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BWRVIP BWR Vessel & Internals Project 2003-137

April 28, 2003

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

Attention: Meena Khanna

Subject: PROJECT NO. 704 -- BWRVIP Response to the NRC Final Safety Evaluation of BWRVIP-63

Reference:
1. Letter from William H. Bateman (NRC) to Carl Terry (BWRVIP Chairman), "Final Safety Evaluation of the BWRVIP Vessel and Internals Project, Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63), EPRI Report TR-113170, June 1999 (TAC NO. MA6015)," dated August 20, 2001.
2. Letter from Carl Terry (BWRVIP Chairman) to NRC Document Control Desk, "Project 704 – BWR Vessel and Internals Project, Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63), EPRI Report TR-1131170, June 1999," dated July 1, 1999.

Enclosed are 10 copies of the BWRVIP response to the issues identified in the NRC Final Safety Evaluation (SE) of the BWRVIP report "BWR Vessel and Internals Project, Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63)" transmitted by the Reference 1 letter identified above.

Please note that the enclosed document contains proprietary information. Therefore the request to withhold the BWRVIP-63 report from public disclosure transmitted to the NRC by the Reference 2 letter identified above also applies to the enclosed document.

If you have any questions on this subject, please contact Robin Dyle of Southern Nuclear (BWRVIP Assessment Committee Technical Chairman) by telephone at 205.992.5885.

Sincerely,

Carl Terry
Constellation Generation Grroup
Nine Mile Point Nuclear Station
Chairman, BWR Vessel and Internals Project

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BWRVIP Response to Issues in NRC Final Safety Evaluation of "BWRVIP Vessel And Internals Project, Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63)," EPRI Report TR-113170, June 1999

Below are the issues identified in the NRC Final Safety Evaluation (SE) of the document entitled "Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63)," followed by the BWRVIP response to each issue. The BWRVIP proposes to incorporate staff comments and other changes, where applicable, into a revised BWRVIP-76 report.

The staff's August 20, 2001 Final SE [1] responded to Reference 2. A meeting was held at Argonne National Labs on October 29-30, 2001 to discuss the BWRVIP proposed response to the Final SE. Responses to the Final SE are provided below to document the BWRVIP positions discussed during the October 29-30, 2001 meeting.

Issue 1:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report uses the "average crack depth" as a parameter for both the inspection and flaw evaluations. The use of average crack depth in the flaw evaluation does not provide adequate conservatism and it is also not consistent with the guidance provided in the BWRVIP-07 report. As approved by the NRC staff, the maximum crack depth should be assumed to ensure a conservative result.

The BWRVIP's May 30, 2001 response [2] stated:

> There are two approaches for the application of average crack depth in BWRVIP-63 (and BWRVIP-76). One approach applies to the screening and acceptance criteria and the second approach applies when performing plant-specific flaw evaluations. These are described in more detail as follows.
>
> The screening and acceptance criteria, presented in Section 3.0 of BWRVIP-63, uses an average crack depth based on the total inspected length. This is appropriate because the models used to develop the screening and acceptance criteria (Section 4.0) are based on conservative LEFM and limit load solutions. The LEFM models assume a uniform depth flaw which is best represented by the average depth. The limit load models are based on the stress condition of the net section remaining, which is also best represented by the average depth. Additional factors of safety, consistent with existing BWRVIP inspection and flaw guidelines, are also included.
>
> The flaw evaluation criteria, presented in Appendices D and F, uses a slightly different approach for determining average crack depth based on only the cracked length, not the total inspected length. However, the guidance provided in BWRVIP-63 (and BWRVIP-76) is stated incorrectly. The BWRVIP intends to clarify only BWRVIP-76 (because BWRVIP-76 supersedes BWRVIP-63) as follows:

Appendix D (page D-1) and Appendix F (page F-11) of BWRVIP-76 presently states "The assumed crack depth in the uninspected region should be set equal to the average crack depth in the inspected region."

BWRVIP-76 should have stated "The assumed crack depth in the uninspected region should be set equal to the average depth of the observed cracks in the inspected region." In other words, the average crack depth should be based on only that portion of the weld that was inspected and found to be cracked. The average crack depth should not be computed based on inspected lengths where no cracking is detected.

The corrected pages of BWRVIP-76 are attached. Note that the example on page F-11 uses the correct crack depth.

Based on the above discussion, the BWRVIP believes that the use of maximum crack depth is excessively conservative whereas the use and application of average crack depth is technically justified and has an adequate level of conservatism.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

Based on discussions the staff has had with the BWRVIP on crack growth rate, the staff finds that, for plants utilizing effective HWC or NMCA, as defined in the staff's SE for the BWRVIP-62 report, the BWRVIP's proposed usage of assumed crack depth in the uninspected region as equal to the average depth of the observed cracks in the inspected region is acceptable. Plants with NWC should use the more conservative maximum crack depth for the uninspected regions. With this revision, the staff considers this item resolved.

Final BWRVIP response:

The BWRVIP continues to disagree with the staff on this issue. There is no information or technical rationale that would indicate cracking in uninspected regions for NWC plants is different than HWC plants. The approach used by the BWRVIP to account for differences in water chemistry is through application of the crack growth rate correlations contained in BWRVIP-14 and BWRVIP-99 for stainless steel materials. These conservative correlations were developed to account for such parameters as ECP, conductivity, stress, fluence, temperature, etc. and have been reviewed by NRC. The BWRVIP believes that use of maximum crack depth for the uninspected regions is overly conservative, regardless of water chemistry conditions. The average crack depth is employed in the screening criteria to determine which welds are to be inspected. It is also used in the acceptance criteria to determine the structural integrity of the welds. Use of maximum depth, as proposed by NRC, will require the BWRVIP to develop a completely revised screening and acceptance criteria based on maximum depth for NWC plants. The BWRVIP continues to believe that sufficient conservatism is included in the BWRVIP-63 methodology to account for the differences in water chemistry. The crack growth rates assumed in the flaw evaluation will be determined based on the water

chemistry conditions, i.e., conductivity and ECP or a stress-intensity-independent based rate will be used.

Issue 2:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 4-1 (Section 4, "Evaluation of Vertical Weld Indications") that "if through-wall cracks in vertical welds were observed during the inspection, leakage from vertical weld cracking must also be evaluated." However, the potential leakage at EOI should also be quantitatively assessed using a conservative evaluation methodology even though through-wall cracks were not detected during the inspection. Therefore, if the cracking is projected to grow through-wall, a leakage assessment should be provided. A similar statement on page 3-4 (Section 3.1.3, "Acceptance Standards for Vertical Welds") should also be revised.

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP recognizes that there is a possibility of through-wall cracking in core shrouds, however, the inspections performed to date have not revealed any through-wall cracking. Furthermore, the issue of leakage through a vertical weld has previously been evaluated. BWRVIP-01, which has been reviewed and approved by the NRC, states that "leakage through a fully cracked vertical weld has also been shown to be acceptably small." Therefore, potential leakage has been evaluated for projected or assumed through-wall flaws and is considered acceptable.
>
> The BWRVIP does believe it is necessary to quantitatively determine the leakage from an actual through-wall flaw as this may have a direct impact on core performance and on the ability to maintain reflood capability.
>
> Therefore, in summary, the BWRVIP believes that only actual through-wall cracks should be evaluated for leakage.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff agrees that actual through-wall cracks should be evaluated for leakage. In addition, if the cracking is not repaired prior to the next operating cycle and the crack is *projected* to grow through-wall, a leakage assessment should also be performed. A similar statement on page 3-4 (Section 3.1.3, "Acceptance Standards for Vertical Welds") should also be revised. With this revision, the staff considers this item closed.

Final BWRVIP response:

> The BWRVIP continues to believe that a requirement to calculate leakage from predicted through-wall cracks is an overly conservative position. Assumptions already embodied in BWRVIP-63 and BWRVIP-76 for postulating the length and depth of flaws are very conservative. These assumptions typically result in an over-predicted amount of cracking

Furthermore, although the crack growth correlations contained in BWRVIP-14 and BWRVIP-99 may predict through-wall cracks, no through-wall cracking has been detected to date in core shrouds. A prediction of through-wall cracks results is an unrealistic prediction of leakage. The BWRVIP has developed conservative methodologies to ensure that structural integrity of the core shroud and other BWR internals is maintained during operating and postulated accident conditions. Assumptions regarding through-wall cracking are invoked to address inspection limitations (i.e, cracks detected by EVT-1 must be assumed through-wall), to simplify the structural analyses and to ensure that the safety margins are robust. To further penalize an owner by requiring the assumption of leakage and potential reduction in unit rating is unwarranted.

As noted above there has been no inspection experience obtained which indicates that through-wall cracks have occurred in the vertical or horizontal core shroud welds. The inspection frequencies contained in BWRVIP-63 and BWRVIP-76 are such that any appreciable through-wall cracks will be detected well before they impact plant operation or structural integrity. The crack growth rates established for stainless steel materials (reported in BWRVIP-14 and BWRVIP-99) are conservative such that the predicted rates bound the inspection data and have added margin to account for unknowns such as weld repairs. The inspection data presented in BWRVIP-99 demonstrates that crack growth rates are slowing substantially as crack depth increases.

Core shroud circumferential welds that have been structurally placed by repair hardware do not require inspections per BWRVIP-76. The design requirement is to assume complete through-wall cracking for each circumferential weld that is structurally replaced. No additional leakage assessments are required by the BWRVIP beyond those considered in the shroud repair design. Therefore, the BWRVIP believes that the requirement to calculate leakage should be only for observed through-wall flaws.

Issue 3:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 4-2 (Section 4, "Evaluation of Vertical Weld Indications") that "K_{IC} = 150 ksi$\sqrt{in}$ based on BWRVIP-01." Elevated fluences on core shroud welds may effect the mechanical properties of the constituent structural materials. Therefore, the material toughness value may vary under high irradiated conditions. Upon availability of relevant data, a fluence threshold should be established for use of this figure in LEFM. When the fluence limit is exceeded, the use of this value should be justified and discussed with the NRC staff.

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP is presently evaluating fracture toughness properties of highly irradiated stainless steel. The BWRVIP expects to submit the results of this work to the NRC in early 2001. The results may indicate that some changes are required to existing BWRVIP guidelines for shroud inspection and flaw evaluation for highly irradiated

welds. However, in the interim, we believe the approach provided in BWRVIP-76, Section D.1.1 is acceptable for evaluating these conditions. If a different method is used by the utility, we agree that it should be justified and discussed with the NRC staff.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> Based on the above, this item remains open and will be addressed in the staff's review of the BWRVIP-76 report.

Final BWRVIP response:

> BWRVIP-100, "BWR Vessel and Internals Project, Updated Assessment of the Fracture Toughness of Irradiated Stainless Steel for BWR Core Shrouds," EPRI Technical Report 1003016, December 2001 has been submitted to NRC for review and approval. This report provides the relationship of toughness versus fluence for core shroud flaw evaluations. The BWRVIP will use the appropriate fracture toughness limits specified in BWRVIP-100 for evaluation of flaws.

Issue 4:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page B-1 (Appendix B, "Plant Specific Flaw Evaluation Methodology") that "plant-specific analysis may be required if acceptance criteria "c" of Section 3.2 .... cannot be satisfied." Section 3.1.3, "Acceptance Standards for Vertical Welds," should be the correct citation not Section 3.2, "Vertical Welds in Repaired Shrouds."

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP agrees that the citation of Section 3.2 should be corrected to Section 3.1.3.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff finds that these actions adequately addresses this open item.

Final BWRVIP response:

> No changes.

Issue 5:

The Staff's April 18, 2000, Initial SE [3] stated:

The BWRVIP-63 report states on page B-2 (Appendix B, "Plant Specific Flaw Evaluation Methodology") that "submittal to the NRC of these analyses along with the inspection results is required within 90 days of the inspection." The reporting requirements for plant- specific flaw analysis should be consistent with those expressed in the BWRVIP-76 report, which states on page 4-1 (Section 4.3, "Analytical Evaluations of Inspection Results") that the analytical results "shall be reported to the NRC within 30 days after completion of the inspection."

The BWRVIP's May 30, 2001 response [2] stated:

The BWRVIP will provide a response to Item 5 at a later date.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

Based on the above, this item remains open and will be addressed in the staff's review of the BWRVIP-76 report.

Final BWRVIP response:

The BWRVIP has developed reporting requirements which are documented in BWRVIP-94, "BWR Vessel and Internals Project, Program Implementation Guide," EPRI Technical Report 1006288, August 2001. The BWRVIP proposes to delete the specific reporting requirements from all the Inspection and Evaluation Guidelines and reference Section 3.5 of BWRVIP-94 which follows:

> Each utility will inform the NRC of any decision to not fully implement a BWRVIP guideline approved by the NRC staff within 45 days of the report approval. This applies to only those BWRVIP guidelines that have received a Final Safety Evaluation without any exceptions to the report. The NRC should be notified if changes are made to the vessel and internals program that affect implementation of BWRVIP guidelines.
>
> Inspection results and flaw evaluations for components within the scope of the BWRVIP shall be reported as described below.
>
> 1. Licensees shall forward a summary of all inspections, associated results and new repairs to the BWRVIP Program Manager within 120 days following completion of an outage.
>
> 2. Flaw evaluations performed in accordance with the guidance in BWRVIP reports for the acceptance of inspection results do not require submittal to, or approval by, the NRC.
>
> 3. Flaw evaluations that deviate from the guidance in BWRVIP reports (e.g., assumptions, methods, acceptance criteria, etc.) shall be submitted to the NRC for approval. If the flaw evaluation is later revised, the results shall be

communicated to the NRC. The submittal schedule for the analyses will be determined by the licensee and the NRC.

4. If it is determined that implementation cannot be achieved as described in the I&E guidelines, or that meaningful results are not obtained, the user shall notify the BWRVIP with sufficient details to support development of alternative actions. These notifications, as well as planned actions by the BWRVIP, will be summarized and reported to the NRC by the BWRVIP.

5. Modifications to plant operation or configurations that may affect BWRVIP guidance (e.g., power uprate) shall also be reported to the BWRVIP Program Manager.

6. Section XI of the ASME Boiler and Pressure Vessel Code contains rules for inspection, flaw evaluation and repair/replacement of certain components that are also addressed as part of the BWRVIP program. The Code requirements are detailed in Table IWB-2500, Category B-N-2, Welded Core Support Structures and Interior Attachments to Reactor Vessel. In order for BWRVIP I&E Guidelines to be used in lieu of the ASME Code requirements, each licensee must obtain relief from the Code via the process described in 10CFR50.55a. This would best be accomplished by using the technical alternative provision contained in 10CFR50.55a(a)(3)(i).

The form and format of the reporting shall be in accordance with licensee's established procedures. This may include, but is not limited to, submittal by letter or as an attachment to ASME Code required documentation (NIS-1, OAR-1, etc.).

Industry reports are necessary to share information on failure mechanisms, NDE technique applications, repair effectiveness, operating experience, and other items. This experience is shared through the BWRVIP and member utilities. Member utilities agree to share results of assessments outlined in Section 3.4 with the BWRVIP. Deviations from BWRVIP guidance approved by the NRC and documented in accordance with Appendix A shall also be shared with the BWRVIP.

The BWRVIP is also developing a standard template for licensees to follow for submitting a technical alternative to use the BWRVIP I&E Guidelines in lieu of the ASME Code requirements.

Issue 6:

The Staff's April 18, 2000, Initial SE [3] stated:

> The effect of neutron fluence level on the crack growth rate should be consistent with that discussed in the BWRVIP-07 report. When the fluence level exceeds $5x10^{20}n/cm^2$, the appropriate crack growth rate to be used in the flaw evaluation should be discussed with and approved by the NRC staff.

The BWRVIP's May 30, 2001 response [2] stated:

> Until such time as the BWRVIP submits a crack growth evaluation for highly irradiated stainless steel, we agree that when the fluence level exceeds $5x10^{20}$ n/cm^2, the appropriate crack growth rate to be used in plant-specific flaw evaluations will be provided to NRC for concurrence.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff finds that this response adequately addresses this open item.

Final BWRVIP response:

> "BWRVIP-99: BWR Vessel and Internals Project, Crack Growth Rates in Irradiated Stainless Steels in BWR Internal Components," EPRI Technical Report 1003018, December 2001 has been submitted to the NRC for review and approval. The report provides the crack growth rates for stainless steel in the fluence range of $5x10^{20}$ n/cm^2 up to $3x10^{21}$ n/cm^2. The BWRVIP will use the appropriate correlation in this report for evaluation of stainless steel materials subjected to the specified fluence range.

Issue 7:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 3-1(Section 3, "Inspection Recommendations") that "NDE uncertainty does not need to be considered since it is adequately covered by conservatisms in the flaw evaluation methods." BWRVIP-member utilities must determine the measurement uncertainty associated with NDE techniques to be used for inspection of the reactor vessel components consistent with the methodology specified in the BWRVIP-03 report (Section 2.3 "Guidelines for Determining NDE Technique Uncertainty") as approved by the NRC staff, and include the measurement uncertainties in the flaw evaluation consistent with guidance in the BWRVIP-07 report.

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP will provide a response to Item 7 at a later date.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> Based on the above, this item remains open and will be addressed in the staff's review of the BWRVIP-76 report.

Final BWRVIP response:

> The BWRVIP provided a response to Issue 7 in Reference 4.

Issue 8:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 3-3 (Section 3.1.3, "Acceptance Standards for Vertical Welds") that "if the weld has been inspected using a one-sided technique and no cracking was detected then the weld is acceptable for 6 EFPY." In order to verify the weld integrity, the inspection should consist of a two-sided (ID and OD) visual examination. Whenever one-sided visual inspection was performed, the use of its results to determine the reinspection interval should be justified and discussed with the NRC staff. Also, the use of effective full power years (EFPY) as a basis to establish the reinspection interval does not correspond with NRC-approved guidelines. Determination of the acceptable operating time, wherever applicable in the subject report, should be in terms of operating hours or years, not EFPY.

The BWRVIP's May 30, 2001 response [2] stated:

> Section 2.2 of BWRVIP-63 specifies that volumetric or two-sided (ID and OD) visual exams are the only acceptable methods for satisfying the acceptance criteria contained in Section 3. This is consistent with the examination guidelines for horizontal welds contained in BWRVIP-76. The beltline region is approximately 75% of the shroud vertical welds and represents a significant two sided or volumetric examination sample. This is considered an adequate sampling to determine if any ID vertical weld cracking exists. However, in some cases a volumetric exam or two-sided visual exam is not possible due to access limitation (obstructions due to hardware, etc.) For these situations, BWRVIP-63 allows for a one-sided exam and states that a maximum EOI of 6 years is acceptable provided that no cracking is detected. If cracks are detected, a plant-specific evaluation must be performed. Therefore, based on the fact that the bulk of the inspections will be volumetric or visual from both the ID and OD, a substantial amount of weld volume will be examined using this criteria. In general, the regions where one-sided visual exams will be employed will be small compared to those examined by volumetric methods. Furthermore, if cracks are detected using one-sided visual exams, analyses must be performed to determine both the structural integrity and future inspection frequency of the vertical weld. If the evaluation performed differs from the acceptable methods described in the report, the evaluation must be submitted to the NRC for approval. Therefore, the BWRVIP believes that one-sided visual examinations are acceptable for certain situations provided that Section 2.2 of the BWRVIP-63 is followed.
>
> The BWRVIP agrees with the NRC that the reinspection intervals should be based on operating years, not EFPY. In fact, this is reflected in the BWRVIP-76 report.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff finds that, with a revision to the BWRVIP-63 report stating that a qualified two-sided EVT-1 type visual exam should encompass *essentially 100 percent* (as defined in 10 CFR 50.55a) of the inspection area, then the EOI criteria, as proposed to be modified,

established in Section 2.2 of the BWRVIP-63 report is acceptable. If a licensee cannot achieve essentially 100 percent coverage utilizing a qualified two-sided EVT-1 type visual exam, or if the licensee utilizes a one-sided EVT-1 type visual exam, then the licensee shall provide a technical justification of the proposed reinspection interval to the NRC staff. With these revisions, and the BWRVIP's agreement regarding operating years vice EFPY, the staff considers this item resolved.

