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2009-174 BWR Vessel & Internals Project (BWRVIP)

May 14, 2009

Document Control Desk
U. S. Nuclear Regulatory Commission
11555 Rockville Pike
Rockville, MD 20852

Attention: Joseph Williams

Subject: Project No. 704 – Re-transmittal of Revised BWRVIP Comments on NRC Draft Safety Evaluation on Treatment of Non-Destructive Examination Flaw Sizing Uncertainty

Reference: BWRVIP Letter 2009-128 from Rick Libra (BWRVIP Chairman) to Joseph Williams (NRC), "Project No. 704- Revised BWRVIP Comments on NRC Draft Safety Evaluation on Treatment of Non-Destructive Examination Flaw Sizing Uncertainty" dated April 1, 2009

The purpose of this letter is to re-transmit five (5) copies of the "Revised BWRVIP Comments on NRC Draft Safety Evaluation on Treatment of Non-Destructive Examination Flaw Sizing Uncertainty". This document was previously transmitted to the NRC by the BWRVIP letter 2009-128 referenced above. This document is being re-transmitted to the NRC due to problems with the hard copies submitted with the original transmittal letter referenced above. This transmittal has been revised to conform to the NRC processing into ADAMS by the Document Control Desk.

Please note that the enclosed document contains proprietary information. A letter requesting that the document be withheld from public disclosure and an affidavit describing the basis for withholding this information were provided as Attachment 4 in BWRVIP letter 2009-128 referenced above. All the proprietary information in Attachments 1 and 3 are considered "trade secrets" in accordance with 10CFR2.390(a)(4).

If you have any questions on this subject please call Bob Geier (Exelon, BWRVIP Assessment Committee Technical Chairman) at 630-657-3830.

Sincerely,

Rick Libra

Rick Libra
Exelon
Chairman, BWR Vessel and Internals Project

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BWRVIP Comments and Clarity Concerns Regarding Draft NRC Safety Evaluation on Treatment of Non-Destructive Examination Flaw Sizing Uncertainty

Attachment 1
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Attachment 1

BWRVIP Comments and Clarity Concerns Regarding Draft NRC Safety Evaluation on Treatment of Non-Destructive Examination Flaw Sizing Uncertainty

1. Background

Since the issuance of the initial BWRVIP core shroud inspection and flaw evaluation guidelines (BWRVIP-01) in 1994, flaw evaluations required non-destructive examination (NDE) uncertainty to be added to all flaws. The BWRVIP considered this to be conservative because at that time industry lacked robust inspection methods and implementation experience for BWR internals. Since that time, demonstrations of inspection techniques have been performed and documented in BWRVIP-03 (RPV and Internals Examination Guidelines) which has been updated yearly since 1995. A root-mean-square (RMS) calculation was performed to define uncertainty values for each component-specific demonstration. For ultrasonic (UT) examinations, the initial uncertainty value for depth sizing was the depth sizing RMS error identified in BWRVIP-03. The uncertainty value for length sizing was the length sizing RMS error identified in BWRVIP-03 divided by two (this length sizing uncertainty value was added to each end of the flaw).

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The issue of including NDE uncertainty in flaw evaluations arose with NRC review of BWRVIP-63 (Shroud Vertical Weld Inspection and Evaluation Guidelines) which was submitted to the NRC in 1999. Page 3-1 of BWRVIP-63 states "NDE uncertainty does not need to be considered since it is adequately covered by conservatisms in the flaw evaluation methods." The basis for this conclusion was the large flaw tolerance of shroud vertical welds. The initial NRC Safety Evaluation (SE) of BWRVIP-63 did not agree with this BWRVIP position and required NDE uncertainty to be included in flaw evaluations. The BWRVIP response to this NRC position was deferred and considered an open item in the final NRC SE of BWRVIP-63.

1.1 BWRVIP Response to the Final NRC SE of BWRVIP-63

In BWRVIP letter 2002-289, "PROJECT NO. 704 -- BWRVIP Partial Response to the NRC Final Safety Evaluation of BWRVIP-63," dated October 22, 2002 the BWRVIP stated in part:

> "The purpose of the BWRVIP demonstration activity is to ensure that the uncertainties are small and are appropriately accounted for in the margins that exist in the flaw evaluation procedures (code margins, crack growth rates, etc.).
>
> This approach is consistent with ASME Section XI rules for evaluation of flaws detected and measured with NDE techniques. ASME Section XI

rules have never required NDE uncertainty to be factored into the flaw evaluation process. NDE uncertainty was accounted for in the margins applied in the flaw analysis process.

