explain how the three conclusions are arrived at in light of the fact that the POD curves are assumed. The NRC staff is concerned about the use of assumed POD curves to reduce the range of depths of cracks that are considered unlikely to be undetected. Please clarify that the dimensions provided in these three conclusion statements are for depths and not lengths.