Final BWRVIP response:

The staff position on vertical welds is not consistent with that of the horizontal welds where the NRC has accepted the BWRVIP position of inspecting essentially 100% of all accessible regions with a minimum of 50% in order to justify structural integrity and future reinspection intervals. The same coverage requirements have been applied to the vertical welds. A further point to make is that except for axial welds, located in the beltline region, that might receive an accumulated fluence greater than $1x10^{21}$ n/cm^2, the allowable flaw length exceeds the length of the weld. Regardless of the actual coverage achieved in excess of 50% or the level of fluence, the flaw evaluation criteria defined in BWRVIP-63 will determine if additional inspections are required for the desired period of operation. Thus, the BWRVIP believes that conservative guidance is provided in BWRVIP-63 to assess integrity of the vertical welds.

Issue 9:

The Staff's April 18, 2000, Initial SE [3] stated:

The BWRVIP-63 report states on page 3-5 (Section 3.1.3, "Radial Ring Welds") that "if the location of the welds is known (e.g., from plant drawings), then those specific locations shall be inspected from the OD of the ring." To assure complete integrity of the weld, the inspection should extend the entire length of the weld and not just the outer surface. In addition, the particular NDE technique used to detect any discontinuities within this component should be given (e.g., UT or 2-sided VT).

The BWRVIP's May 30, 2001 response [2] stated:

Inspection of radial ring welds to date has not revealed any significant cracking or structural integrity concerns. The BWRVIP is recommending that the inspection begin at the OD of the rings. If cracking is detected it is expected that additional surfaces will be examined, on an as-needed basis, as input to plant-specific structural evaluations.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

As stated in the staff findings for Issue 8, above, and the staff's April 18, 2000, initial SE, if the licensee is utilizing a visual exam, it should be a qualified two-sided (OD and ID) EVT-1 type visual exam which encompasses *essentially 100 percent* (as defined in 10 CFR 50.55a) of the inspection area. With this revision, the staff considers this item resolved.

Final BWRVIP response:

Radial ring welds have not reveal any significant cracking. Inspections are currently being performed of all accessible areas following the same approach as horizontal and vertical welds. Examination of the ring welds on the ID and bottom surface is generally impractical or not possible because there is either no access or it would require disassembly of the top guide and associated hardware. Therefore, for the same reasons as discussed in the response to Issue 8, the BWRVIP believes that the current guidance specified in BWRVIP-63 is sufficient to detect cracking in the radial ring welds.

References:

1. Letter from William H. Bateman (NRC) to Carl Terry (BWRVIP Chairman), "Final Safety Evaluation of the BWRVIP Vessel and Internals Project, Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63), EPRI Report TR-113170, June 1999 (TAC NO. MA6015)," dated August 20, 2001.
2. Letter from Carl Terry (BWRVIP Chairman) to NRC Document Control Desk, "Project 704 – BWRVIP Response to NRC Safety Evaluation of BWRVIP-63," dated May 30, 2001.
3. Letter from Jack R. Strosnider (NRC) to Carl Terry (BWRVIP Chairman), "Safety Evaluation of the BWRVIP Vessel and Internals Project, Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63), EPRI Report TR-113170, June 1999 (TAC NO. MA6015)," dated April 18, 2000.
4. Letter from Carl Terry (BWRVIP Chairman) to NRC Document Control Desk, "PROJECT NO. 704 -- BWRVIP Partial Response to the NRC Final Safety Evaluation of BWRVIP-63," dated October 22, 2002.

BWRVIP Response to Issues in NRC Final Safety Evaluation of "BWRVIP Vessel And Internals Project, Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63)," EPRI Report TR-113170, June 1999

Below are the issues identified in the NRC Final Safety Evaluation (SE) of the document entitled "Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63)," followed by the BWRVIP response to each issue. The BWRVIP proposes to incorporate staff comments and other changes, where applicable, into a revised BWRVIP-76 report.

The staff's August 20, 2001 Final SE [1] responded to Reference 2. A meeting was held at Argonne National Labs on October 29-30, 2001 to discuss the BWRVIP proposed response to the Final SE. Responses to the Final SE are provided below to document the BWRVIP positions discussed during the October 29-30, 2001 meeting.

Issue 1:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report uses the "average crack depth" as a parameter for both the inspection and flaw evaluations. The use of average crack depth in the flaw evaluation does not provide adequate conservatism and it is also not consistent with the guidance provided in the BWRVIP-07 report. As approved by the NRC staff, the maximum crack depth should be assumed to ensure a conservative result.

The BWRVIP's May 30, 2001 response [2] stated:

> There are two approaches for the application of average crack depth in BWRVIP-63 (and BWRVIP-76). One approach applies to the screening and acceptance criteria and the second approach applies when performing plant-specific flaw evaluations. These are described in more detail as follows.
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> The screening and acceptance criteria, presented in Section 3.0 of BWRVIP-63, uses an average crack depth based on the total inspected length. This is appropriate because the models used to develop the screening and acceptance criteria (Section 4.0) are based on conservative LEFM and limit load solutions. The LEFM models assume a uniform depth flaw which is best represented by the average depth. The limit load models are based on the stress condition of the net section remaining, which is also best represented by the average depth. Additional factors of safety, consistent with existing BWRVIP inspection and flaw guidelines, are also included.
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> The flaw evaluation criteria, presented in Appendices D and F, uses a slightly different approach for determining average crack depth based on only the cracked length, not the total inspected length. However, the guidance provided in BWRVIP-63 (and BWRVIP-76) is stated incorrectly. The BWRVIP intends to clarify only BWRVIP-76 (because BWRVIP-76 supersedes BWRVIP-63) as follows:

Appendix D (page D-1) and Appendix F (page F-11) of BWRVIP-76 presently states "The assumed crack depth in the uninspected region should be set equal to the average crack depth in the inspected region."

BWRVIP-76 should have stated "The assumed crack depth in the uninspected region should be set equal to the average depth of the observed cracks in the inspected region." In other words, the average crack depth should be based on only that portion of the weld that was inspected and found to be cracked. The average crack depth should not be computed based on inspected lengths where no cracking is detected.

The corrected pages of BWRVIP-76 are attached. Note that the example on page F-11 uses the correct crack depth.

Based on the above discussion, the BWRVIP believes that the use of maximum crack depth is excessively conservative whereas the use and application of average crack depth is technically justified and has an adequate level of conservatism.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

Based on discussions the staff has had with the BWRVIP on crack growth rate, the staff finds that, for plants utilizing effective HWC or NMCA, as defined in the staff's SE for the BWRVIP-62 report, the BWRVIP's proposed usage of assumed crack depth in the uninspected region as equal to the average depth of the observed cracks in the inspected region is acceptable. Plants with NWC should use the more conservative maximum crack depth for the uninspected regions. With this revision, the staff considers this item resolved.

Final BWRVIP response:

The BWRVIP continues to disagree with the staff on this issue. There is no information or technical rationale that would indicate cracking in uninspected regions for NWC plants is different than HWC plants. The approach used by the BWRVIP to account for differences in water chemistry is through application of the crack growth rate correlations contained in BWRVIP-14 and BWRVIP-99 for stainless steel materials. These conservative correlations were developed to account for such parameters as ECP, conductivity, stress, fluence, temperature, etc. and have been reviewed by NRC. The BWRVIP believes that use of maximum crack depth for the uninspected regions is overly conservative, regardless of water chemistry conditions. The average crack depth is employed in the screening criteria to determine which welds are to be inspected. It is also used in the acceptance criteria to determine the structural integrity of the welds. Use of maximum depth, as proposed by NRC, will require the BWRVIP to develop a completely revised screening and acceptance criteria based on maximum depth for NWC plants. The BWRVIP continues to believe that sufficient conservatism is included in the BWRVIP-63 methodology to account for the differences in water chemistry. The crack growth rates assumed in the flaw evaluation will be determined based on the water

chemistry conditions, i.e., conductivity and ECP or a stress-intensity-independent based rate will be used.

Issue 2:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 4-1 (Section 4, "Evaluation of Vertical Weld Indications") that "if through-wall cracks in vertical welds were observed during the inspection, leakage from vertical weld cracking must also be evaluated." However, the potential leakage at EOI should also be quantitatively assessed using a conservative evaluation methodology even though through-wall cracks were not detected during the inspection. Therefore, if the cracking is projected to grow through-wall, a leakage assessment should be provided. A similar statement on page 3-4 (Section 3.1.3, "Acceptance Standards for Vertical Welds") should also be revised.

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP recognizes that there is a possibility of through-wall cracking in core shrouds, however, the inspections performed to date have not revealed any through-wall cracking. Furthermore, the issue of leakage through a vertical weld has previously been evaluated. BWRVIP-01, which has been reviewed and approved by the NRC, states that "leakage through a fully cracked vertical weld has also been shown to be acceptably small." Therefore, potential leakage has been evaluated for projected or assumed through-wall flaws and is considered acceptable.
>
> The BWRVIP does believe it is necessary to quantitatively determine the leakage from an actual through-wall flaw as this may have a direct impact on core performance and on the ability to maintain reflood capability.
>
> Therefore, in summary, the BWRVIP believes that only actual through-wall cracks should be evaluated for leakage.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff agrees that actual through-wall cracks should be evaluated for leakage. In addition, if the cracking is not repaired prior to the next operating cycle and the crack is *projected* to grow through-wall, a leakage assessment should also be performed. A similar statement on page 3-4 (Section 3.1.3, "Acceptance Standards for Vertical Welds") should also be revised. With this revision, the staff considers this item closed.

Final BWRVIP response:

> The BWRVIP continues to believe that a requirement to calculate leakage from predicted through-wall cracks is an overly conservative position. Assumptions already embodied in BWRVIP-63 and BWRVIP-76 for postulating the length and depth of flaws are very conservative. These assumptions typically result in an over-predicted amount of cracking

Furthermore, although the crack growth correlations contained in BWRVIP-14 and BWRVIP-99 may predict through-wall cracks, no through-wall cracking has been detected to date in core shrouds. A prediction of through-wall cracks results is an unrealistic prediction of leakage. The BWRVIP has developed conservative methodologies to ensure that structural integrity of the core shroud and other BWR internals is maintained during operating and postulated accident conditions. Assumptions regarding through-wall cracking are invoked to address inspection limitations (i.e, cracks detected by EVT-1 must be assumed through-wall), to simplify the structural analyses and to ensure that the safety margins are robust. To further penalize an owner by requiring the assumption of leakage and potential reduction in unit rating is unwarranted.

As noted above there has been no inspection experience obtained which indicates that through-wall cracks have occurred in the vertical or horizontal core shroud welds. The inspection frequencies contained in BWRVIP-63 and BWRVIP-76 are such that any appreciable through-wall cracks will be detected well before they impact plant operation or structural integrity. The crack growth rates established for stainless steel materials (reported in BWRVIP-14 and BWRVIP-99) are conservative such that the predicted rates bound the inspection data and have added margin to account for unknowns such as weld repairs. The inspection data presented in BWRVIP-99 demonstrates that crack growth rates are slowing substantially as crack depth increases.

Core shroud circumferential welds that have been structurally placed by repair hardware do not require inspections per BWRVIP-76. The design requirement is to assume complete through-wall cracking for each circumferential weld that is structurally replaced. No additional leakage assessments are required by the BWRVIP beyond those considered in the shroud repair design. Therefore, the BWRVIP believes that the requirement to calculate leakage should be only for observed through-wall flaws.

Issue 3:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 4-2 (Section 4, "Evaluation of Vertical Weld Indications") that "K_{IC} = 150 ksi$\sqrt{in}$ based on BWRVIP-01." Elevated fluences on core shroud welds may effect the mechanical properties of the constituent structural materials. Therefore, the material toughness value may vary under high irradiated conditions. Upon availability of relevant data, a fluence threshold should be established for use of this figure in LEFM. When the fluence limit is exceeded, the use of this value should be justified and discussed with the NRC staff.

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP is presently evaluating fracture toughness properties of highly irradiated stainless steel. The BWRVIP expects to submit the results of this work to the NRC in early 2001. The results may indicate that some changes are required to existing BWRVIP guidelines for shroud inspection and flaw evaluation for highly irradiated

welds. However, in the interim, we believe the approach provided in BWRVIP-76, Section D.1.1 is acceptable for evaluating these conditions. If a different method is used by the utility, we agree that it should be justified and discussed with the NRC staff.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> Based on the above, this item remains open and will be addressed in the staff's review of the BWRVIP-76 report.

Final BWRVIP response:

> BWRVIP-100, "BWR Vessel and Internals Project, Updated Assessment of the Fracture Toughness of Irradiated Stainless Steel for BWR Core Shrouds," EPRI Technical Report 1003016, December 2001 has been submitted to NRC for review and approval. This report provides the relationship of toughness versus fluence for core shroud flaw evaluations. The BWRVIP will use the appropriate fracture toughness limits specified in BWRVIP-100 for evaluation of flaws.

Issue 4:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page B-1 (Appendix B, "Plant Specific Flaw Evaluation Methodology") that "plant-specific analysis may be required if acceptance criteria "c" of Section 3.2 .... cannot be satisfied." Section 3.1.3, "Acceptance Standards for Vertical Welds," should be the correct citation not Section 3.2, "Vertical Welds in Repaired Shrouds."

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP agrees that the citation of Section 3.2 should be corrected to Section 3.1.3.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff finds that these actions adequately addresses this open item.

Final BWRVIP response:

> No changes.

Issue 5:

The Staff's April 18, 2000, Initial SE [3] stated:

The BWRVIP-63 report states on page B-2 (Appendix B, "Plant Specific Flaw Evaluation Methodology") that "submittal to the NRC of these analyses along with the inspection results is required within 90 days of the inspection." The reporting requirements for plant- specific flaw analysis should be consistent with those expressed in the BWRVIP-76 report, which states on page 4-1 (Section 4.3, "Analytical Evaluations of Inspection Results") that the analytical results "shall be reported to the NRC within 30 days after completion of the inspection."

The BWRVIP's May 30, 2001 response [2] stated:

The BWRVIP will provide a response to Item 5 at a later date.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

Based on the above, this item remains open and will be addressed in the staff's review of the BWRVIP-76 report.

Final BWRVIP response:

The BWRVIP has developed reporting requirements which are documented in BWRVIP-94, "BWR Vessel and Internals Project, Program Implementation Guide," EPRI Technical Report 1006288, August 2001. The BWRVIP proposes to delete the specific reporting requirements from all the Inspection and Evaluation Guidelines and reference Section 3.5 of BWRVIP-94 which follows:

> Each utility will inform the NRC of any decision to not fully implement a BWRVIP guideline approved by the NRC staff within 45 days of the report approval. This applies to only those BWRVIP guidelines that have received a Final Safety Evaluation without any exceptions to the report. The NRC should be notified if changes are made to the vessel and internals program that affect implementation of BWRVIP guidelines.
>
> Inspection results and flaw evaluations for components within the scope of the BWRVIP shall be reported as described below.
>
> 1. Licensees shall forward a summary of all inspections, associated results and new repairs to the BWRVIP Program Manager within 120 days following completion of an outage.
>
> 2. Flaw evaluations performed in accordance with the guidance in BWRVIP reports for the acceptance of inspection results do not require submittal to, or approval by, the NRC.
>
> 3. Flaw evaluations that deviate from the guidance in BWRVIP reports (e.g., assumptions, methods, acceptance criteria, etc.) shall be submitted to the NRC for approval. If the flaw evaluation is later revised, the results shall be

communicated to the NRC. The submittal schedule for the analyses will be determined by the licensee and the NRC.

4. If it is determined that implementation cannot be achieved as described in the I&E guidelines, or that meaningful results are not obtained, the user shall notify the BWRVIP with sufficient details to support development of alternative actions. These notifications, as well as planned actions by the BWRVIP, will be summarized and reported to the NRC by the BWRVIP.

5. Modifications to plant operation or configurations that may affect BWRVIP guidance (e.g., power uprate) shall also be reported to the BWRVIP Program Manager.

6. Section XI of the ASME Boiler and Pressure Vessel Code contains rules for inspection, flaw evaluation and repair/replacement of certain components that are also addressed as part of the BWRVIP program. The Code requirements are detailed in Table IWB-2500, Category B-N-2, Welded Core Support Structures and Interior Attachments to Reactor Vessel. In order for BWRVIP I&E Guidelines to be used in lieu of the ASME Code requirements, each licensee must obtain relief from the Code via the process described in 10CFR50.55a. This would best be accomplished by using the technical alternative provision contained in 10CFR50.55a(a)(3)(i).

The form and format of the reporting shall be in accordance with licensee's established procedures. This may include, but is not limited to, submittal by letter or as an attachment to ASME Code required documentation (NIS-1, OAR-1, etc.).

Industry reports are necessary to share information on failure mechanisms, NDE technique applications, repair effectiveness, operating experience, and other items. This experience is shared through the BWRVIP and member utilities. Member utilities agree to share results of assessments outlined in Section 3.4 with the BWRVIP. Deviations from BWRVIP guidance approved by the NRC and documented in accordance with Appendix A shall also be shared with the BWRVIP.

The BWRVIP is also developing a standard template for licensees to follow for submitting a technical alternative to use the BWRVIP I&E Guidelines in lieu of the ASME Code requirements.

Issue 6:

The Staff's April 18, 2000, Initial SE [3] stated:

> The effect of neutron fluence level on the crack growth rate should be consistent with that discussed in the BWRVIP-07 report. When the fluence level exceeds $5x10^{20}n/cm^2$, the appropriate crack growth rate to be used in the flaw evaluation should be discussed with and approved by the NRC staff.

The BWRVIP's May 30, 2001 response [2] stated:

> Until such time as the BWRVIP submits a crack growth evaluation for highly irradiated stainless steel, we agree that when the fluence level exceeds $5x10^{20}$ n/cm^2, the appropriate crack growth rate to be used in plant-specific flaw evaluations will be provided to NRC for concurrence.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff finds that this response adequately addresses this open item.

Final BWRVIP response:

> "BWRVIP-99: BWR Vessel and Internals Project, Crack Growth Rates in Irradiated Stainless Steels in BWR Internal Components," EPRI Technical Report 1003018, December 2001 has been submitted to the NRC for review and approval. The report provides the crack growth rates for stainless steel in the fluence range of $5x10^{20}$ n/cm^2 up to $3x10^{21}$ n/cm^2. The BWRVIP will use the appropriate correlation in this report for evaluation of stainless steel materials subjected to the specified fluence range.

Issue 7:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 3-1(Section 3, "Inspection Recommendations") that "NDE uncertainty does not need to be considered since it is adequately covered by conservatisms in the flaw evaluation methods." BWRVIP-member utilities must determine the measurement uncertainty associated with NDE techniques to be used for inspection of the reactor vessel components consistent with the methodology specified in the BWRVIP-03 report (Section 2.3 "Guidelines for Determining NDE Technique Uncertainty") as approved by the NRC staff, and include the measurement uncertainties in the flaw evaluation consistent with guidance in the BWRVIP-07 report.