The BWRVIP and the EPRI NDE Center have worked together to develop the qualification process and have confirmed that the uncertainties for demonstrated techniques are generally small. It has been the BWRVIP's contention that, except as defined below, the uncertainties do not warrant any unique recognition in the analytical evaluation process. BWRVIP has utilized "code methodologies and margins" in the flaw evaluation criteria. As is the case with Section XI evaluations, sufficient conservatisms are embedded in the methodology of the I&E guidelines to address inspection capabilities. For these reasons it is reasonable to not require adding "NDE uncertainty" to flaws for BWRVIP-scope components when appropriately qualified techniques are used.

Therefore, in order to provide an objective standard to assure that NDE results are evaluated properly, the BWRVIP proposes to require that the ASME Section XI, Appendix VIII UT sizing criteria be satisfied. Specifically, Appendix VIII states the following:

> 1. For UT depth sizing, the RMS value of the flaw depth measurement errors experienced during the performance demonstration must be equal to or less than 0.125 inches.
>
> 2. For UT length sizing, the RMS value of the flaw length measurement errors experienced during the performance demonstration must be equal to or less than 0.75 inches.

Appendix VIII does not provide measurement error criteria for visual or eddy current techniques. To address this issue, the BWRVIP plans to apply the same standard for visual examination and eddy current uncertainty length sizing as Section XI requires for UT.

Therefore, the BWRVIP proposes the following criteria:

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As was stated earlier, this is completely consistent with Section XI. If the NDE method is qualified to a sufficient level, any uncertainty is accounted for in the flaw evaluation margins. It is not important what the method is, but whether the size measured in the field can be considered sufficiently accurate. For example, if the flaw measurement of concern is flaw length, it does not matter whether that length is determined by UT, ET or VT, provided the method used satisfies the 0.75 inches RMS criteria. In that scenario the flaw analyst can have equivalent levels of confidence that the result obtained is conservative.

In addition to the fact that the proposed approach is consistent with Section XI, the BWRVIP has imposed additional conservative assumptions that provide added margins of safety. For example, cracks detected using EVT-1 are assumed to be through-wall because the depth cannot be determined. This is obviously conservative since field results to date have identified no through-wall flaws in core shrouds. Additionally, the BWRVIP I&E guidelines require conservative assumptions to be made regarding the extent of cracking to be postulated in inaccessible regions of the component when performing flaw evaluations. These conservative assumptions along with the use of code margins and conservative crack growth rates supports the BWRVIP contention that flaws sized with techniques that satisfy the proposed criteria need no additional NDE uncertainty added to the measured flaw size.

1.2 NRC Request for Additional Information – March 2003

The NRC transmitted a letter to the NRC entitled "Non-Destructive Examination Flaw Sizing Uncertainty," dated March 25, 2003 that requested that the BWRVIP provide the following:

- Evaluate the components which are covered by BWRVIP I&E guidelines and which are, or may be, subject to volumetric examination methods under the BWRVIP programs. Identify a component (e.g., core spray piping/header) which generally exhibits a lesser degree of "flaw tolerance" (i.e., one for which the flaw size which would lead to structural factors not being met is relatively small). Provide an evaluation which demonstrates the structural factors which would be maintained if the predetermined maximum value established for volumetric examination NDE flaw sizing uncertainty were added to the largest flaw (without NDE flaw sizing uncertainty) which would just meet the flaw evaluation structural factors.

- Evaluate the components which are covered by BWRVIP I&E guidelines and which are, or may be, subject to surface examination methods under the BWRVIP programs. Identify a component (e.g., core should vertical welds) which generally exhibits a lesser degree of "flaw tolerance" (i.e., one for which the flaw size which would lead to structural factors not being met is relatively small). Provide an evaluation which demonstrates the structural factors which would be maintained if the predetermined maximum value established for surface examination NDE flaw sizing uncertainty were added to the largest flaw (without NDE flaw sizing uncertainty) which would just meet the flaw evaluation structural factors.