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP will provide a response to Item 7 at a later date.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> Based on the above, this item remains open and will be addressed in the staff's review of the BWRVIP-76 report.

Final BWRVIP response:

> The BWRVIP provided a response to Issue 7 in Reference 4.

Issue 8:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 3-3 (Section 3.1.3, "Acceptance Standards for Vertical Welds") that "if the weld has been inspected using a one-sided technique and no cracking was detected then the weld is acceptable for 6 EFPY." In order to verify the weld integrity, the inspection should consist of a two-sided (ID and OD) visual examination. Whenever one-sided visual inspection was performed, the use of its results to determine the reinspection interval should be justified and discussed with the NRC staff. Also, the use of effective full power years (EFPY) as a basis to establish the reinspection interval does not correspond with NRC-approved guidelines. Determination of the acceptable operating time, wherever applicable in the subject report, should be in terms of operating hours or years, not EFPY.

The BWRVIP's May 30, 2001 response [2] stated:

> Section 2.2 of BWRVIP-63 specifies that volumetric or two-sided (ID and OD) visual exams are the only acceptable methods for satisfying the acceptance criteria contained in Section 3. This is consistent with the examination guidelines for horizontal welds contained in BWRVIP-76. The beltline region is approximately 75% of the shroud vertical welds and represents a significant two sided or volumetric examination sample. This is considered an adequate sampling to determine if any ID vertical weld cracking exists. However, in some cases a volumetric exam or two-sided visual exam is not possible due to access limitation (obstructions due to hardware, etc.) For these situations, BWRVIP-63 allows for a one-sided exam and states that a maximum EOI of 6 years is acceptable provided that no cracking is detected. If cracks are detected, a plant-specific evaluation must be performed. Therefore, based on the fact that the bulk of the inspections will be volumetric or visual from both the ID and OD, a substantial amount of weld volume will be examined using this criteria. In general, the regions where one-sided visual exams will be employed will be small compared to those examined by volumetric methods. Furthermore, if cracks are detected using one-sided visual exams, analyses must be performed to determine both the structural integrity and future inspection frequency of the vertical weld. If the evaluation performed differs from the acceptable methods described in the report, the evaluation must be submitted to the NRC for approval. Therefore, the BWRVIP believes that one-sided visual examinations are acceptable for certain situations provided that Section 2.2 of the BWRVIP-63 is followed.
>
> The BWRVIP agrees with the NRC that the reinspection intervals should be based on operating years, not EFPY. In fact, this is reflected in the BWRVIP-76 report.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff finds that, with a revision to the BWRVIP-63 report stating that a qualified two-sided EVT-1 type visual exam should encompass *essentially 100 percent* (as defined in 10 CFR 50.55a) of the inspection area, then the EOI criteria, as proposed to be modified,

established in Section 2.2 of the BWRVIP-63 report is acceptable. If a licensee cannot achieve essentially 100 percent coverage utilizing a qualified two-sided EVT-1 type visual exam, or if the licensee utilizes a one-sided EVT-1 type visual exam, then the licensee shall provide a technical justification of the proposed reinspection interval to the NRC staff. With these revisions, and the BWRVIP's agreement regarding operating years vice EFPY, the staff considers this item resolved.

Final BWRVIP response:

The staff position on vertical welds is not consistent with that of the horizontal welds where the NRC has accepted the BWRVIP position of inspecting essentially 100% of all accessible regions with a minimum of 50% in order to justify structural integrity and future reinspection intervals. The same coverage requirements have been applied to the vertical welds. A further point to make is that except for axial welds, located in the beltline region, that might receive an accumulated fluence greater than $1x10^{21}$ n/cm^2, the allowable flaw length exceeds the length of the weld. Regardless of the actual coverage achieved in excess of 50% or the level of fluence, the flaw evaluation criteria defined in BWRVIP-63 will determine if additional inspections are required for the desired period of operation. Thus, the BWRVIP believes that conservative guidance is provided in BWRVIP-63 to assess integrity of the vertical welds.

Issue 9:

The Staff's April 18, 2000, Initial SE [3] stated:

The BWRVIP-63 report states on page 3-5 (Section 3.1.3, "Radial Ring Welds") that "if the location of the welds is known (e.g., from plant drawings), then those specific locations shall be inspected from the OD of the ring." To assure complete integrity of the weld, the inspection should extend the entire length of the weld and not just the outer surface. In addition, the particular NDE technique used to detect any discontinuities within this component should be given (e.g., UT or 2-sided VT).

The BWRVIP's May 30, 2001 response [2] stated:

Inspection of radial ring welds to date has not revealed any significant cracking or structural integrity concerns. The BWRVIP is recommending that the inspection begin at the OD of the rings. If cracking is detected it is expected that additional surfaces will be examined, on an as-needed basis, as input to plant-specific structural evaluations.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

As stated in the staff findings for Issue 8, above, and the staff's April 18, 2000, initial SE, if the licensee is utilizing a visual exam, it should be a qualified two-sided (OD and ID) EVT-1 type visual exam which encompasses *essentially 100 percent* (as defined in 10 CFR 50.55a) of the inspection area. With this revision, the staff considers this item resolved.

Final BWRVIP response:

Radial ring welds have not reveal any significant cracking. Inspections are currently being performed of all accessible areas following the same approach as horizontal and vertical welds. Examination of the ring welds on the ID and bottom surface is generally impractical or not possible because there is either no access or it would require disassembly of the top guide and associated hardware. Therefore, for the same reasons as discussed in the response to Issue 8, the BWRVIP believes that the current guidance specified in BWRVIP-63 is sufficient to detect cracking in the radial ring welds.

References:

1. Letter from William H. Bateman (NRC) to Carl Terry (BWRVIP Chairman), "Final Safety Evaluation of the BWRVIP Vessel and Internals Project, Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63), EPRI Report TR-113170, June 1999 (TAC NO. MA6015)," dated August 20, 2001.
2. Letter from Carl Terry (BWRVIP Chairman) to NRC Document Control Desk, "Project 704 – BWRVIP Response to NRC Safety Evaluation of BWRVIP-63," dated May 30, 2001.
3. Letter from Jack R. Strosnider (NRC) to Carl Terry (BWRVIP Chairman), "Safety Evaluation of the BWRVIP Vessel and Internals Project, Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63), EPRI Report TR-113170, June 1999 (TAC NO. MA6015)," dated April 18, 2000.
4. Letter from Carl Terry (BWRVIP Chairman) to NRC Document Control Desk, "PROJECT NO. 704 -- BWRVIP Partial Response to the NRC Final Safety Evaluation of BWRVIP-63," dated October 22, 2002.

BWRVIP Response to Issues in NRC Final Safety Evaluation of "BWRVIP Vessel And Internals Project, Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63)," EPRI Report TR-113170, June 1999

Below are the issues identified in the NRC Final Safety Evaluation (SE) of the document entitled "Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63)," followed by the BWRVIP response to each issue. The BWRVIP proposes to incorporate staff comments and other changes, where applicable, into a revised BWRVIP-76 report.

The staff's August 20, 2001 Final SE [1] responded to Reference 2. A meeting was held at Argonne National Labs on October 29-30, 2001 to discuss the BWRVIP proposed response to the Final SE. Responses to the Final SE are provided below to document the BWRVIP positions discussed during the October 29-30, 2001 meeting.

Issue 1:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report uses the "average crack depth" as a parameter for both the inspection and flaw evaluations. The use of average crack depth in the flaw evaluation does not provide adequate conservatism and it is also not consistent with the guidance provided in the BWRVIP-07 report. As approved by the NRC staff, the maximum crack depth should be assumed to ensure a conservative result.

The BWRVIP's May 30, 2001 response [2] stated:

> There are two approaches for the application of average crack depth in BWRVIP-63 (and BWRVIP-76). One approach applies to the screening and acceptance criteria and the second approach applies when performing plant-specific flaw evaluations. These are described in more detail as follows.
>
> The screening and acceptance criteria, presented in Section 3.0 of BWRVIP-63, uses an average crack depth based on the total inspected length. This is appropriate because the models used to develop the screening and acceptance criteria (Section 4.0) are based on conservative LEFM and limit load solutions. The LEFM models assume a uniform depth flaw which is best represented by the average depth. The limit load models are based on the stress condition of the net section remaining, which is also best represented by the average depth. Additional factors of safety, consistent with existing BWRVIP inspection and flaw guidelines, are also included.
>
> The flaw evaluation criteria, presented in Appendices D and F, uses a slightly different approach for determining average crack depth based on only the cracked length, not the total inspected length. However, the guidance provided in BWRVIP-63 (and BWRVIP-76) is stated incorrectly. The BWRVIP intends to clarify only BWRVIP-76 (because BWRVIP-76 supersedes BWRVIP-63) as follows:

Appendix D (page D-1) and Appendix F (page F-11) of BWRVIP-76 presently states "The assumed crack depth in the uninspected region should be set equal to the average crack depth in the inspected region."

BWRVIP-76 should have stated "The assumed crack depth in the uninspected region should be set equal to the average depth of the observed cracks in the inspected region." In other words, the average crack depth should be based on only that portion of the weld that was inspected and found to be cracked. The average crack depth should not be computed based on inspected lengths where no cracking is detected.

The corrected pages of BWRVIP-76 are attached. Note that the example on page F-11 uses the correct crack depth.

Based on the above discussion, the BWRVIP believes that the use of maximum crack depth is excessively conservative whereas the use and application of average crack depth is technically justified and has an adequate level of conservatism.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

Based on discussions the staff has had with the BWRVIP on crack growth rate, the staff finds that, for plants utilizing effective HWC or NMCA, as defined in the staff's SE for the BWRVIP-62 report, the BWRVIP's proposed usage of assumed crack depth in the uninspected region as equal to the average depth of the observed cracks in the inspected region is acceptable. Plants with NWC should use the more conservative maximum crack depth for the uninspected regions. With this revision, the staff considers this item resolved.

Final BWRVIP response:

The BWRVIP continues to disagree with the staff on this issue. There is no information or technical rationale that would indicate cracking in uninspected regions for NWC plants is different than HWC plants. The approach used by the BWRVIP to account for differences in water chemistry is through application of the crack growth rate correlations contained in BWRVIP-14 and BWRVIP-99 for stainless steel materials. These conservative correlations were developed to account for such parameters as ECP, conductivity, stress, fluence, temperature, etc. and have been reviewed by NRC. The BWRVIP believes that use of maximum crack depth for the uninspected regions is overly conservative, regardless of water chemistry conditions. The average crack depth is employed in the screening criteria to determine which welds are to be inspected. It is also used in the acceptance criteria to determine the structural integrity of the welds. Use of maximum depth, as proposed by NRC, will require the BWRVIP to develop a completely revised screening and acceptance criteria based on maximum depth for NWC plants. The BWRVIP continues to believe that sufficient conservatism is included in the BWRVIP-63 methodology to account for the differences in water chemistry. The crack growth rates assumed in the flaw evaluation will be determined based on the water

chemistry conditions, i.e., conductivity and ECP or a stress-intensity-independent based rate will be used.

Issue 2:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 4-1 (Section 4, "Evaluation of Vertical Weld Indications") that "if through-wall cracks in vertical welds were observed during the inspection, leakage from vertical weld cracking must also be evaluated." However, the potential leakage at EOI should also be quantitatively assessed using a conservative evaluation methodology even though through-wall cracks were not detected during the inspection. Therefore, if the cracking is projected to grow through-wall, a leakage assessment should be provided. A similar statement on page 3-4 (Section 3.1.3, "Acceptance Standards for Vertical Welds") should also be revised.

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP recognizes that there is a possibility of through-wall cracking in core shrouds, however, the inspections performed to date have not revealed any through-wall cracking. Furthermore, the issue of leakage through a vertical weld has previously been evaluated. BWRVIP-01, which has been reviewed and approved by the NRC, states that "leakage through a fully cracked vertical weld has also been shown to be acceptably small." Therefore, potential leakage has been evaluated for projected or assumed through-wall flaws and is considered acceptable.
>
> The BWRVIP does believe it is necessary to quantitatively determine the leakage from an actual through-wall flaw as this may have a direct impact on core performance and on the ability to maintain reflood capability.
>
> Therefore, in summary, the BWRVIP believes that only actual through-wall cracks should be evaluated for leakage.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff agrees that actual through-wall cracks should be evaluated for leakage. In addition, if the cracking is not repaired prior to the next operating cycle and the crack is *projected* to grow through-wall, a leakage assessment should also be performed. A similar statement on page 3-4 (Section 3.1.3, "Acceptance Standards for Vertical Welds") should also be revised. With this revision, the staff considers this item closed.

Final BWRVIP response:

> The BWRVIP continues to believe that a requirement to calculate leakage from predicted through-wall cracks is an overly conservative position. Assumptions already embodied in BWRVIP-63 and BWRVIP-76 for postulating the length and depth of flaws are very conservative. These assumptions typically result in an over-predicted amount of cracking

Furthermore, although the crack growth correlations contained in BWRVIP-14 and BWRVIP-99 may predict through-wall cracks, no through-wall cracking has been detected to date in core shrouds. A prediction of through-wall cracks results is an unrealistic prediction of leakage. The BWRVIP has developed conservative methodologies to ensure that structural integrity of the core shroud and other BWR internals is maintained during operating and postulated accident conditions. Assumptions regarding through-wall cracking are invoked to address inspection limitations (i.e, cracks detected by EVT-1 must be assumed through-wall), to simplify the structural analyses and to ensure that the safety margins are robust. To further penalize an owner by requiring the assumption of leakage and potential reduction in unit rating is unwarranted.

As noted above there has been no inspection experience obtained which indicates that through-wall cracks have occurred in the vertical or horizontal core shroud welds. The inspection frequencies contained in BWRVIP-63 and BWRVIP-76 are such that any appreciable through-wall cracks will be detected well before they impact plant operation or structural integrity. The crack growth rates established for stainless steel materials (reported in BWRVIP-14 and BWRVIP-99) are conservative such that the predicted rates bound the inspection data and have added margin to account for unknowns such as weld repairs. The inspection data presented in BWRVIP-99 demonstrates that crack growth rates are slowing substantially as crack depth increases.

Core shroud circumferential welds that have been structurally placed by repair hardware do not require inspections per BWRVIP-76. The design requirement is to assume complete through-wall cracking for each circumferential weld that is structurally replaced. No additional leakage assessments are required by the BWRVIP beyond those considered in the shroud repair design. Therefore, the BWRVIP believes that the requirement to calculate leakage should be only for observed through-wall flaws.

Issue 3:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 4-2 (Section 4, "Evaluation of Vertical Weld Indications") that "K_{IC} = 150 ksi$\sqrt{in}$ based on BWRVIP-01." Elevated fluences on core shroud welds may effect the mechanical properties of the constituent structural materials. Therefore, the material toughness value may vary under high irradiated conditions. Upon availability of relevant data, a fluence threshold should be established for use of this figure in LEFM. When the fluence limit is exceeded, the use of this value should be justified and discussed with the NRC staff.

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP is presently evaluating fracture toughness properties of highly irradiated stainless steel. The BWRVIP expects to submit the results of this work to the NRC in early 2001. The results may indicate that some changes are required to existing BWRVIP guidelines for shroud inspection and flaw evaluation for highly irradiated

welds. However, in the interim, we believe the approach provided in BWRVIP-76, Section D.1.1 is acceptable for evaluating these conditions. If a different method is used by the utility, we agree that it should be justified and discussed with the NRC staff.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> Based on the above, this item remains open and will be addressed in the staff's review of the BWRVIP-76 report.

Final BWRVIP response:

> BWRVIP-100, "BWR Vessel and Internals Project, Updated Assessment of the Fracture Toughness of Irradiated Stainless Steel for BWR Core Shrouds," EPRI Technical Report 1003016, December 2001 has been submitted to NRC for review and approval. This report provides the relationship of toughness versus fluence for core shroud flaw evaluations. The BWRVIP will use the appropriate fracture toughness limits specified in BWRVIP-100 for evaluation of flaws.

Issue 4:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page B-1 (Appendix B, "Plant Specific Flaw Evaluation Methodology") that "plant-specific analysis may be required if acceptance criteria "c" of Section 3.2 .... cannot be satisfied." Section 3.1.3, "Acceptance Standards for Vertical Welds," should be the correct citation not Section 3.2, "Vertical Welds in Repaired Shrouds."

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP agrees that the citation of Section 3.2 should be corrected to Section 3.1.3.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff finds that these actions adequately addresses this open item.

Final BWRVIP response:

> No changes.

Issue 5:

The Staff's April 18, 2000, Initial SE [3] stated:

The BWRVIP-63 report states on page B-2 (Appendix B, "Plant Specific Flaw Evaluation Methodology") that "submittal to the NRC of these analyses along with the inspection results is required within 90 days of the inspection." The reporting requirements for plant- specific flaw analysis should be consistent with those expressed in the BWRVIP-76 report, which states on page 4-1 (Section 4.3, "Analytical Evaluations of Inspection Results") that the analytical results "shall be reported to the NRC within 30 days after completion of the inspection."

The BWRVIP's May 30, 2001 response [2] stated:

The BWRVIP will provide a response to Item 5 at a later date.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

Based on the above, this item remains open and will be addressed in the staff's review of the BWRVIP-76 report.

Final BWRVIP response:

The BWRVIP has developed reporting requirements which are documented in BWRVIP-94, "BWR Vessel and Internals Project, Program Implementation Guide," EPRI Technical Report 1006288, August 2001. The BWRVIP proposes to delete the specific reporting requirements from all the Inspection and Evaluation Guidelines and reference Section 3.5 of BWRVIP-94 which follows:

> Each utility will inform the NRC of any decision to not fully implement a BWRVIP guideline approved by the NRC staff within 45 days of the report approval. This applies to only those BWRVIP guidelines that have received a Final Safety Evaluation without any exceptions to the report. The NRC should be notified if changes are made to the vessel and internals program that affect implementation of BWRVIP guidelines.
>
> Inspection results and flaw evaluations for components within the scope of the BWRVIP shall be reported as described below.
>
> 1. Licensees shall forward a summary of all inspections, associated results and new repairs to the BWRVIP Program Manager within 120 days following completion of an outage.
>
> 2. Flaw evaluations performed in accordance with the guidance in BWRVIP reports for the acceptance of inspection results do not require submittal to, or approval by, the NRC.
>
> 3. Flaw evaluations that deviate from the guidance in BWRVIP reports (e.g., assumptions, methods, acceptance criteria, etc.) shall be submitted to the NRC for approval. If the flaw evaluation is later revised, the results shall be

communicated to the NRC. The submittal schedule for the analyses will be determined by the licensee and the NRC.

4. If it is determined that implementation cannot be achieved as described in the I&E guidelines, or that meaningful results are not obtained, the user shall notify the BWRVIP with sufficient details to support development of alternative actions. These notifications, as well as planned actions by the BWRVIP, will be summarized and reported to the NRC by the BWRVIP.

5. Modifications to plant operation or configurations that may affect BWRVIP guidance (e.g., power uprate) shall also be reported to the BWRVIP Program Manager.

6. Section XI of the ASME Boiler and Pressure Vessel Code contains rules for inspection, flaw evaluation and repair/replacement of certain components that are also addressed as part of the BWRVIP program. The Code requirements are detailed in Table IWB-2500, Category B-N-2, Welded Core Support Structures and Interior Attachments to Reactor Vessel. In order for BWRVIP I&E Guidelines to be used in lieu of the ASME Code requirements, each licensee must obtain relief from the Code via the process described in 10CFR50.55a. This would best be accomplished by using the technical alternative provision contained in 10CFR50.55a(a)(3)(i).

The form and format of the reporting shall be in accordance with licensee's established procedures. This may include, but is not limited to, submittal by letter or as an attachment to ASME Code required documentation (NIS-1, OAR-1, etc.).

Industry reports are necessary to share information on failure mechanisms, NDE technique applications, repair effectiveness, operating experience, and other items. This experience is shared through the BWRVIP and member utilities. Member utilities agree to share results of assessments outlined in Section 3.4 with the BWRVIP. Deviations from BWRVIP guidance approved by the NRC and documented in accordance with Appendix A shall also be shared with the BWRVIP.

The BWRVIP is also developing a standard template for licensees to follow for submitting a technical alternative to use the BWRVIP I&E Guidelines in lieu of the ASME Code requirements.

Issue 6:

The Staff's April 18, 2000, Initial SE [3] stated:

> The effect of neutron fluence level on the crack growth rate should be consistent with that discussed in the BWRVIP-07 report. When the fluence level exceeds $5x10^{20}n/cm^2$, the appropriate crack growth rate to be used in the flaw evaluation should be discussed with and approved by the NRC staff.

The BWRVIP's May 30, 2001 response [2] stated:

> Until such time as the BWRVIP submits a crack growth evaluation for highly irradiated stainless steel, we agree that when the fluence level exceeds $5x10^{20}$ n/cm^2, the appropriate crack growth rate to be used in plant-specific flaw evaluations will be provided to NRC for concurrence.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff finds that this response adequately addresses this open item.

Final BWRVIP response:

> "BWRVIP-99: BWR Vessel and Internals Project, Crack Growth Rates in Irradiated Stainless Steels in BWR Internal Components," EPRI Technical Report 1003018, December 2001 has been submitted to the NRC for review and approval. The report provides the crack growth rates for stainless steel in the fluence range of $5x10^{20}$ n/cm^2 up to $3x10^{21}$ n/cm^2. The BWRVIP will use the appropriate correlation in this report for evaluation of stainless steel materials subjected to the specified fluence range.

Issue 7:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 3-1(Section 3, "Inspection Recommendations") that "NDE uncertainty does not need to be considered since it is adequately covered by conservatisms in the flaw evaluation methods." BWRVIP-member utilities must determine the measurement uncertainty associated with NDE techniques to be used for inspection of the reactor vessel components consistent with the methodology specified in the BWRVIP-03 report (Section 2.3 "Guidelines for Determining NDE Technique Uncertainty") as approved by the NRC staff, and include the measurement uncertainties in the flaw evaluation consistent with guidance in the BWRVIP-07 report.

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP will provide a response to Item 7 at a later date.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> Based on the above, this item remains open and will be addressed in the staff's review of the BWRVIP-76 report.

Final BWRVIP response:

> The BWRVIP provided a response to Issue 7 in Reference 4.

Issue 8:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 3-3 (Section 3.1.3, "Acceptance Standards for Vertical Welds") that "if the weld has been inspected using a one-sided technique and no cracking was detected then the weld is acceptable for 6 EFPY." In order to verify the weld integrity, the inspection should consist of a two-sided (ID and OD) visual examination. Whenever one-sided visual inspection was performed, the use of its results to determine the reinspection interval should be justified and discussed with the NRC staff. Also, the use of effective full power years (EFPY) as a basis to establish the reinspection interval does not correspond with NRC-approved guidelines. Determination of the acceptable operating time, wherever applicable in the subject report, should be in terms of operating hours or years, not EFPY.

The BWRVIP's May 30, 2001 response [2] stated:

> Section 2.2 of BWRVIP-63 specifies that volumetric or two-sided (ID and OD) visual exams are the only acceptable methods for satisfying the acceptance criteria contained in Section 3. This is consistent with the examination guidelines for horizontal welds contained in BWRVIP-76. The beltline region is approximately 75% of the shroud vertical welds and represents a significant two sided or volumetric examination sample. This is considered an adequate sampling to determine if any ID vertical weld cracking exists. However, in some cases a volumetric exam or two-sided visual exam is not possible due to access limitation (obstructions due to hardware, etc.) For these situations, BWRVIP-63 allows for a one-sided exam and states that a maximum EOI of 6 years is acceptable provided that no cracking is detected. If cracks are detected, a plant-specific evaluation must be performed. Therefore, based on the fact that the bulk of the inspections will be volumetric or visual from both the ID and OD, a substantial amount of weld volume will be examined using this criteria. In general, the regions where one-sided visual exams will be employed will be small compared to those examined by volumetric methods. Furthermore, if cracks are detected using one-sided visual exams, analyses must be performed to determine both the structural integrity and future inspection frequency of the vertical weld. If the evaluation performed differs from the acceptable methods described in the report, the evaluation must be submitted to the NRC for approval. Therefore, the BWRVIP believes that one-sided visual examinations are acceptable for certain situations provided that Section 2.2 of the BWRVIP-63 is followed.
>
> The BWRVIP agrees with the NRC that the reinspection intervals should be based on operating years, not EFPY. In fact, this is reflected in the BWRVIP-76 report.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff finds that, with a revision to the BWRVIP-63 report stating that a qualified two-sided EVT-1 type visual exam should encompass *essentially 100 percent* (as defined in 10 CFR 50.55a) of the inspection area, then the EOI criteria, as proposed to be modified,

established in Section 2.2 of the BWRVIP-63 report is acceptable. If a licensee cannot achieve essentially 100 percent coverage utilizing a qualified two-sided EVT-1 type visual exam, or if the licensee utilizes a one-sided EVT-1 type visual exam, then the licensee shall provide a technical justification of the proposed reinspection interval to the NRC staff. With these revisions, and the BWRVIP's agreement regarding operating years vice EFPY, the staff considers this item resolved.

Final BWRVIP response:

The staff position on vertical welds is not consistent with that of the horizontal welds where the NRC has accepted the BWRVIP position of inspecting essentially 100% of all accessible regions with a minimum of 50% in order to justify structural integrity and future reinspection intervals. The same coverage requirements have been applied to the vertical welds. A further point to make is that except for axial welds, located in the beltline region, that might receive an accumulated fluence greater than $1x10^{21}$ n/cm^2, the allowable flaw length exceeds the length of the weld. Regardless of the actual coverage achieved in excess of 50% or the level of fluence, the flaw evaluation criteria defined in BWRVIP-63 will determine if additional inspections are required for the desired period of operation. Thus, the BWRVIP believes that conservative guidance is provided in BWRVIP-63 to assess integrity of the vertical welds.

Issue 9:

The Staff's April 18, 2000, Initial SE [3] stated:

The BWRVIP-63 report states on page 3-5 (Section 3.1.3, "Radial Ring Welds") that "if the location of the welds is known (e.g., from plant drawings), then those specific locations shall be inspected from the OD of the ring." To assure complete integrity of the weld, the inspection should extend the entire length of the weld and not just the outer surface. In addition, the particular NDE technique used to detect any discontinuities within this component should be given (e.g., UT or 2-sided VT).

The BWRVIP's May 30, 2001 response [2] stated:

Inspection of radial ring welds to date has not revealed any significant cracking or structural integrity concerns. The BWRVIP is recommending that the inspection begin at the OD of the rings. If cracking is detected it is expected that additional surfaces will be examined, on an as-needed basis, as input to plant-specific structural evaluations.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

As stated in the staff findings for Issue 8, above, and the staff's April 18, 2000, initial SE, if the licensee is utilizing a visual exam, it should be a qualified two-sided (OD and ID) EVT-1 type visual exam which encompasses *essentially 100 percent* (as defined in 10 CFR 50.55a) of the inspection area. With this revision, the staff considers this item resolved.

Final BWRVIP response:

Radial ring welds have not reveal any significant cracking. Inspections are currently being performed of all accessible areas following the same approach as horizontal and vertical welds. Examination of the ring welds on the ID and bottom surface is generally impractical or not possible because there is either no access or it would require disassembly of the top guide and associated hardware. Therefore, for the same reasons as discussed in the response to Issue 8, the BWRVIP believes that the current guidance specified in BWRVIP-63 is sufficient to detect cracking in the radial ring welds.

References:

1. Letter from William H. Bateman (NRC) to Carl Terry (BWRVIP Chairman), "Final Safety Evaluation of the BWRVIP Vessel and Internals Project, Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63), EPRI Report TR-113170, June 1999 (TAC NO. MA6015)," dated August 20, 2001.
2. Letter from Carl Terry (BWRVIP Chairman) to NRC Document Control Desk, "Project 704 – BWRVIP Response to NRC Safety Evaluation of BWRVIP-63," dated May 30, 2001.
3. Letter from Jack R. Strosnider (NRC) to Carl Terry (BWRVIP Chairman), "Safety Evaluation of the BWRVIP Vessel and Internals Project, Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63), EPRI Report TR-113170, June 1999 (TAC NO. MA6015)," dated April 18, 2000.
4. Letter from Carl Terry (BWRVIP Chairman) to NRC Document Control Desk, "PROJECT NO. 704 -- BWRVIP Partial Response to the NRC Final Safety Evaluation of BWRVIP-63," dated October 22, 2002.

BWRVIP Response to Issues in NRC Final Safety Evaluation of "BWRVIP Vessel And Internals Project, Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63)," EPRI Report TR-113170, June 1999

Below are the issues identified in the NRC Final Safety Evaluation (SE) of the document entitled "Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63)," followed by the BWRVIP response to each issue. The BWRVIP proposes to incorporate staff comments and other changes, where applicable, into a revised BWRVIP-76 report.

The staff's August 20, 2001 Final SE [1] responded to Reference 2. A meeting was held at Argonne National Labs on October 29-30, 2001 to discuss the BWRVIP proposed response to the Final SE. Responses to the Final SE are provided below to document the BWRVIP positions discussed during the October 29-30, 2001 meeting.

Issue 1:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report uses the "average crack depth" as a parameter for both the inspection and flaw evaluations. The use of average crack depth in the flaw evaluation does not provide adequate conservatism and it is also not consistent with the guidance provided in the BWRVIP-07 report. As approved by the NRC staff, the maximum crack depth should be assumed to ensure a conservative result.

The BWRVIP's May 30, 2001 response [2] stated:

> There are two approaches for the application of average crack depth in BWRVIP-63 (and BWRVIP-76). One approach applies to the screening and acceptance criteria and the second approach applies when performing plant-specific flaw evaluations. These are described in more detail as follows.
>
> The screening and acceptance criteria, presented in Section 3.0 of BWRVIP-63, uses an average crack depth based on the total inspected length. This is appropriate because the models used to develop the screening and acceptance criteria (Section 4.0) are based on conservative LEFM and limit load solutions. The LEFM models assume a uniform depth flaw which is best represented by the average depth. The limit load models are based on the stress condition of the net section remaining, which is also best represented by the average depth. Additional factors of safety, consistent with existing BWRVIP inspection and flaw guidelines, are also included.
>
> The flaw evaluation criteria, presented in Appendices D and F, uses a slightly different approach for determining average crack depth based on only the cracked length, not the total inspected length. However, the guidance provided in BWRVIP-63 (and BWRVIP-76) is stated incorrectly. The BWRVIP intends to clarify only BWRVIP-76 (because BWRVIP-76 supersedes BWRVIP-63) as follows:

Appendix D (page D-1) and Appendix F (page F-11) of BWRVIP-76 presently states "The assumed crack depth in the uninspected region should be set equal to the average crack depth in the inspected region."

BWRVIP-76 should have stated "The assumed crack depth in the uninspected region should be set equal to the average depth of the observed cracks in the inspected region." In other words, the average crack depth should be based on only that portion of the weld that was inspected and found to be cracked. The average crack depth should not be computed based on inspected lengths where no cracking is detected.

The corrected pages of BWRVIP-76 are attached. Note that the example on page F-11 uses the correct crack depth.

Based on the above discussion, the BWRVIP believes that the use of maximum crack depth is excessively conservative whereas the use and application of average crack depth is technically justified and has an adequate level of conservatism.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

Based on discussions the staff has had with the BWRVIP on crack growth rate, the staff finds that, for plants utilizing effective HWC or NMCA, as defined in the staff's SE for the BWRVIP-62 report, the BWRVIP's proposed usage of assumed crack depth in the uninspected region as equal to the average depth of the observed cracks in the inspected region is acceptable. Plants with NWC should use the more conservative maximum crack depth for the uninspected regions. With this revision, the staff considers this item resolved.

Final BWRVIP response:

The BWRVIP continues to disagree with the staff on this issue. There is no information or technical rationale that would indicate cracking in uninspected regions for NWC plants is different than HWC plants. The approach used by the BWRVIP to account for differences in water chemistry is through application of the crack growth rate correlations contained in BWRVIP-14 and BWRVIP-99 for stainless steel materials. These conservative correlations were developed to account for such parameters as ECP, conductivity, stress, fluence, temperature, etc. and have been reviewed by NRC. The BWRVIP believes that use of maximum crack depth for the uninspected regions is overly conservative, regardless of water chemistry conditions. The average crack depth is employed in the screening criteria to determine which welds are to be inspected. It is also used in the acceptance criteria to determine the structural integrity of the welds. Use of maximum depth, as proposed by NRC, will require the BWRVIP to develop a completely revised screening and acceptance criteria based on maximum depth for NWC plants. The BWRVIP continues to believe that sufficient conservatism is included in the BWRVIP-63 methodology to account for the differences in water chemistry. The crack growth rates assumed in the flaw evaluation will be determined based on the water

chemistry conditions, i.e., conductivity and ECP or a stress-intensity-independent based rate will be used.

Issue 2:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 4-1 (Section 4, "Evaluation of Vertical Weld Indications") that "if through-wall cracks in vertical welds were observed during the inspection, leakage from vertical weld cracking must also be evaluated." However, the potential leakage at EOI should also be quantitatively assessed using a conservative evaluation methodology even though through-wall cracks were not detected during the inspection. Therefore, if the cracking is projected to grow through-wall, a leakage assessment should be provided. A similar statement on page 3-4 (Section 3.1.3, "Acceptance Standards for Vertical Welds") should also be revised.

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP recognizes that there is a possibility of through-wall cracking in core shrouds, however, the inspections performed to date have not revealed any through-wall cracking. Furthermore, the issue of leakage through a vertical weld has previously been evaluated. BWRVIP-01, which has been reviewed and approved by the NRC, states that "leakage through a fully cracked vertical weld has also been shown to be acceptably small." Therefore, potential leakage has been evaluated for projected or assumed through-wall flaws and is considered acceptable.
>
> The BWRVIP does believe it is necessary to quantitatively determine the leakage from an actual through-wall flaw as this may have a direct impact on core performance and on the ability to maintain reflood capability.
>
> Therefore, in summary, the BWRVIP believes that only actual through-wall cracks should be evaluated for leakage.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff agrees that actual through-wall cracks should be evaluated for leakage. In addition, if the cracking is not repaired prior to the next operating cycle and the crack is *projected* to grow through-wall, a leakage assessment should also be performed. A similar statement on page 3-4 (Section 3.1.3, "Acceptance Standards for Vertical Welds") should also be revised. With this revision, the staff considers this item closed.

Final BWRVIP response:

> The BWRVIP continues to believe that a requirement to calculate leakage from predicted through-wall cracks is an overly conservative position. Assumptions already embodied in BWRVIP-63 and BWRVIP-76 for postulating the length and depth of flaws are very conservative. These assumptions typically result in an over-predicted amount of cracking

Furthermore, although the crack growth correlations contained in BWRVIP-14 and BWRVIP-99 may predict through-wall cracks, no through-wall cracking has been detected to date in core shrouds. A prediction of through-wall cracks results is an unrealistic prediction of leakage. The BWRVIP has developed conservative methodologies to ensure that structural integrity of the core shroud and other BWR internals is maintained during operating and postulated accident conditions. Assumptions regarding through-wall cracking are invoked to address inspection limitations (i.e, cracks detected by EVT-1 must be assumed through-wall), to simplify the structural analyses and to ensure that the safety margins are robust. To further penalize an owner by requiring the assumption of leakage and potential reduction in unit rating is unwarranted.

As noted above there has been no inspection experience obtained which indicates that through-wall cracks have occurred in the vertical or horizontal core shroud welds. The inspection frequencies contained in BWRVIP-63 and BWRVIP-76 are such that any appreciable through-wall cracks will be detected well before they impact plant operation or structural integrity. The crack growth rates established for stainless steel materials (reported in BWRVIP-14 and BWRVIP-99) are conservative such that the predicted rates bound the inspection data and have added margin to account for unknowns such as weld repairs. The inspection data presented in BWRVIP-99 demonstrates that crack growth rates are slowing substantially as crack depth increases.

Core shroud circumferential welds that have been structurally placed by repair hardware do not require inspections per BWRVIP-76. The design requirement is to assume complete through-wall cracking for each circumferential weld that is structurally replaced. No additional leakage assessments are required by the BWRVIP beyond those considered in the shroud repair design. Therefore, the BWRVIP believes that the requirement to calculate leakage should be only for observed through-wall flaws.

Issue 3:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 4-2 (Section 4, "Evaluation of Vertical Weld Indications") that "K_{IC} = 150 ksi$\sqrt{in}$ based on BWRVIP-01." Elevated fluences on core shroud welds may effect the mechanical properties of the constituent structural materials. Therefore, the material toughness value may vary under high irradiated conditions. Upon availability of relevant data, a fluence threshold should be established for use of this figure in LEFM. When the fluence limit is exceeded, the use of this value should be justified and discussed with the NRC staff.

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP is presently evaluating fracture toughness properties of highly irradiated stainless steel. The BWRVIP expects to submit the results of this work to the NRC in early 2001. The results may indicate that some changes are required to existing BWRVIP guidelines for shroud inspection and flaw evaluation for highly irradiated

welds. However, in the interim, we believe the approach provided in BWRVIP-76, Section D.1.1 is acceptable for evaluating these conditions. If a different method is used by the utility, we agree that it should be justified and discussed with the NRC staff.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> Based on the above, this item remains open and will be addressed in the staff's review of the BWRVIP-76 report.

Final BWRVIP response:

> BWRVIP-100, "BWR Vessel and Internals Project, Updated Assessment of the Fracture Toughness of Irradiated Stainless Steel for BWR Core Shrouds," EPRI Technical Report 1003016, December 2001 has been submitted to NRC for review and approval. This report provides the relationship of toughness versus fluence for core shroud flaw evaluations. The BWRVIP will use the appropriate fracture toughness limits specified in BWRVIP-100 for evaluation of flaws.

Issue 4:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page B-1 (Appendix B, "Plant Specific Flaw Evaluation Methodology") that "plant-specific analysis may be required if acceptance criteria "c" of Section 3.2 .... cannot be satisfied." Section 3.1.3, "Acceptance Standards for Vertical Welds," should be the correct citation not Section 3.2, "Vertical Welds in Repaired Shrouds."

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP agrees that the citation of Section 3.2 should be corrected to Section 3.1.3.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff finds that these actions adequately addresses this open item.

Final BWRVIP response:

> No changes.

Issue 5:

The Staff's April 18, 2000, Initial SE [3] stated:

The BWRVIP-63 report states on page B-2 (Appendix B, "Plant Specific Flaw Evaluation Methodology") that "submittal to the NRC of these analyses along with the inspection results is required within 90 days of the inspection." The reporting requirements for plant- specific flaw analysis should be consistent with those expressed in the BWRVIP-76 report, which states on page 4-1 (Section 4.3, "Analytical Evaluations of Inspection Results") that the analytical results "shall be reported to the NRC within 30 days after completion of the inspection."

The BWRVIP's May 30, 2001 response [2] stated:

The BWRVIP will provide a response to Item 5 at a later date.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

Based on the above, this item remains open and will be addressed in the staff's review of the BWRVIP-76 report.