- In light of the observed structural factor reductions from items a. and b. above, discuss the various conservative assumptions (e.g., use of a bounding crack growth rate, lower bound material properties, etc.) which are included in BWRVIP I&E flaw evaluation guidelines. Discuss how these conservatisms support the conclusion that the affect of excluding the predetermined maximum value established for NDE flaw sizing uncertainty is insignificant in the overall flaw evaluation process.

1.3 November 3-4, 2003 BWRVIP/NRC Meeting

The BWRVIP met with the NRC staff on November 3-4, 2003 to discuss the topic of NDE uncertainty. The BWRVIP presented an update on the assessment of NDE uncertainty for the core shroud, jet pump riser and core spray piping in response to the March 25, 2003 NRC request for additional information. The core spray piping was shown to be less flaw tolerant than the other components evaluated. The BWRVIP committed to develop treatment of NDE uncertainty for core spray piping and other cylindrical components.

1.4 Final BWRVIP Position on NDE Uncertainty

The BWRVIP performed additional analyses and evaluations and transmitted the results to the NRC by BWRVIP letter 2004-191 dated May 25, 2004. This transmittal was in response to the March 25, 2003 NRC letter and to the discussions held on November 3-4, 2003. As part of that transmittal, the BWRVIP presented results showing structural factors for core spray piping utilizing different NDE uncertainty assumptions. Enclosed Figures 10 and 16 from the May 25, 2004 transmittal show structural factors using NDE uncertainties of 0.75 inches and 2% of circumference, respectively. Based on these results, the BWRVIP position on NDE uncertainty was revised to include an additional element as described below (the additional element is in bold type):

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Based on the analysis provided in the May 25, 2005 transmittal, the BWRVIP concluded that the revised position is a conservative treatment of NDE uncertainty for the evaluation of flaws in BWR internal components.

2. Specific BWRVIP Comments on the Draft SE

2.1 In the last sentence of Section 2.1 of the draft SE, it states that the BWRVIP's proposed NDE uncertainty must consider the NRC staff position established in the SE for BWRVIP-03, Revision 6, dated June 30, 2008. The subject SE found the NDE methodologies employed by the BWRVIP in accordance with BWRVIP-03 to be acceptable without limitation and conditions. As such, the SE for BWRVIP-03 should have no negative bearing on the BWRVIP's proposed NDE uncertainty.

2.2 The draft SE recognizes that an ASME Code, Section XI flaw evaluation does not require adding NDE uncertainty to characterize flaw size, instead relying on conservatism in its evaluation methodologies and the specified structural factors (SFs) to address NDE uncertainty. As documented in the various NRC approved Inspection and Evaluation Guidelines for BWR vessel internal components, the flaw evaluation methodologies and specified structural factors are consistent with the rules of ASME Section XI and include additional conservatism beyond that specified by the ASME Code. Based on this and the fact that core shrouds are very flaw tolerant, the NRC accepts the BWRVIP proposed use of NDE uncertainty for UT, VT, and ET for core shroud examinations. However, in the last sentence of Section 2.2.2 of the draft SE the NRC states that the staff does not accept the BWRVIP proposed criterion for UT length sizing uncertainty for internal core spray piping and other internals with similar flaw tolerance trends. ASME Section XI NDE examinations also cover a wide range of components with varying degrees of flaw tolerance. Thus, based on comparison to ASME Section XI flaw evaluation criteria, the BWRVIP proposed criteria for NDE uncertainty should be acceptable.

2.3 The last paragraph of Section 2.2.3 of the draft SE references the additional BWRVIP criterion regarding UT or VT/ET length sizing of cylindrical piping components and states that the response was acceptable. This conflicts with Section 3.0, Limitations and Conditions, item 1, which states that the BWRVIP NDE uncertainty criteria can not be applied unless certain conditions are met.