Final BWRVIP response:

The BWRVIP has developed reporting requirements which are documented in BWRVIP-94, "BWR Vessel and Internals Project, Program Implementation Guide," EPRI Technical Report 1006288, August 2001. The BWRVIP proposes to delete the specific reporting requirements from all the Inspection and Evaluation Guidelines and reference Section 3.5 of BWRVIP-94 which follows:

> Each utility will inform the NRC of any decision to not fully implement a BWRVIP guideline approved by the NRC staff within 45 days of the report approval. This applies to only those BWRVIP guidelines that have received a Final Safety Evaluation without any exceptions to the report. The NRC should be notified if changes are made to the vessel and internals program that affect implementation of BWRVIP guidelines.
>
> Inspection results and flaw evaluations for components within the scope of the BWRVIP shall be reported as described below.
>
> 1. Licensees shall forward a summary of all inspections, associated results and new repairs to the BWRVIP Program Manager within 120 days following completion of an outage.
>
> 2. Flaw evaluations performed in accordance with the guidance in BWRVIP reports for the acceptance of inspection results do not require submittal to, or approval by, the NRC.
>
> 3. Flaw evaluations that deviate from the guidance in BWRVIP reports (e.g., assumptions, methods, acceptance criteria, etc.) shall be submitted to the NRC for approval. If the flaw evaluation is later revised, the results shall be

communicated to the NRC. The submittal schedule for the analyses will be determined by the licensee and the NRC.

4. If it is determined that implementation cannot be achieved as described in the I&E guidelines, or that meaningful results are not obtained, the user shall notify the BWRVIP with sufficient details to support development of alternative actions. These notifications, as well as planned actions by the BWRVIP, will be summarized and reported to the NRC by the BWRVIP.

5. Modifications to plant operation or configurations that may affect BWRVIP guidance (e.g., power uprate) shall also be reported to the BWRVIP Program Manager.

6. Section XI of the ASME Boiler and Pressure Vessel Code contains rules for inspection, flaw evaluation and repair/replacement of certain components that are also addressed as part of the BWRVIP program. The Code requirements are detailed in Table IWB-2500, Category B-N-2, Welded Core Support Structures and Interior Attachments to Reactor Vessel. In order for BWRVIP I&E Guidelines to be used in lieu of the ASME Code requirements, each licensee must obtain relief from the Code via the process described in 10CFR50.55a. This would best be accomplished by using the technical alternative provision contained in 10CFR50.55a(a)(3)(i).

The form and format of the reporting shall be in accordance with licensee's established procedures. This may include, but is not limited to, submittal by letter or as an attachment to ASME Code required documentation (NIS-1, OAR-1, etc.).

Industry reports are necessary to share information on failure mechanisms, NDE technique applications, repair effectiveness, operating experience, and other items. This experience is shared through the BWRVIP and member utilities. Member utilities agree to share results of assessments outlined in Section 3.4 with the BWRVIP. Deviations from BWRVIP guidance approved by the NRC and documented in accordance with Appendix A shall also be shared with the BWRVIP.

The BWRVIP is also developing a standard template for licensees to follow for submitting a technical alternative to use the BWRVIP I&E Guidelines in lieu of the ASME Code requirements.

Issue 6:

The Staff's April 18, 2000, Initial SE [3] stated:

> The effect of neutron fluence level on the crack growth rate should be consistent with that discussed in the BWRVIP-07 report. When the fluence level exceeds $5x10^{20}n/cm^2$, the appropriate crack growth rate to be used in the flaw evaluation should be discussed with and approved by the NRC staff.

The BWRVIP's May 30, 2001 response [2] stated:

> Until such time as the BWRVIP submits a crack growth evaluation for highly irradiated stainless steel, we agree that when the fluence level exceeds $5x10^{20}$ n/cm^2, the appropriate crack growth rate to be used in plant-specific flaw evaluations will be provided to NRC for concurrence.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff finds that this response adequately addresses this open item.

Final BWRVIP response:

> "BWRVIP-99: BWR Vessel and Internals Project, Crack Growth Rates in Irradiated Stainless Steels in BWR Internal Components," EPRI Technical Report 1003018, December 2001 has been submitted to the NRC for review and approval. The report provides the crack growth rates for stainless steel in the fluence range of $5x10^{20}$ n/cm^2 up to $3x10^{21}$ n/cm^2. The BWRVIP will use the appropriate correlation in this report for evaluation of stainless steel materials subjected to the specified fluence range.

Issue 7:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 3-1(Section 3, "Inspection Recommendations") that "NDE uncertainty does not need to be considered since it is adequately covered by conservatisms in the flaw evaluation methods." BWRVIP-member utilities must determine the measurement uncertainty associated with NDE techniques to be used for inspection of the reactor vessel components consistent with the methodology specified in the BWRVIP-03 report (Section 2.3 "Guidelines for Determining NDE Technique Uncertainty") as approved by the NRC staff, and include the measurement uncertainties in the flaw evaluation consistent with guidance in the BWRVIP-07 report.

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP will provide a response to Item 7 at a later date.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> Based on the above, this item remains open and will be addressed in the staff's review of the BWRVIP-76 report.

Final BWRVIP response:

> The BWRVIP provided a response to Issue 7 in Reference 4.

Issue 8:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 3-3 (Section 3.1.3, "Acceptance Standards for Vertical Welds") that "if the weld has been inspected using a one-sided technique and no cracking was detected then the weld is acceptable for 6 EFPY." In order to verify the weld integrity, the inspection should consist of a two-sided (ID and OD) visual examination. Whenever one-sided visual inspection was performed, the use of its results to determine the reinspection interval should be justified and discussed with the NRC staff. Also, the use of effective full power years (EFPY) as a basis to establish the reinspection interval does not correspond with NRC-approved guidelines. Determination of the acceptable operating time, wherever applicable in the subject report, should be in terms of operating hours or years, not EFPY.

The BWRVIP's May 30, 2001 response [2] stated:

> Section 2.2 of BWRVIP-63 specifies that volumetric or two-sided (ID and OD) visual exams are the only acceptable methods for satisfying the acceptance criteria contained in Section 3. This is consistent with the examination guidelines for horizontal welds contained in BWRVIP-76. The beltline region is approximately 75% of the shroud vertical welds and represents a significant two sided or volumetric examination sample. This is considered an adequate sampling to determine if any ID vertical weld cracking exists. However, in some cases a volumetric exam or two-sided visual exam is not possible due to access limitation (obstructions due to hardware, etc.) For these situations, BWRVIP-63 allows for a one-sided exam and states that a maximum EOI of 6 years is acceptable provided that no cracking is detected. If cracks are detected, a plant-specific evaluation must be performed. Therefore, based on the fact that the bulk of the inspections will be volumetric or visual from both the ID and OD, a substantial amount of weld volume will be examined using this criteria. In general, the regions where one-sided visual exams will be employed will be small compared to those examined by volumetric methods. Furthermore, if cracks are detected using one-sided visual exams, analyses must be performed to determine both the structural integrity and future inspection frequency of the vertical weld. If the evaluation performed differs from the acceptable methods described in the report, the evaluation must be submitted to the NRC for approval. Therefore, the BWRVIP believes that one-sided visual examinations are acceptable for certain situations provided that Section 2.2 of the BWRVIP-63 is followed.
>
> The BWRVIP agrees with the NRC that the reinspection intervals should be based on operating years, not EFPY. In fact, this is reflected in the BWRVIP-76 report.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff finds that, with a revision to the BWRVIP-63 report stating that a qualified two-sided EVT-1 type visual exam should encompass *essentially 100 percent* (as defined in 10 CFR 50.55a) of the inspection area, then the EOI criteria, as proposed to be modified,

established in Section 2.2 of the BWRVIP-63 report is acceptable. If a licensee cannot achieve essentially 100 percent coverage utilizing a qualified two-sided EVT-1 type visual exam, or if the licensee utilizes a one-sided EVT-1 type visual exam, then the licensee shall provide a technical justification of the proposed reinspection interval to the NRC staff. With these revisions, and the BWRVIP's agreement regarding operating years vice EFPY, the staff considers this item resolved.

Final BWRVIP response:

The staff position on vertical welds is not consistent with that of the horizontal welds where the NRC has accepted the BWRVIP position of inspecting essentially 100% of all accessible regions with a minimum of 50% in order to justify structural integrity and future reinspection intervals. The same coverage requirements have been applied to the vertical welds. A further point to make is that except for axial welds, located in the beltline region, that might receive an accumulated fluence greater than $1x10^{21}$ n/cm^2, the allowable flaw length exceeds the length of the weld. Regardless of the actual coverage achieved in excess of 50% or the level of fluence, the flaw evaluation criteria defined in BWRVIP-63 will determine if additional inspections are required for the desired period of operation. Thus, the BWRVIP believes that conservative guidance is provided in BWRVIP-63 to assess integrity of the vertical welds.

Issue 9:

The Staff's April 18, 2000, Initial SE [3] stated:

The BWRVIP-63 report states on page 3-5 (Section 3.1.3, "Radial Ring Welds") that "if the location of the welds is known (e.g., from plant drawings), then those specific locations shall be inspected from the OD of the ring." To assure complete integrity of the weld, the inspection should extend the entire length of the weld and not just the outer surface. In addition, the particular NDE technique used to detect any discontinuities within this component should be given (e.g., UT or 2-sided VT).

The BWRVIP's May 30, 2001 response [2] stated:

Inspection of radial ring welds to date has not revealed any significant cracking or structural integrity concerns. The BWRVIP is recommending that the inspection begin at the OD of the rings. If cracking is detected it is expected that additional surfaces will be examined, on an as-needed basis, as input to plant-specific structural evaluations.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

As stated in the staff findings for Issue 8, above, and the staff's April 18, 2000, initial SE, if the licensee is utilizing a visual exam, it should be a qualified two-sided (OD and ID) EVT-1 type visual exam which encompasses *essentially 100 percent* (as defined in 10 CFR 50.55a) of the inspection area. With this revision, the staff considers this item resolved.

Final BWRVIP response:

Radial ring welds have not reveal any significant cracking. Inspections are currently being performed of all accessible areas following the same approach as horizontal and vertical welds. Examination of the ring welds on the ID and bottom surface is generally impractical or not possible because there is either no access or it would require disassembly of the top guide and associated hardware. Therefore, for the same reasons as discussed in the response to Issue 8, the BWRVIP believes that the current guidance specified in BWRVIP-63 is sufficient to detect cracking in the radial ring welds.

References:

1. Letter from William H. Bateman (NRC) to Carl Terry (BWRVIP Chairman), "Final Safety Evaluation of the BWRVIP Vessel and Internals Project, Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63), EPRI Report TR-113170, June 1999 (TAC NO. MA6015)," dated August 20, 2001.
2. Letter from Carl Terry (BWRVIP Chairman) to NRC Document Control Desk, "Project 704 – BWRVIP Response to NRC Safety Evaluation of BWRVIP-63," dated May 30, 2001.
3. Letter from Jack R. Strosnider (NRC) to Carl Terry (BWRVIP Chairman), "Safety Evaluation of the BWRVIP Vessel and Internals Project, Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63), EPRI Report TR-113170, June 1999 (TAC NO. MA6015)," dated April 18, 2000.
4. Letter from Carl Terry (BWRVIP Chairman) to NRC Document Control Desk, "PROJECT NO. 704 -- BWRVIP Partial Response to the NRC Final Safety Evaluation of BWRVIP-63," dated October 22, 2002.

BWRVIP Response to Issues in NRC Final Safety Evaluation of "BWRVIP Vessel And Internals Project, Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63)," EPRI Report TR-113170, June 1999

Below are the issues identified in the NRC Final Safety Evaluation (SE) of the document entitled "Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63)," followed by the BWRVIP response to each issue. The BWRVIP proposes to incorporate staff comments and other changes, where applicable, into a revised BWRVIP-76 report.

The staff's August 20, 2001 Final SE [1] responded to Reference 2. A meeting was held at Argonne National Labs on October 29-30, 2001 to discuss the BWRVIP proposed response to the Final SE. Responses to the Final SE are provided below to document the BWRVIP positions discussed during the October 29-30, 2001 meeting.

Issue 1:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report uses the "average crack depth" as a parameter for both the inspection and flaw evaluations. The use of average crack depth in the flaw evaluation does not provide adequate conservatism and it is also not consistent with the guidance provided in the BWRVIP-07 report. As approved by the NRC staff, the maximum crack depth should be assumed to ensure a conservative result.

The BWRVIP's May 30, 2001 response [2] stated:

> There are two approaches for the application of average crack depth in BWRVIP-63 (and BWRVIP-76). One approach applies to the screening and acceptance criteria and the second approach applies when performing plant-specific flaw evaluations. These are described in more detail as follows.
>
> The screening and acceptance criteria, presented in Section 3.0 of BWRVIP-63, uses an average crack depth based on the total inspected length. This is appropriate because the models used to develop the screening and acceptance criteria (Section 4.0) are based on conservative LEFM and limit load solutions. The LEFM models assume a uniform depth flaw which is best represented by the average depth. The limit load models are based on the stress condition of the net section remaining, which is also best represented by the average depth. Additional factors of safety, consistent with existing BWRVIP inspection and flaw guidelines, are also included.
>
> The flaw evaluation criteria, presented in Appendices D and F, uses a slightly different approach for determining average crack depth based on only the cracked length, not the total inspected length. However, the guidance provided in BWRVIP-63 (and BWRVIP-76) is stated incorrectly. The BWRVIP intends to clarify only BWRVIP-76 (because BWRVIP-76 supersedes BWRVIP-63) as follows:

Appendix D (page D-1) and Appendix F (page F-11) of BWRVIP-76 presently states "The assumed crack depth in the uninspected region should be set equal to the average crack depth in the inspected region."

BWRVIP-76 should have stated "The assumed crack depth in the uninspected region should be set equal to the average depth of the observed cracks in the inspected region." In other words, the average crack depth should be based on only that portion of the weld that was inspected and found to be cracked. The average crack depth should not be computed based on inspected lengths where no cracking is detected.

The corrected pages of BWRVIP-76 are attached. Note that the example on page F-11 uses the correct crack depth.

Based on the above discussion, the BWRVIP believes that the use of maximum crack depth is excessively conservative whereas the use and application of average crack depth is technically justified and has an adequate level of conservatism.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

Based on discussions the staff has had with the BWRVIP on crack growth rate, the staff finds that, for plants utilizing effective HWC or NMCA, as defined in the staff's SE for the BWRVIP-62 report, the BWRVIP's proposed usage of assumed crack depth in the uninspected region as equal to the average depth of the observed cracks in the inspected region is acceptable. Plants with NWC should use the more conservative maximum crack depth for the uninspected regions. With this revision, the staff considers this item resolved.

Final BWRVIP response:

The BWRVIP continues to disagree with the staff on this issue. There is no information or technical rationale that would indicate cracking in uninspected regions for NWC plants is different than HWC plants. The approach used by the BWRVIP to account for differences in water chemistry is through application of the crack growth rate correlations contained in BWRVIP-14 and BWRVIP-99 for stainless steel materials. These conservative correlations were developed to account for such parameters as ECP, conductivity, stress, fluence, temperature, etc. and have been reviewed by NRC. The BWRVIP believes that use of maximum crack depth for the uninspected regions is overly conservative, regardless of water chemistry conditions. The average crack depth is employed in the screening criteria to determine which welds are to be inspected. It is also used in the acceptance criteria to determine the structural integrity of the welds. Use of maximum depth, as proposed by NRC, will require the BWRVIP to develop a completely revised screening and acceptance criteria based on maximum depth for NWC plants. The BWRVIP continues to believe that sufficient conservatism is included in the BWRVIP-63 methodology to account for the differences in water chemistry. The crack growth rates assumed in the flaw evaluation will be determined based on the water

chemistry conditions, i.e., conductivity and ECP or a stress-intensity-independent based rate will be used.

Issue 2:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 4-1 (Section 4, "Evaluation of Vertical Weld Indications") that "if through-wall cracks in vertical welds were observed during the inspection, leakage from vertical weld cracking must also be evaluated." However, the potential leakage at EOI should also be quantitatively assessed using a conservative evaluation methodology even though through-wall cracks were not detected during the inspection. Therefore, if the cracking is projected to grow through-wall, a leakage assessment should be provided. A similar statement on page 3-4 (Section 3.1.3, "Acceptance Standards for Vertical Welds") should also be revised.

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP recognizes that there is a possibility of through-wall cracking in core shrouds, however, the inspections performed to date have not revealed any through-wall cracking. Furthermore, the issue of leakage through a vertical weld has previously been evaluated. BWRVIP-01, which has been reviewed and approved by the NRC, states that "leakage through a fully cracked vertical weld has also been shown to be acceptably small." Therefore, potential leakage has been evaluated for projected or assumed through-wall flaws and is considered acceptable.
>
> The BWRVIP does believe it is necessary to quantitatively determine the leakage from an actual through-wall flaw as this may have a direct impact on core performance and on the ability to maintain reflood capability.
>
> Therefore, in summary, the BWRVIP believes that only actual through-wall cracks should be evaluated for leakage.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff agrees that actual through-wall cracks should be evaluated for leakage. In addition, if the cracking is not repaired prior to the next operating cycle and the crack is *projected* to grow through-wall, a leakage assessment should also be performed. A similar statement on page 3-4 (Section 3.1.3, "Acceptance Standards for Vertical Welds") should also be revised. With this revision, the staff considers this item closed.

Final BWRVIP response:

> The BWRVIP continues to believe that a requirement to calculate leakage from predicted through-wall cracks is an overly conservative position. Assumptions already embodied in BWRVIP-63 and BWRVIP-76 for postulating the length and depth of flaws are very conservative. These assumptions typically result in an over-predicted amount of cracking

Furthermore, although the crack growth correlations contained in BWRVIP-14 and BWRVIP-99 may predict through-wall cracks, no through-wall cracking has been detected to date in core shrouds. A prediction of through-wall cracks results is an unrealistic prediction of leakage. The BWRVIP has developed conservative methodologies to ensure that structural integrity of the core shroud and other BWR internals is maintained during operating and postulated accident conditions. Assumptions regarding through-wall cracking are invoked to address inspection limitations (i.e, cracks detected by EVT-1 must be assumed through-wall), to simplify the structural analyses and to ensure that the safety margins are robust. To further penalize an owner by requiring the assumption of leakage and potential reduction in unit rating is unwarranted.

As noted above there has been no inspection experience obtained which indicates that through-wall cracks have occurred in the vertical or horizontal core shroud welds. The inspection frequencies contained in BWRVIP-63 and BWRVIP-76 are such that any appreciable through-wall cracks will be detected well before they impact plant operation or structural integrity. The crack growth rates established for stainless steel materials (reported in BWRVIP-14 and BWRVIP-99) are conservative such that the predicted rates bound the inspection data and have added margin to account for unknowns such as weld repairs. The inspection data presented in BWRVIP-99 demonstrates that crack growth rates are slowing substantially as crack depth increases.

Core shroud circumferential welds that have been structurally placed by repair hardware do not require inspections per BWRVIP-76. The design requirement is to assume complete through-wall cracking for each circumferential weld that is structurally replaced. No additional leakage assessments are required by the BWRVIP beyond those considered in the shroud repair design. Therefore, the BWRVIP believes that the requirement to calculate leakage should be only for observed through-wall flaws.

Issue 3:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 4-2 (Section 4, "Evaluation of Vertical Weld Indications") that "K_{IC} = 150 ksi$\sqrt{in}$ based on BWRVIP-01." Elevated fluences on core shroud welds may effect the mechanical properties of the constituent structural materials. Therefore, the material toughness value may vary under high irradiated conditions. Upon availability of relevant data, a fluence threshold should be established for use of this figure in LEFM. When the fluence limit is exceeded, the use of this value should be justified and discussed with the NRC staff.

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP is presently evaluating fracture toughness properties of highly irradiated stainless steel. The BWRVIP expects to submit the results of this work to the NRC in early 2001. The results may indicate that some changes are required to existing BWRVIP guidelines for shroud inspection and flaw evaluation for highly irradiated

welds. However, in the interim, we believe the approach provided in BWRVIP-76, Section D.1.1 is acceptable for evaluating these conditions. If a different method is used by the utility, we agree that it should be justified and discussed with the NRC staff.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> Based on the above, this item remains open and will be addressed in the staff's review of the BWRVIP-76 report.

Final BWRVIP response:

> BWRVIP-100, "BWR Vessel and Internals Project, Updated Assessment of the Fracture Toughness of Irradiated Stainless Steel for BWR Core Shrouds," EPRI Technical Report 1003016, December 2001 has been submitted to NRC for review and approval. This report provides the relationship of toughness versus fluence for core shroud flaw evaluations. The BWRVIP will use the appropriate fracture toughness limits specified in BWRVIP-100 for evaluation of flaws.

Issue 4:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page B-1 (Appendix B, "Plant Specific Flaw Evaluation Methodology") that "plant-specific analysis may be required if acceptance criteria "c" of Section 3.2 .... cannot be satisfied." Section 3.1.3, "Acceptance Standards for Vertical Welds," should be the correct citation not Section 3.2, "Vertical Welds in Repaired Shrouds."

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP agrees that the citation of Section 3.2 should be corrected to Section 3.1.3.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff finds that these actions adequately addresses this open item.

Final BWRVIP response:

> No changes.

Issue 5:

The Staff's April 18, 2000, Initial SE [3] stated:

The BWRVIP-63 report states on page B-2 (Appendix B, "Plant Specific Flaw Evaluation Methodology") that "submittal to the NRC of these analyses along with the inspection results is required within 90 days of the inspection." The reporting requirements for plant- specific flaw analysis should be consistent with those expressed in the BWRVIP-76 report, which states on page 4-1 (Section 4.3, "Analytical Evaluations of Inspection Results") that the analytical results "shall be reported to the NRC within 30 days after completion of the inspection."

The BWRVIP's May 30, 2001 response [2] stated:

The BWRVIP will provide a response to Item 5 at a later date.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

Based on the above, this item remains open and will be addressed in the staff's review of the BWRVIP-76 report.

Final BWRVIP response:

The BWRVIP has developed reporting requirements which are documented in BWRVIP-94, "BWR Vessel and Internals Project, Program Implementation Guide," EPRI Technical Report 1006288, August 2001. The BWRVIP proposes to delete the specific reporting requirements from all the Inspection and Evaluation Guidelines and reference Section 3.5 of BWRVIP-94 which follows:

> Each utility will inform the NRC of any decision to not fully implement a BWRVIP guideline approved by the NRC staff within 45 days of the report approval. This applies to only those BWRVIP guidelines that have received a Final Safety Evaluation without any exceptions to the report. The NRC should be notified if changes are made to the vessel and internals program that affect implementation of BWRVIP guidelines.
>
> Inspection results and flaw evaluations for components within the scope of the BWRVIP shall be reported as described below.
>
> 1. Licensees shall forward a summary of all inspections, associated results and new repairs to the BWRVIP Program Manager within 120 days following completion of an outage.
>
> 2. Flaw evaluations performed in accordance with the guidance in BWRVIP reports for the acceptance of inspection results do not require submittal to, or approval by, the NRC.
>
> 3. Flaw evaluations that deviate from the guidance in BWRVIP reports (e.g., assumptions, methods, acceptance criteria, etc.) shall be submitted to the NRC for approval. If the flaw evaluation is later revised, the results shall be

communicated to the NRC. The submittal schedule for the analyses will be determined by the licensee and the NRC.

4. If it is determined that implementation cannot be achieved as described in the I&E guidelines, or that meaningful results are not obtained, the user shall notify the BWRVIP with sufficient details to support development of alternative actions. These notifications, as well as planned actions by the BWRVIP, will be summarized and reported to the NRC by the BWRVIP.

5. Modifications to plant operation or configurations that may affect BWRVIP guidance (e.g., power uprate) shall also be reported to the BWRVIP Program Manager.

6. Section XI of the ASME Boiler and Pressure Vessel Code contains rules for inspection, flaw evaluation and repair/replacement of certain components that are also addressed as part of the BWRVIP program. The Code requirements are detailed in Table IWB-2500, Category B-N-2, Welded Core Support Structures and Interior Attachments to Reactor Vessel. In order for BWRVIP I&E Guidelines to be used in lieu of the ASME Code requirements, each licensee must obtain relief from the Code via the process described in 10CFR50.55a. This would best be accomplished by using the technical alternative provision contained in 10CFR50.55a(a)(3)(i).

The form and format of the reporting shall be in accordance with licensee's established procedures. This may include, but is not limited to, submittal by letter or as an attachment to ASME Code required documentation (NIS-1, OAR-1, etc.).

Industry reports are necessary to share information on failure mechanisms, NDE technique applications, repair effectiveness, operating experience, and other items. This experience is shared through the BWRVIP and member utilities. Member utilities agree to share results of assessments outlined in Section 3.4 with the BWRVIP. Deviations from BWRVIP guidance approved by the NRC and documented in accordance with Appendix A shall also be shared with the BWRVIP.

The BWRVIP is also developing a standard template for licensees to follow for submitting a technical alternative to use the BWRVIP I&E Guidelines in lieu of the ASME Code requirements.

Issue 6:

The Staff's April 18, 2000, Initial SE [3] stated:

> The effect of neutron fluence level on the crack growth rate should be consistent with that discussed in the BWRVIP-07 report. When the fluence level exceeds $5x10^{20}n/cm^2$, the appropriate crack growth rate to be used in the flaw evaluation should be discussed with and approved by the NRC staff.

The BWRVIP's May 30, 2001 response [2] stated:

> Until such time as the BWRVIP submits a crack growth evaluation for highly irradiated stainless steel, we agree that when the fluence level exceeds $5x10^{20}$ n/cm^2, the appropriate crack growth rate to be used in plant-specific flaw evaluations will be provided to NRC for concurrence.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff finds that this response adequately addresses this open item.

Final BWRVIP response:

> "BWRVIP-99: BWR Vessel and Internals Project, Crack Growth Rates in Irradiated Stainless Steels in BWR Internal Components," EPRI Technical Report 1003018, December 2001 has been submitted to the NRC for review and approval. The report provides the crack growth rates for stainless steel in the fluence range of $5x10^{20}$ n/cm^2 up to $3x10^{21}$ n/cm^2. The BWRVIP will use the appropriate correlation in this report for evaluation of stainless steel materials subjected to the specified fluence range.

<u>Issue 7</u>:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 3-1(Section 3, "Inspection Recommendations") that "NDE uncertainty does not need to be considered since it is adequately covered by conservatisms in the flaw evaluation methods." BWRVIP-member utilities must determine the measurement uncertainty associated with NDE techniques to be used for inspection of the reactor vessel components consistent with the methodology specified in the BWRVIP-03 report (Section 2.3 "Guidelines for Determining NDE Technique Uncertainty") as approved by the NRC staff, and include the measurement uncertainties in the flaw evaluation consistent with guidance in the BWRVIP-07 report.

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP will provide a response to Item 7 at a later date.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> Based on the above, this item remains open and will be addressed in the staff's review of the BWRVIP-76 report.

Final BWRVIP response:

> The BWRVIP provided a response to Issue 7 in Reference 4.

Issue 8:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 3-3 (Section 3.1.3, "Acceptance Standards for Vertical Welds") that "if the weld has been inspected using a one-sided technique and no cracking was detected then the weld is acceptable for 6 EFPY." In order to verify the weld integrity, the inspection should consist of a two-sided (ID and OD) visual examination. Whenever one-sided visual inspection was performed, the use of its results to determine the reinspection interval should be justified and discussed with the NRC staff. Also, the use of effective full power years (EFPY) as a basis to establish the reinspection interval does not correspond with NRC-approved guidelines. Determination of the acceptable operating time, wherever applicable in the subject report, should be in terms of operating hours or years, not EFPY.

The BWRVIP's May 30, 2001 response [2] stated:

> Section 2.2 of BWRVIP-63 specifies that volumetric or two-sided (ID and OD) visual exams are the only acceptable methods for satisfying the acceptance criteria contained in Section 3. This is consistent with the examination guidelines for horizontal welds contained in BWRVIP-76. The beltline region is approximately 75% of the shroud vertical welds and represents a significant two sided or volumetric examination sample. This is considered an adequate sampling to determine if any ID vertical weld cracking exists. However, in some cases a volumetric exam or two-sided visual exam is not possible due to access limitation (obstructions due to hardware, etc.) For these situations, BWRVIP-63 allows for a one-sided exam and states that a maximum EOI of 6 years is acceptable provided that no cracking is detected. If cracks are detected, a plant-specific evaluation must be performed. Therefore, based on the fact that the bulk of the inspections will be volumetric or visual from both the ID and OD, a substantial amount of weld volume will be examined using this criteria. In general, the regions where one-sided visual exams will be employed will be small compared to those examined by volumetric methods. Furthermore, if cracks are detected using one-sided visual exams, analyses must be performed to determine both the structural integrity and future inspection frequency of the vertical weld. If the evaluation performed differs from the acceptable methods described in the report, the evaluation must be submitted to the NRC for approval. Therefore, the BWRVIP believes that one-sided visual examinations are acceptable for certain situations provided that Section 2.2 of the BWRVIP-63 is followed.
>
> The BWRVIP agrees with the NRC that the reinspection intervals should be based on operating years, not EFPY. In fact, this is reflected in the BWRVIP-76 report.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff finds that, with a revision to the BWRVIP-63 report stating that a qualified two-sided EVT-1 type visual exam should encompass *essentially 100 percent* (as defined in 10 CFR 50.55a) of the inspection area, then the EOI criteria, as proposed to be modified,

established in Section 2.2 of the BWRVIP-63 report is acceptable. If a licensee cannot achieve essentially 100 percent coverage utilizing a qualified two-sided EVT-1 type visual exam, or if the licensee utilizes a one-sided EVT-1 type visual exam, then the licensee shall provide a technical justification of the proposed reinspection interval to the NRC staff. With these revisions, and the BWRVIP's agreement regarding operating years vice EFPY, the staff considers this item resolved.

Final BWRVIP response:

The staff position on vertical welds is not consistent with that of the horizontal welds where the NRC has accepted the BWRVIP position of inspecting essentially 100% of all accessible regions with a minimum of 50% in order to justify structural integrity and future reinspection intervals. The same coverage requirements have been applied to the vertical welds. A further point to make is that except for axial welds, located in the beltline region, that might receive an accumulated fluence greater than $1x10^{21}$ n/cm^2, the allowable flaw length exceeds the length of the weld. Regardless of the actual coverage achieved in excess of 50% or the level of fluence, the flaw evaluation criteria defined in BWRVIP-63 will determine if additional inspections are required for the desired period of operation. Thus, the BWRVIP believes that conservative guidance is provided in BWRVIP-63 to assess integrity of the vertical welds.

Issue 9:

The Staff's April 18, 2000, Initial SE [3] stated:

The BWRVIP-63 report states on page 3-5 (Section 3.1.3, "Radial Ring Welds") that "if the location of the welds is known (e.g., from plant drawings), then those specific locations shall be inspected from the OD of the ring." To assure complete integrity of the weld, the inspection should extend the entire length of the weld and not just the outer surface. In addition, the particular NDE technique used to detect any discontinuities within this component should be given (e.g., UT or 2-sided VT).

The BWRVIP's May 30, 2001 response [2] stated:

Inspection of radial ring welds to date has not revealed any significant cracking or structural integrity concerns. The BWRVIP is recommending that the inspection begin at the OD of the rings. If cracking is detected it is expected that additional surfaces will be examined, on an as-needed basis, as input to plant-specific structural evaluations.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

As stated in the staff findings for Issue 8, above, and the staff's April 18, 2000, initial SE, if the licensee is utilizing a visual exam, it should be a qualified two-sided (OD and ID) EVT-1 type visual exam which encompasses *essentially 100 percent* (as defined in 10 CFR 50.55a) of the inspection area. With this revision, the staff considers this item resolved.

Final BWRVIP response:

Radial ring welds have not reveal any significant cracking. Inspections are currently being performed of all accessible areas following the same approach as horizontal and vertical welds. Examination of the ring welds on the ID and bottom surface is generally impractical or not possible because there is either no access or it would require disassembly of the top guide and associated hardware. Therefore, for the same reasons as discussed in the response to Issue 8, the BWRVIP believes that the current guidance specified in BWRVIP-63 is sufficient to detect cracking in the radial ring welds.

References:

1. Letter from William H. Bateman (NRC) to Carl Terry (BWRVIP Chairman), "Final Safety Evaluation of the BWRVIP Vessel and Internals Project, Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63), EPRI Report TR-113170, June 1999 (TAC NO. MA6015)," dated August 20, 2001.
2. Letter from Carl Terry (BWRVIP Chairman) to NRC Document Control Desk, "Project 704 – BWRVIP Response to NRC Safety Evaluation of BWRVIP-63," dated May 30, 2001.
3. Letter from Jack R. Strosnider (NRC) to Carl Terry (BWRVIP Chairman), "Safety Evaluation of the BWRVIP Vessel and Internals Project, Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63), EPRI Report TR-113170, June 1999 (TAC NO. MA6015)," dated April 18, 2000.
4. Letter from Carl Terry (BWRVIP Chairman) to NRC Document Control Desk, "PROJECT NO. 704 -- BWRVIP Partial Response to the NRC Final Safety Evaluation of BWRVIP-63," dated October 22, 2002.

BWRVIP Response to Issues in NRC Final Safety Evaluation of "BWRVIP Vessel And Internals Project, Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63)," EPRI Report TR-113170, June 1999

Below are the issues identified in the NRC Final Safety Evaluation (SE) of the document entitled "Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63)," followed by the BWRVIP response to each issue. The BWRVIP proposes to incorporate staff comments and other changes, where applicable, into a revised BWRVIP-76 report.

The staff's August 20, 2001 Final SE [1] responded to Reference 2. A meeting was held at Argonne National Labs on October 29-30, 2001 to discuss the BWRVIP proposed response to the Final SE. Responses to the Final SE are provided below to document the BWRVIP positions discussed during the October 29-30, 2001 meeting.

Issue 1:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report uses the "average crack depth" as a parameter for both the inspection and flaw evaluations. The use of average crack depth in the flaw evaluation does not provide adequate conservatism and it is also not consistent with the guidance provided in the BWRVIP-07 report. As approved by the NRC staff, the maximum crack depth should be assumed to ensure a conservative result.

The BWRVIP's May 30, 2001 response [2] stated:

> There are two approaches for the application of average crack depth in BWRVIP-63 (and BWRVIP-76). One approach applies to the screening and acceptance criteria and the second approach applies when performing plant-specific flaw evaluations. These are described in more detail as follows.
>
> The screening and acceptance criteria, presented in Section 3.0 of BWRVIP-63, uses an average crack depth based on the total inspected length. This is appropriate because the models used to develop the screening and acceptance criteria (Section 4.0) are based on conservative LEFM and limit load solutions. The LEFM models assume a uniform depth flaw which is best represented by the average depth. The limit load models are based on the stress condition of the net section remaining, which is also best represented by the average depth. Additional factors of safety, consistent with existing BWRVIP inspection and flaw guidelines, are also included.
>
> The flaw evaluation criteria, presented in Appendices D and F, uses a slightly different approach for determining average crack depth based on only the cracked length, not the total inspected length. However, the guidance provided in BWRVIP-63 (and BWRVIP-76) is stated incorrectly. The BWRVIP intends to clarify only BWRVIP-76 (because BWRVIP-76 supersedes BWRVIP-63) as follows:

Appendix D (page D-1) and Appendix F (page F-11) of BWRVIP-76 presently states "The assumed crack depth in the uninspected region should be set equal to the average crack depth in the inspected region."

BWRVIP-76 should have stated "The assumed crack depth in the uninspected region should be set equal to the average depth of the observed cracks in the inspected region." In other words, the average crack depth should be based on only that portion of the weld that was inspected and found to be cracked. The average crack depth should not be computed based on inspected lengths where no cracking is detected.

The corrected pages of BWRVIP-76 are attached. Note that the example on page F-11 uses the correct crack depth.

Based on the above discussion, the BWRVIP believes that the use of maximum crack depth is excessively conservative whereas the use and application of average crack depth is technically justified and has an adequate level of conservatism.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

Based on discussions the staff has had with the BWRVIP on crack growth rate, the staff finds that, for plants utilizing effective HWC or NMCA, as defined in the staff's SE for the BWRVIP-62 report, the BWRVIP's proposed usage of assumed crack depth in the uninspected region as equal to the average depth of the observed cracks in the inspected region is acceptable. Plants with NWC should use the more conservative maximum crack depth for the uninspected regions. With this revision, the staff considers this item resolved.

Final BWRVIP response:

The BWRVIP continues to disagree with the staff on this issue. There is no information or technical rationale that would indicate cracking in uninspected regions for NWC plants is different than HWC plants. The approach used by the BWRVIP to account for differences in water chemistry is through application of the crack growth rate correlations contained in BWRVIP-14 and BWRVIP-99 for stainless steel materials. These conservative correlations were developed to account for such parameters as ECP, conductivity, stress, fluence, temperature, etc. and have been reviewed by NRC. The BWRVIP believes that use of maximum crack depth for the uninspected regions is overly conservative, regardless of water chemistry conditions. The average crack depth is employed in the screening criteria to determine which welds are to be inspected. It is also used in the acceptance criteria to determine the structural integrity of the welds. Use of maximum depth, as proposed by NRC, will require the BWRVIP to develop a completely revised screening and acceptance criteria based on maximum depth for NWC plants. The BWRVIP continues to believe that sufficient conservatism is included in the BWRVIP-63 methodology to account for the differences in water chemistry. The crack growth rates assumed in the flaw evaluation will be determined based on the water

chemistry conditions, i.e., conductivity and ECP or a stress-intensity-independent based rate will be used.

Issue 2:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 4-1 (Section 4, "Evaluation of Vertical Weld Indications") that "if through-wall cracks in vertical welds were observed during the inspection, leakage from vertical weld cracking must also be evaluated." However, the potential leakage at EOI should also be quantitatively assessed using a conservative evaluation methodology even though through-wall cracks were not detected during the inspection. Therefore, if the cracking is projected to grow through-wall, a leakage assessment should be provided. A similar statement on page 3-4 (Section 3.1.3, "Acceptance Standards for Vertical Welds") should also be revised.

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP recognizes that there is a possibility of through-wall cracking in core shrouds, however, the inspections performed to date have not revealed any through-wall cracking. Furthermore, the issue of leakage through a vertical weld has previously been evaluated. BWRVIP-01, which has been reviewed and approved by the NRC, states that "leakage through a fully cracked vertical weld has also been shown to be acceptably small." Therefore, potential leakage has been evaluated for projected or assumed through-wall flaws and is considered acceptable.
>
> The BWRVIP does believe it is necessary to quantitatively determine the leakage from an actual through-wall flaw as this may have a direct impact on core performance and on the ability to maintain reflood capability.
>
> Therefore, in summary, the BWRVIP believes that only actual through-wall cracks should be evaluated for leakage.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff agrees that actual through-wall cracks should be evaluated for leakage. In addition, if the cracking is not repaired prior to the next operating cycle and the crack is *projected* to grow through-wall, a leakage assessment should also be performed. A similar statement on page 3-4 (Section 3.1.3, "Acceptance Standards for Vertical Welds") should also be revised. With this revision, the staff considers this item closed.