2.4 The last sentence of the first excerpt of the BWRVIP-03, Revision 6, SE that is given in Section 2.2.4 states, "The BWRVIP program leaves to the licensees the responsibility of determining the effects a detected crack has on structural integrity." The BWRVIP acknowledges that this is a direct quote from the BWRVIP-03 SE, but requests that this sentence be struck from this SE as the statement is incorrect. Licensees are required to follow the flaw evaluation methods that are given in the applicable BWRVIP Inspection and Evaluation Guidelines (most of which are NRC approved and all use methods consistent with the rules of ASME Section XI). During a January 22, 2009 teleconference with the NRC to discuss the draft SE, the NRC staff agreed to remove this statement from the SE.

2.5 In the last paragraph of Section 2.2.4 of the draft SE, it states, "Although the June 30, 2008 SE determined that the reliability of the BWRVIP-03 RMS values is less than the reliability of the RMS values developed from blind performance demonstrations ...." The use of the word "determined" is imprecise. In the BWRVIP-03 SE, the NRC did not "determine" the difference in the non-blind versus blind RMS values, rather the NRC simply stated that they were "considered" to be less reliable.

2.6 Item (1) in the last sentence of Section 2.2.4 states: "the determination is only qualitative." It is not clear what "determination" is being referenced. The tie between this statement and the acceptance of the BWRVIP position on NDE uncertainty for core shrouds and recirculation riser welds is unclear and needs to be clarified in the final SE.

2.7 Section 3.0, Limitations and Conditions, of the draft SE states that the proposed BWRVIP NDE uncertainty criteria cannot be applied to internal core spray piping welds unless the applicant has plant-specific, quantitative information to appropriately address the NRC staff concerns on BWRVIP NDE quoted in Section 2.2.4. It is unclear what would constitute the "quantitative" assessment that the NRC proposes. The BWRVIP provides "quantitative" NDE uncertainty RMS sizing error values in BWRVIP-03 for every technique demonstration that could be employed by a licensee. There is no additional guidance regarding what this plant-specific, quantitative information should be or what would be acceptable. This leaves the issue open-ended with no means to identify acceptable closure. The BWRVIP believes this is an unnecessary burden on the licensee with no improvement in safety of the component and thus is not warranted.

2.8 In Section 3.0, Limitations and Conditions, the first bullet of item 2 requires a sensitivity study for all BWR vessel internals other than core shroud welds, recirculation riser welds, and internal core spray piping welds. This request is unrealistic. There are literally hundreds of components within the scope of BWR vessel internals examinations. They include bolting, brackets, plate components, cast fittings, forged fittings, tack welds, piping components, and other cylindrical components. The BWRVIP provided sensitivity studies for 3 of the typical component geometries and agreed to apply an additional criterion (i.e., add NDE uncertainty when the demonstrated RMS length sizing error is greater than the lesser of 0.75" or 2% of the circumference) for all cylindrical components since the sensitivity study for core spray internal piping found that it was less flaw tolerant than the other components evaluated. Given this additional conservatism and the other conservatism in the BWRVIP flaw evaluation methodologies (see Section 4 below) the BWRVIP does not believe it should be treated any differently than the NRC treats those items within the scope of ASME Section XI examinations that are not covered by blind demonstrations (e.g., all VT, surface, and ET examinations; and UT examinations of components such as reactor vessel-to-flange welds, vessels less than 2" in thickness, and pump and valve welds).

3. <u>ASME Code Appendix VIII vs. BWRVIP RMS Comparison</u>

Section 2.2.4 of the draft SE on NDE uncertainty quotes from the June 30, 2008 NRC SE on BWRVIP-03, Revision 6, as follows:

> "Because these RMS values were developed using non-blind examinations, the reliability of RMS values is considered less than the reliability of RMS values developed from blind performance demonstrations developed per ASME Code, Section XI, Appendix VIII."

The NRC accepts sizing qualified to the ASME Code where RMS values are developed blind. However, these RMS values are not published but NRC is comfortable knowing that there is a range of sizing accuracy among the qualified techniques as long as it is bounded. For non-blind examinations, the NRC draft SE states "...the reliability of RMS values is considered less..." but no basis or justification for this conclusion is given. For example, there is no implication in the draft SE about how much less or why it is considered less or whether the degradation of reliability is dependent on the component or technique.