Final BWRVIP response:

> The BWRVIP continues to believe that a requirement to calculate leakage from predicted through-wall cracks is an overly conservative position. Assumptions already embodied in BWRVIP-63 and BWRVIP-76 for postulating the length and depth of flaws are very conservative. These assumptions typically result in an over-predicted amount of cracking

Furthermore, although the crack growth correlations contained in BWRVIP-14 and BWRVIP-99 may predict through-wall cracks, no through-wall cracking has been detected to date in core shrouds. A prediction of through-wall cracks results is an unrealistic prediction of leakage. The BWRVIP has developed conservative methodologies to ensure that structural integrity of the core shroud and other BWR internals is maintained during operating and postulated accident conditions. Assumptions regarding through-wall cracking are invoked to address inspection limitations (i.e, cracks detected by EVT-1 must be assumed through-wall), to simplify the structural analyses and to ensure that the safety margins are robust. To further penalize an owner by requiring the assumption of leakage and potential reduction in unit rating is unwarranted.

As noted above there has been no inspection experience obtained which indicates that through-wall cracks have occurred in the vertical or horizontal core shroud welds. The inspection frequencies contained in BWRVIP-63 and BWRVIP-76 are such that any appreciable through-wall cracks will be detected well before they impact plant operation or structural integrity. The crack growth rates established for stainless steel materials (reported in BWRVIP-14 and BWRVIP-99) are conservative such that the predicted rates bound the inspection data and have added margin to account for unknowns such as weld repairs. The inspection data presented in BWRVIP-99 demonstrates that crack growth rates are slowing substantially as crack depth increases.

Core shroud circumferential welds that have been structurally placed by repair hardware do not require inspections per BWRVIP-76. The design requirement is to assume complete through-wall cracking for each circumferential weld that is structurally replaced. No additional leakage assessments are required by the BWRVIP beyond those considered in the shroud repair design. Therefore, the BWRVIP believes that the requirement to calculate leakage should be only for observed through-wall flaws.

Issue 3:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 4-2 (Section 4, "Evaluation of Vertical Weld Indications") that "K_{IC} = 150 ksi$\sqrt{in}$ based on BWRVIP-01." Elevated fluences on core shroud welds may effect the mechanical properties of the constituent structural materials. Therefore, the material toughness value may vary under high irradiated conditions. Upon availability of relevant data, a fluence threshold should be established for use of this figure in LEFM. When the fluence limit is exceeded, the use of this value should be justified and discussed with the NRC staff.

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP is presently evaluating fracture toughness properties of highly irradiated stainless steel. The BWRVIP expects to submit the results of this work to the NRC in early 2001. The results may indicate that some changes are required to existing BWRVIP guidelines for shroud inspection and flaw evaluation for highly irradiated

welds. However, in the interim, we believe the approach provided in BWRVIP-76, Section D.1.1 is acceptable for evaluating these conditions. If a different method is used by the utility, we agree that it should be justified and discussed with the NRC staff.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> Based on the above, this item remains open and will be addressed in the staff's review of the BWRVIP-76 report.

Final BWRVIP response:

> BWRVIP-100, "BWR Vessel and Internals Project, Updated Assessment of the Fracture Toughness of Irradiated Stainless Steel for BWR Core Shrouds," EPRI Technical Report 1003016, December 2001 has been submitted to NRC for review and approval. This report provides the relationship of toughness versus fluence for core shroud flaw evaluations. The BWRVIP will use the appropriate fracture toughness limits specified in BWRVIP-100 for evaluation of flaws.

Issue 4:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page B-1 (Appendix B, "Plant Specific Flaw Evaluation Methodology") that "plant-specific analysis may be required if acceptance criteria "c" of Section 3.2 .... cannot be satisfied." Section 3.1.3, "Acceptance Standards for Vertical Welds," should be the correct citation not Section 3.2, "Vertical Welds in Repaired Shrouds."

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP agrees that the citation of Section 3.2 should be corrected to Section 3.1.3.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff finds that these actions adequately addresses this open item.

Final BWRVIP response:

> No changes.

Issue 5:

The Staff's April 18, 2000, Initial SE [3] stated:

The BWRVIP-63 report states on page B-2 (Appendix B, "Plant Specific Flaw Evaluation Methodology") that "submittal to the NRC of these analyses along with the inspection results is required within 90 days of the inspection." The reporting requirements for plant- specific flaw analysis should be consistent with those expressed in the BWRVIP-76 report, which states on page 4-1 (Section 4.3, "Analytical Evaluations of Inspection Results") that the analytical results "shall be reported to the NRC within 30 days after completion of the inspection."

The BWRVIP's May 30, 2001 response [2] stated:

The BWRVIP will provide a response to Item 5 at a later date.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

Based on the above, this item remains open and will be addressed in the staff's review of the BWRVIP-76 report.

Final BWRVIP response:

The BWRVIP has developed reporting requirements which are documented in BWRVIP-94, "BWR Vessel and Internals Project, Program Implementation Guide," EPRI Technical Report 1006288, August 2001. The BWRVIP proposes to delete the specific reporting requirements from all the Inspection and Evaluation Guidelines and reference Section 3.5 of BWRVIP-94 which follows:

> Each utility will inform the NRC of any decision to not fully implement a BWRVIP guideline approved by the NRC staff within 45 days of the report approval. This applies to only those BWRVIP guidelines that have received a Final Safety Evaluation without any exceptions to the report. The NRC should be notified if changes are made to the vessel and internals program that affect implementation of BWRVIP guidelines.
>
> Inspection results and flaw evaluations for components within the scope of the BWRVIP shall be reported as described below.
>
> 1. Licensees shall forward a summary of all inspections, associated results and new repairs to the BWRVIP Program Manager within 120 days following completion of an outage.
>
> 2. Flaw evaluations performed in accordance with the guidance in BWRVIP reports for the acceptance of inspection results do not require submittal to, or approval by, the NRC.
>
> 3. Flaw evaluations that deviate from the guidance in BWRVIP reports (e.g., assumptions, methods, acceptance criteria, etc.) shall be submitted to the NRC for approval. If the flaw evaluation is later revised, the results shall be

communicated to the NRC. The submittal schedule for the analyses will be determined by the licensee and the NRC.

4. If it is determined that implementation cannot be achieved as described in the I&E guidelines, or that meaningful results are not obtained, the user shall notify the BWRVIP with sufficient details to support development of alternative actions. These notifications, as well as planned actions by the BWRVIP, will be summarized and reported to the NRC by the BWRVIP.

5. Modifications to plant operation or configurations that may affect BWRVIP guidance (e.g., power uprate) shall also be reported to the BWRVIP Program Manager.

6. Section XI of the ASME Boiler and Pressure Vessel Code contains rules for inspection, flaw evaluation and repair/replacement of certain components that are also addressed as part of the BWRVIP program. The Code requirements are detailed in Table IWB-2500, Category B-N-2, Welded Core Support Structures and Interior Attachments to Reactor Vessel. In order for BWRVIP I&E Guidelines to be used in lieu of the ASME Code requirements, each licensee must obtain relief from the Code via the process described in 10CFR50.55a. This would best be accomplished by using the technical alternative provision contained in 10CFR50.55a(a)(3)(i).

The form and format of the reporting shall be in accordance with licensee's established procedures. This may include, but is not limited to, submittal by letter or as an attachment to ASME Code required documentation (NIS-1, OAR-1, etc.).

Industry reports are necessary to share information on failure mechanisms, NDE technique applications, repair effectiveness, operating experience, and other items. This experience is shared through the BWRVIP and member utilities. Member utilities agree to share results of assessments outlined in Section 3.4 with the BWRVIP. Deviations from BWRVIP guidance approved by the NRC and documented in accordance with Appendix A shall also be shared with the BWRVIP.

The BWRVIP is also developing a standard template for licensees to follow for submitting a technical alternative to use the BWRVIP I&E Guidelines in lieu of the ASME Code requirements.

Issue 6:

The Staff's April 18, 2000, Initial SE [3] stated:

> The effect of neutron fluence level on the crack growth rate should be consistent with that discussed in the BWRVIP-07 report. When the fluence level exceeds $5x10^{20}n/cm^2$, the appropriate crack growth rate to be used in the flaw evaluation should be discussed with and approved by the NRC staff.

The BWRVIP's May 30, 2001 response [2] stated:

> Until such time as the BWRVIP submits a crack growth evaluation for highly irradiated stainless steel, we agree that when the fluence level exceeds $5x10^{20}$ n/cm^2, the appropriate crack growth rate to be used in plant-specific flaw evaluations will be provided to NRC for concurrence.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff finds that this response adequately addresses this open item.

Final BWRVIP response:

> "BWRVIP-99: BWR Vessel and Internals Project, Crack Growth Rates in Irradiated Stainless Steels in BWR Internal Components," EPRI Technical Report 1003018, December 2001 has been submitted to the NRC for review and approval. The report provides the crack growth rates for stainless steel in the fluence range of $5x10^{20}$ n/cm^2 up to $3x10^{21}$ n/cm^2. The BWRVIP will use the appropriate correlation in this report for evaluation of stainless steel materials subjected to the specified fluence range.

<u>Issue 7</u>:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 3-1(Section 3, "Inspection Recommendations") that "NDE uncertainty does not need to be considered since it is adequately covered by conservatisms in the flaw evaluation methods." BWRVIP-member utilities must determine the measurement uncertainty associated with NDE techniques to be used for inspection of the reactor vessel components consistent with the methodology specified in the BWRVIP-03 report (Section 2.3 "Guidelines for Determining NDE Technique Uncertainty") as approved by the NRC staff, and include the measurement uncertainties in the flaw evaluation consistent with guidance in the BWRVIP-07 report.

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP will provide a response to Item 7 at a later date.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> Based on the above, this item remains open and will be addressed in the staff's review of the BWRVIP-76 report.

Final BWRVIP response:

> The BWRVIP provided a response to Issue 7 in Reference 4.

Issue 8:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 3-3 (Section 3.1.3, "Acceptance Standards for Vertical Welds") that "if the weld has been inspected using a one-sided technique and no cracking was detected then the weld is acceptable for 6 EFPY." In order to verify the weld integrity, the inspection should consist of a two-sided (ID and OD) visual examination. Whenever one-sided visual inspection was performed, the use of its results to determine the reinspection interval should be justified and discussed with the NRC staff. Also, the use of effective full power years (EFPY) as a basis to establish the reinspection interval does not correspond with NRC-approved guidelines. Determination of the acceptable operating time, wherever applicable in the subject report, should be in terms of operating hours or years, not EFPY.

The BWRVIP's May 30, 2001 response [2] stated:

> Section 2.2 of BWRVIP-63 specifies that volumetric or two-sided (ID and OD) visual exams are the only acceptable methods for satisfying the acceptance criteria contained in Section 3. This is consistent with the examination guidelines for horizontal welds contained in BWRVIP-76. The beltline region is approximately 75% of the shroud vertical welds and represents a significant two sided or volumetric examination sample. This is considered an adequate sampling to determine if any ID vertical weld cracking exists. However, in some cases a volumetric exam or two-sided visual exam is not possible due to access limitation (obstructions due to hardware, etc.) For these situations, BWRVIP-63 allows for a one-sided exam and states that a maximum EOI of 6 years is acceptable provided that no cracking is detected. If cracks are detected, a plant-specific evaluation must be performed. Therefore, based on the fact that the bulk of the inspections will be volumetric or visual from both the ID and OD, a substantial amount of weld volume will be examined using this criteria. In general, the regions where one-sided visual exams will be employed will be small compared to those examined by volumetric methods. Furthermore, if cracks are detected using one-sided visual exams, analyses must be performed to determine both the structural integrity and future inspection frequency of the vertical weld. If the evaluation performed differs from the acceptable methods described in the report, the evaluation must be submitted to the NRC for approval. Therefore, the BWRVIP believes that one-sided visual examinations are acceptable for certain situations provided that Section 2.2 of the BWRVIP-63 is followed.
>
> The BWRVIP agrees with the NRC that the reinspection intervals should be based on operating years, not EFPY. In fact, this is reflected in the BWRVIP-76 report.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff finds that, with a revision to the BWRVIP-63 report stating that a qualified two-sided EVT-1 type visual exam should encompass *essentially 100 percent* (as defined in 10 CFR 50.55a) of the inspection area, then the EOI criteria, as proposed to be modified,

established in Section 2.2 of the BWRVIP-63 report is acceptable. If a licensee cannot achieve essentially 100 percent coverage utilizing a qualified two-sided EVT-1 type visual exam, or if the licensee utilizes a one-sided EVT-1 type visual exam, then the licensee shall provide a technical justification of the proposed reinspection interval to the NRC staff. With these revisions, and the BWRVIP's agreement regarding operating years vice EFPY, the staff considers this item resolved.

Final BWRVIP response:

The staff position on vertical welds is not consistent with that of the horizontal welds where the NRC has accepted the BWRVIP position of inspecting essentially 100% of all accessible regions with a minimum of 50% in order to justify structural integrity and future reinspection intervals. The same coverage requirements have been applied to the vertical welds. A further point to make is that except for axial welds, located in the beltline region, that might receive an accumulated fluence greater than $1x10^{21}$ n/cm^2, the allowable flaw length exceeds the length of the weld. Regardless of the actual coverage achieved in excess of 50% or the level of fluence, the flaw evaluation criteria defined in BWRVIP-63 will determine if additional inspections are required for the desired period of operation. Thus, the BWRVIP believes that conservative guidance is provided in BWRVIP-63 to assess integrity of the vertical welds.

Issue 9:

The Staff's April 18, 2000, Initial SE [3] stated:

The BWRVIP-63 report states on page 3-5 (Section 3.1.3, "Radial Ring Welds") that "if the location of the welds is known (e.g., from plant drawings), then those specific locations shall be inspected from the OD of the ring." To assure complete integrity of the weld, the inspection should extend the entire length of the weld and not just the outer surface. In addition, the particular NDE technique used to detect any discontinuities within this component should be given (e.g., UT or 2-sided VT).

The BWRVIP's May 30, 2001 response [2] stated:

Inspection of radial ring welds to date has not revealed any significant cracking or structural integrity concerns. The BWRVIP is recommending that the inspection begin at the OD of the rings. If cracking is detected it is expected that additional surfaces will be examined, on an as-needed basis, as input to plant-specific structural evaluations.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

As stated in the staff findings for Issue 8, above, and the staff's April 18, 2000, initial SE, if the licensee is utilizing a visual exam, it should be a qualified two-sided (OD and ID) EVT-1 type visual exam which encompasses *essentially 100 percent* (as defined in 10 CFR 50.55a) of the inspection area. With this revision, the staff considers this item resolved.

Final BWRVIP response:

Radial ring welds have not reveal any significant cracking. Inspections are currently being performed of all accessible areas following the same approach as horizontal and vertical welds. Examination of the ring welds on the ID and bottom surface is generally impractical or not possible because there is either no access or it would require disassembly of the top guide and associated hardware. Therefore, for the same reasons as discussed in the response to Issue 8, the BWRVIP believes that the current guidance specified in BWRVIP-63 is sufficient to detect cracking in the radial ring welds.

References:

1. Letter from William H. Bateman (NRC) to Carl Terry (BWRVIP Chairman), "Final Safety Evaluation of the BWRVIP Vessel and Internals Project, Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63), EPRI Report TR-113170, June 1999 (TAC NO. MA6015)," dated August 20, 2001.
2. Letter from Carl Terry (BWRVIP Chairman) to NRC Document Control Desk, "Project 704 – BWRVIP Response to NRC Safety Evaluation of BWRVIP-63," dated May 30, 2001.
3. Letter from Jack R. Strosnider (NRC) to Carl Terry (BWRVIP Chairman), "Safety Evaluation of the BWRVIP Vessel and Internals Project, Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63), EPRI Report TR-113170, June 1999 (TAC NO. MA6015)," dated April 18, 2000.
4. Letter from Carl Terry (BWRVIP Chairman) to NRC Document Control Desk, "PROJECT NO. 704 -- BWRVIP Partial Response to the NRC Final Safety Evaluation of BWRVIP-63," dated October 22, 2002.

BWRVIP Response to Issues in NRC Final Safety Evaluation of "BWRVIP Vessel And Internals Project, Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63)," EPRI Report TR-113170, June 1999

Below are the issues identified in the NRC Final Safety Evaluation (SE) of the document entitled "Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63)," followed by the BWRVIP response to each issue. The BWRVIP proposes to incorporate staff comments and other changes, where applicable, into a revised BWRVIP-76 report.

The staff's August 20, 2001 Final SE [1] responded to Reference 2. A meeting was held at Argonne National Labs on October 29-30, 2001 to discuss the BWRVIP proposed response to the Final SE. Responses to the Final SE are provided below to document the BWRVIP positions discussed during the October 29-30, 2001 meeting.

Issue 1:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report uses the "average crack depth" as a parameter for both the inspection and flaw evaluations. The use of average crack depth in the flaw evaluation does not provide adequate conservatism and it is also not consistent with the guidance provided in the BWRVIP-07 report. As approved by the NRC staff, the maximum crack depth should be assumed to ensure a conservative result.

The BWRVIP's May 30, 2001 response [2] stated:

> There are two approaches for the application of average crack depth in BWRVIP-63 (and BWRVIP-76). One approach applies to the screening and acceptance criteria and the second approach applies when performing plant-specific flaw evaluations. These are described in more detail as follows.
>
> The screening and acceptance criteria, presented in Section 3.0 of BWRVIP-63, uses an average crack depth based on the total inspected length. This is appropriate because the models used to develop the screening and acceptance criteria (Section 4.0) are based on conservative LEFM and limit load solutions. The LEFM models assume a uniform depth flaw which is best represented by the average depth. The limit load models are based on the stress condition of the net section remaining, which is also best represented by the average depth. Additional factors of safety, consistent with existing BWRVIP inspection and flaw guidelines, are also included.
>
> The flaw evaluation criteria, presented in Appendices D and F, uses a slightly different approach for determining average crack depth based on only the cracked length, not the total inspected length. However, the guidance provided in BWRVIP-63 (and BWRVIP-76) is stated incorrectly. The BWRVIP intends to clarify only BWRVIP-76 (because BWRVIP-76 supersedes BWRVIP-63) as follows:

Appendix D (page D-1) and Appendix F (page F-11) of BWRVIP-76 presently states "The assumed crack depth in the uninspected region should be set equal to the average crack depth in the inspected region."

BWRVIP-76 should have stated "The assumed crack depth in the uninspected region should be set equal to the average depth of the observed cracks in the inspected region." In other words, the average crack depth should be based on only that portion of the weld that was inspected and found to be cracked. The average crack depth should not be computed based on inspected lengths where no cracking is detected.

The corrected pages of BWRVIP-76 are attached. Note that the example on page F-11 uses the correct crack depth.

Based on the above discussion, the BWRVIP believes that the use of maximum crack depth is excessively conservative whereas the use and application of average crack depth is technically justified and has an adequate level of conservatism.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

Based on discussions the staff has had with the BWRVIP on crack growth rate, the staff finds that, for plants utilizing effective HWC or NMCA, as defined in the staff's SE for the BWRVIP-62 report, the BWRVIP's proposed usage of assumed crack depth in the uninspected region as equal to the average depth of the observed cracks in the inspected region is acceptable. Plants with NWC should use the more conservative maximum crack depth for the uninspected regions. With this revision, the staff considers this item resolved.