The BWRVIP does not concur with the NRC position on RMS values as stated above. BWRVIP UT examinations are typically automated, and in documenting the demonstrations, each measurement is confirmed to have resulted from faithful application of the written procedure. Further support of the BWRVIP position is provided in Attachments 2 and 3 which provide a comparison of BWRVIP RMS values to ASME Code, Appendix VIII values.

Attachment 2, Table 1, shows that the standard deviation value for length sizing errors in stainless steel piping Appendix VIII demonstrations is 0.498 inches which equates to an RMS value of 0.4986 inches, or approximately 0.5 inches. Attachment 3 is information excerpted from BWRVIP-03, Revision 10, for core spray piping demonstrations that shows the average RMS value for length sizing error was 0.277 inches or approximately 0.3 inches. The comparison shows that the average RMS value for length sizing error in the BWRVIP demonstrations (non-blind) is approximately 0.2 inches better than the Appendix VIII demonstrations (blind).

The Appendix VIII demonstrations evaluated in Attachment 2 included both automated and manual exams, with a larger percentage of manual than automated. The BWRVIP demonstrations involve automated exams and it is widely acknowledged that automated data analysis is more accurate than manual. The Appendix VIII demonstrations involved a range of pipe sizes and thicknesses that include mostly piping that was significantly thicker than BWR internal core spray piping. Length sizing accuracy decreases with an increase in wall thickness due to beam spread.

The comparison described above found that there was no significant difference between the blind Appendix VIII and non-blind BWRVIP-03 RMS values for length sizing. Furthermore, ASME Section XI VT, Surface, and ET examinations; and UT examinations of components such as reactor vessel-to-flange welds, vessels less than 2" in thickness, and pump and valve welds are all performed using procedures that do not require blind demonstrations and the NRC does not require consideration of NDE uncertainty for these exams.

4. Additional BWRVIP Conservatisms

In addition to the items addressed above, there are additional conservatisms in the assumptions and application of the BWRVIP flaw evaluation methods for cylindrical components including the following:

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5. BWRVIP Conclusions on NRC Draft Safety Evaluation on Treatment of Non-Destructive Examination Flaw Sizing Uncertainty

The BWRVIP asserts that the difference in the accuracy of the BWRVIP length sizing compared to Appendix VIII length sizing is not significant. The difference is attributable to the fact that the BWRVIP demonstrations were automated and involve thinner piping than the average pipe thickness for the Appendix VIII demonstrations. Thus, the comparison indicates that there is no significant difference in the reliability of BWRVIP RMS values and the Appendix VIII RMS values. Furthermore, any differences in the reliability would be offset by the additional BWRVIP conservatisms described in Section 3 above.

Considering the comments provided in Section 2.7 above, the BWRVIP believes that the requirement to perform quantitative assessments of NDE uncertainty for all components other than core shroud welds and recirculation riser pipe welds is not warranted.

Considering the comments provided in Section 2.8 above, the BWRVIP believes that the requirement to perform a sensitivity study for all BWR vessel internals other than core shroud welds, recirculation riser welds, and internal core spray piping welds is unwarranted.

In summary, the BWRVIP believes that the revised position on NDE uncertainty as described in Section 1.4 above is a conservative treatment of NDE uncertainty for the evaluation of flaws in BWR internal components and the final NRC SE on NDE flaw sizing uncertainty should reflect that conclusion.

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Figure 10. Structural factor vs. Crack Length with and without UT Sizing Correction (Core Spray) for Non-Flux Welds
(Internal core spray pipe; normal/upset condition; 0.75 inch NDE uncertainty)

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Figure 16. Structural factor vs. Crack Length with and without UT Sizing Correction (Core Spray) for Flux Welds
(Internal core spray pipe; emergency/faulted condition; 2% circumference uncertainty factor)

Technical note
"Experience with inspection qualifications for austentitic piping"

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Electric Power Research Institute, SMIRT 14, PCS 2, Lyon, France
Accepted 16 September 1999

Attachment 2
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Technical note

Experience with inspection qualifications for austentitic piping

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BWRVIP Core Spray Piping Demonstration RMS Values
(BWRVIP-03, Revistion 10)

Attachment 3
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Attachment 3

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BWRVIP Core Spray Piping Demonstration RMS Values
(BWRVIP-03, Revision 10)

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