Final BWRVIP response:

The BWRVIP continues to disagree with the staff on this issue. There is no information or technical rationale that would indicate cracking in uninspected regions for NWC plants is different than HWC plants. The approach used by the BWRVIP to account for differences in water chemistry is through application of the crack growth rate correlations contained in BWRVIP-14 and BWRVIP-99 for stainless steel materials. These conservative correlations were developed to account for such parameters as ECP, conductivity, stress, fluence, temperature, etc. and have been reviewed by NRC. The BWRVIP believes that use of maximum crack depth for the uninspected regions is overly conservative, regardless of water chemistry conditions. The average crack depth is employed in the screening criteria to determine which welds are to be inspected. It is also used in the acceptance criteria to determine the structural integrity of the welds. Use of maximum depth, as proposed by NRC, will require the BWRVIP to develop a completely revised screening and acceptance criteria based on maximum depth for NWC plants. The BWRVIP continues to believe that sufficient conservatism is included in the BWRVIP-63 methodology to account for the differences in water chemistry. The crack growth rates assumed in the flaw evaluation will be determined based on the water

chemistry conditions, i.e., conductivity and ECP or a stress-intensity-independent based rate will be used.

Issue 2:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 4-1 (Section 4, "Evaluation of Vertical Weld Indications") that "if through-wall cracks in vertical welds were observed during the inspection, leakage from vertical weld cracking must also be evaluated." However, the potential leakage at EOI should also be quantitatively assessed using a conservative evaluation methodology even though through-wall cracks were not detected during the inspection. Therefore, if the cracking is projected to grow through-wall, a leakage assessment should be provided. A similar statement on page 3-4 (Section 3.1.3, "Acceptance Standards for Vertical Welds") should also be revised.

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP recognizes that there is a possibility of through-wall cracking in core shrouds, however, the inspections performed to date have not revealed any through-wall cracking. Furthermore, the issue of leakage through a vertical weld has previously been evaluated. BWRVIP-01, which has been reviewed and approved by the NRC, states that "leakage through a fully cracked vertical weld has also been shown to be acceptably small." Therefore, potential leakage has been evaluated for projected or assumed through-wall flaws and is considered acceptable.
>
> The BWRVIP does believe it is necessary to quantitatively determine the leakage from an actual through-wall flaw as this may have a direct impact on core performance and on the ability to maintain reflood capability.
>
> Therefore, in summary, the BWRVIP believes that only actual through-wall cracks should be evaluated for leakage.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff agrees that actual through-wall cracks should be evaluated for leakage. In addition, if the cracking is not repaired prior to the next operating cycle and the crack is *projected* to grow through-wall, a leakage assessment should also be performed. A similar statement on page 3-4 (Section 3.1.3, "Acceptance Standards for Vertical Welds") should also be revised. With this revision, the staff considers this item closed.

Final BWRVIP response:

> The BWRVIP continues to believe that a requirement to calculate leakage from predicted through-wall cracks is an overly conservative position. Assumptions already embodied in BWRVIP-63 and BWRVIP-76 for postulating the length and depth of flaws are very conservative. These assumptions typically result in an over-predicted amount of cracking

Furthermore, although the crack growth correlations contained in BWRVIP-14 and BWRVIP-99 may predict through-wall cracks, no through-wall cracking has been detected to date in core shrouds. A prediction of through-wall cracks results is an unrealistic prediction of leakage. The BWRVIP has developed conservative methodologies to ensure that structural integrity of the core shroud and other BWR internals is maintained during operating and postulated accident conditions. Assumptions regarding through-wall cracking are invoked to address inspection limitations (i.e, cracks detected by EVT-1 must be assumed through-wall), to simplify the structural analyses and to ensure that the safety margins are robust. To further penalize an owner by requiring the assumption of leakage and potential reduction in unit rating is unwarranted.

As noted above there has been no inspection experience obtained which indicates that through-wall cracks have occurred in the vertical or horizontal core shroud welds. The inspection frequencies contained in BWRVIP-63 and BWRVIP-76 are such that any appreciable through-wall cracks will be detected well before they impact plant operation or structural integrity. The crack growth rates established for stainless steel materials (reported in BWRVIP-14 and BWRVIP-99) are conservative such that the predicted rates bound the inspection data and have added margin to account for unknowns such as weld repairs. The inspection data presented in BWRVIP-99 demonstrates that crack growth rates are slowing substantially as crack depth increases.

Core shroud circumferential welds that have been structurally placed by repair hardware do not require inspections per BWRVIP-76. The design requirement is to assume complete through-wall cracking for each circumferential weld that is structurally replaced. No additional leakage assessments are required by the BWRVIP beyond those considered in the shroud repair design. Therefore, the BWRVIP believes that the requirement to calculate leakage should be only for observed through-wall flaws.

Issue 3:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 4-2 (Section 4, "Evaluation of Vertical Weld Indications") that "K_{IC} = 150 ksi$\sqrt{in}$ based on BWRVIP-01." Elevated fluences on core shroud welds may effect the mechanical properties of the constituent structural materials. Therefore, the material toughness value may vary under high irradiated conditions. Upon availability of relevant data, a fluence threshold should be established for use of this figure in LEFM. When the fluence limit is exceeded, the use of this value should be justified and discussed with the NRC staff.

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP is presently evaluating fracture toughness properties of highly irradiated stainless steel. The BWRVIP expects to submit the results of this work to the NRC in early 2001. The results may indicate that some changes are required to existing BWRVIP guidelines for shroud inspection and flaw evaluation for highly irradiated

welds. However, in the interim, we believe the approach provided in BWRVIP-76, Section D.1.1 is acceptable for evaluating these conditions. If a different method is used by the utility, we agree that it should be justified and discussed with the NRC staff.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> Based on the above, this item remains open and will be addressed in the staff's review of the BWRVIP-76 report.

Final BWRVIP response:

> BWRVIP-100, "BWR Vessel and Internals Project, Updated Assessment of the Fracture Toughness of Irradiated Stainless Steel for BWR Core Shrouds," EPRI Technical Report 1003016, December 2001 has been submitted to NRC for review and approval. This report provides the relationship of toughness versus fluence for core shroud flaw evaluations. The BWRVIP will use the appropriate fracture toughness limits specified in BWRVIP-100 for evaluation of flaws.

Issue 4:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page B-1 (Appendix B, "Plant Specific Flaw Evaluation Methodology") that "plant-specific analysis may be required if acceptance criteria "c" of Section 3.2 .... cannot be satisfied." Section 3.1.3, "Acceptance Standards for Vertical Welds," should be the correct citation not Section 3.2, "Vertical Welds in Repaired Shrouds."

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP agrees that the citation of Section 3.2 should be corrected to Section 3.1.3.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff finds that these actions adequately addresses this open item.

Final BWRVIP response:

> No changes.

Issue 5:

The Staff's April 18, 2000, Initial SE [3] stated:

The BWRVIP-63 report states on page B-2 (Appendix B, "Plant Specific Flaw Evaluation Methodology") that "submittal to the NRC of these analyses along with the inspection results is required within 90 days of the inspection." The reporting requirements for plant- specific flaw analysis should be consistent with those expressed in the BWRVIP-76 report, which states on page 4-1 (Section 4.3, "Analytical Evaluations of Inspection Results") that the analytical results "shall be reported to the NRC within 30 days after completion of the inspection."

The BWRVIP's May 30, 2001 response [2] stated:

The BWRVIP will provide a response to Item 5 at a later date.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

Based on the above, this item remains open and will be addressed in the staff's review of the BWRVIP-76 report.

Final BWRVIP response:

The BWRVIP has developed reporting requirements which are documented in BWRVIP-94, "BWR Vessel and Internals Project, Program Implementation Guide," EPRI Technical Report 1006288, August 2001. The BWRVIP proposes to delete the specific reporting requirements from all the Inspection and Evaluation Guidelines and reference Section 3.5 of BWRVIP-94 which follows:

> Each utility will inform the NRC of any decision to not fully implement a BWRVIP guideline approved by the NRC staff within 45 days of the report approval. This applies to only those BWRVIP guidelines that have received a Final Safety Evaluation without any exceptions to the report. The NRC should be notified if changes are made to the vessel and internals program that affect implementation of BWRVIP guidelines.
>
> Inspection results and flaw evaluations for components within the scope of the BWRVIP shall be reported as described below.
>
> 1. Licensees shall forward a summary of all inspections, associated results and new repairs to the BWRVIP Program Manager within 120 days following completion of an outage.
>
> 2. Flaw evaluations performed in accordance with the guidance in BWRVIP reports for the acceptance of inspection results do not require submittal to, or approval by, the NRC.
>
> 3. Flaw evaluations that deviate from the guidance in BWRVIP reports (e.g., assumptions, methods, acceptance criteria, etc.) shall be submitted to the NRC for approval. If the flaw evaluation is later revised, the results shall be

communicated to the NRC. The submittal schedule for the analyses will be determined by the licensee and the NRC.

4. If it is determined that implementation cannot be achieved as described in the I&E guidelines, or that meaningful results are not obtained, the user shall notify the BWRVIP with sufficient details to support development of alternative actions. These notifications, as well as planned actions by the BWRVIP, will be summarized and reported to the NRC by the BWRVIP.

5. Modifications to plant operation or configurations that may affect BWRVIP guidance (e.g., power uprate) shall also be reported to the BWRVIP Program Manager.

6. Section XI of the ASME Boiler and Pressure Vessel Code contains rules for inspection, flaw evaluation and repair/replacement of certain components that are also addressed as part of the BWRVIP program. The Code requirements are detailed in Table IWB-2500, Category B-N-2, Welded Core Support Structures and Interior Attachments to Reactor Vessel. In order for BWRVIP I&E Guidelines to be used in lieu of the ASME Code requirements, each licensee must obtain relief from the Code via the process described in 10CFR50.55a. This would best be accomplished by using the technical alternative provision contained in 10CFR50.55a(a)(3)(i).

The form and format of the reporting shall be in accordance with licensee's established procedures. This may include, but is not limited to, submittal by letter or as an attachment to ASME Code required documentation (NIS-1, OAR-1, etc.).

Industry reports are necessary to share information on failure mechanisms, NDE technique applications, repair effectiveness, operating experience, and other items. This experience is shared through the BWRVIP and member utilities. Member utilities agree to share results of assessments outlined in Section 3.4 with the BWRVIP. Deviations from BWRVIP guidance approved by the NRC and documented in accordance with Appendix A shall also be shared with the BWRVIP.

The BWRVIP is also developing a standard template for licensees to follow for submitting a technical alternative to use the BWRVIP I&E Guidelines in lieu of the ASME Code requirements.

Issue 6:

The Staff's April 18, 2000, Initial SE [3] stated:

> The effect of neutron fluence level on the crack growth rate should be consistent with that discussed in the BWRVIP-07 report. When the fluence level exceeds $5x10^{20}n/cm^2$, the appropriate crack growth rate to be used in the flaw evaluation should be discussed with and approved by the NRC staff.

The BWRVIP's May 30, 2001 response [2] stated:

> Until such time as the BWRVIP submits a crack growth evaluation for highly irradiated stainless steel, we agree that when the fluence level exceeds $5x10^{20}$ n/cm^2, the appropriate crack growth rate to be used in plant-specific flaw evaluations will be provided to NRC for concurrence.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff finds that this response adequately addresses this open item.

Final BWRVIP response:

> "BWRVIP-99: BWR Vessel and Internals Project, Crack Growth Rates in Irradiated Stainless Steels in BWR Internal Components," EPRI Technical Report 1003018, December 2001 has been submitted to the NRC for review and approval. The report provides the crack growth rates for stainless steel in the fluence range of $5x10^{20}$ n/cm^2 up to $3x10^{21}$ n/cm^2. The BWRVIP will use the appropriate correlation in this report for evaluation of stainless steel materials subjected to the specified fluence range.

Issue 7:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 3-1(Section 3, "Inspection Recommendations") that "NDE uncertainty does not need to be considered since it is adequately covered by conservatisms in the flaw evaluation methods." BWRVIP-member utilities must determine the measurement uncertainty associated with NDE techniques to be used for inspection of the reactor vessel components consistent with the methodology specified in the BWRVIP-03 report (Section 2.3 "Guidelines for Determining NDE Technique Uncertainty") as approved by the NRC staff, and include the measurement uncertainties in the flaw evaluation consistent with guidance in the BWRVIP-07 report.

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP will provide a response to Item 7 at a later date.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> Based on the above, this item remains open and will be addressed in the staff's review of the BWRVIP-76 report.

Final BWRVIP response:

> The BWRVIP provided a response to Issue 7 in Reference 4.

Issue 8:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 3-3 (Section 3.1.3, "Acceptance Standards for Vertical Welds") that "if the weld has been inspected using a one-sided technique and no cracking was detected then the weld is acceptable for 6 EFPY." In order to verify the weld integrity, the inspection should consist of a two-sided (ID and OD) visual examination. Whenever one-sided visual inspection was performed, the use of its results to determine the reinspection interval should be justified and discussed with the NRC staff. Also, the use of effective full power years (EFPY) as a basis to establish the reinspection interval does not correspond with NRC-approved guidelines. Determination of the acceptable operating time, wherever applicable in the subject report, should be in terms of operating hours or years, not EFPY.

The BWRVIP's May 30, 2001 response [2] stated:

> Section 2.2 of BWRVIP-63 specifies that volumetric or two-sided (ID and OD) visual exams are the only acceptable methods for satisfying the acceptance criteria contained in Section 3. This is consistent with the examination guidelines for horizontal welds contained in BWRVIP-76. The beltline region is approximately 75% of the shroud vertical welds and represents a significant two sided or volumetric examination sample. This is considered an adequate sampling to determine if any ID vertical weld cracking exists. However, in some cases a volumetric exam or two-sided visual exam is not possible due to access limitation (obstructions due to hardware, etc.) For these situations, BWRVIP-63 allows for a one-sided exam and states that a maximum EOI of 6 years is acceptable provided that no cracking is detected. If cracks are detected, a plant-specific evaluation must be performed. Therefore, based on the fact that the bulk of the inspections will be volumetric or visual from both the ID and OD, a substantial amount of weld volume will be examined using this criteria. In general, the regions where one-sided visual exams will be employed will be small compared to those examined by volumetric methods. Furthermore, if cracks are detected using one-sided visual exams, analyses must be performed to determine both the structural integrity and future inspection frequency of the vertical weld. If the evaluation performed differs from the acceptable methods described in the report, the evaluation must be submitted to the NRC for approval. Therefore, the BWRVIP believes that one-sided visual examinations are acceptable for certain situations provided that Section 2.2 of the BWRVIP-63 is followed.
>
> The BWRVIP agrees with the NRC that the reinspection intervals should be based on operating years, not EFPY. In fact, this is reflected in the BWRVIP-76 report.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff finds that, with a revision to the BWRVIP-63 report stating that a qualified two-sided EVT-1 type visual exam should encompass *essentially 100 percent* (as defined in 10 CFR 50.55a) of the inspection area, then the EOI criteria, as proposed to be modified,

established in Section 2.2 of the BWRVIP-63 report is acceptable. If a licensee cannot achieve essentially 100 percent coverage utilizing a qualified two-sided EVT-1 type visual exam, or if the licensee utilizes a one-sided EVT-1 type visual exam, then the licensee shall provide a technical justification of the proposed reinspection interval to the NRC staff. With these revisions, and the BWRVIP's agreement regarding operating years vice EFPY, the staff considers this item resolved.

Final BWRVIP response:

The staff position on vertical welds is not consistent with that of the horizontal welds where the NRC has accepted the BWRVIP position of inspecting essentially 100% of all accessible regions with a minimum of 50% in order to justify structural integrity and future reinspection intervals. The same coverage requirements have been applied to the vertical welds. A further point to make is that except for axial welds, located in the beltline region, that might receive an accumulated fluence greater than $1x10^{21}$ n/cm^2, the allowable flaw length exceeds the length of the weld. Regardless of the actual coverage achieved in excess of 50% or the level of fluence, the flaw evaluation criteria defined in BWRVIP-63 will determine if additional inspections are required for the desired period of operation. Thus, the BWRVIP believes that conservative guidance is provided in BWRVIP-63 to assess integrity of the vertical welds.

Issue 9:

The Staff's April 18, 2000, Initial SE [3] stated:

The BWRVIP-63 report states on page 3-5 (Section 3.1.3, "Radial Ring Welds") that "if the location of the welds is known (e.g., from plant drawings), then those specific locations shall be inspected from the OD of the ring." To assure complete integrity of the weld, the inspection should extend the entire length of the weld and not just the outer surface. In addition, the particular NDE technique used to detect any discontinuities within this component should be given (e.g., UT or 2-sided VT).

The BWRVIP's May 30, 2001 response [2] stated:

Inspection of radial ring welds to date has not revealed any significant cracking or structural integrity concerns. The BWRVIP is recommending that the inspection begin at the OD of the rings. If cracking is detected it is expected that additional surfaces will be examined, on an as-needed basis, as input to plant-specific structural evaluations.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

As stated in the staff findings for Issue 8, above, and the staff's April 18, 2000, initial SE, if the licensee is utilizing a visual exam, it should be a qualified two-sided (OD and ID) EVT-1 type visual exam which encompasses *essentially 100 percent* (as defined in 10 CFR 50.55a) of the inspection area. With this revision, the staff considers this item resolved.

Final BWRVIP response:

Radial ring welds have not reveal any significant cracking. Inspections are currently being performed of all accessible areas following the same approach as horizontal and vertical welds. Examination of the ring welds on the ID and bottom surface is generally impractical or not possible because there is either no access or it would require disassembly of the top guide and associated hardware. Therefore, for the same reasons as discussed in the response to Issue 8, the BWRVIP believes that the current guidance specified in BWRVIP-63 is sufficient to detect cracking in the radial ring welds.

References:

1. Letter from William H. Bateman (NRC) to Carl Terry (BWRVIP Chairman), "Final Safety Evaluation of the BWRVIP Vessel and Internals Project, Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63), EPRI Report TR-113170, June 1999 (TAC NO. MA6015)," dated August 20, 2001.
2. Letter from Carl Terry (BWRVIP Chairman) to NRC Document Control Desk, "Project 704 – BWRVIP Response to NRC Safety Evaluation of BWRVIP-63," dated May 30, 2001.
3. Letter from Jack R. Strosnider (NRC) to Carl Terry (BWRVIP Chairman), "Safety Evaluation of the BWRVIP Vessel and Internals Project, Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63), EPRI Report TR-113170, June 1999 (TAC NO. MA6015)," dated April 18, 2000.
4. Letter from Carl Terry (BWRVIP Chairman) to NRC Document Control Desk, "PROJECT NO. 704 -- BWRVIP Partial Response to the NRC Final Safety Evaluation of BWRVIP-63," dated October 22, 2002.

BWRVIP Response to Issues in NRC Final Safety Evaluation of "BWRVIP Vessel And Internals Project, Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63)," EPRI Report TR-113170, June 1999

Below are the issues identified in the NRC Final Safety Evaluation (SE) of the document entitled "Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63)," followed by the BWRVIP response to each issue. The BWRVIP proposes to incorporate staff comments and other changes, where applicable, into a revised BWRVIP-76 report.

The staff's August 20, 2001 Final SE [1] responded to Reference 2. A meeting was held at Argonne National Labs on October 29-30, 2001 to discuss the BWRVIP proposed response to the Final SE. Responses to the Final SE are provided below to document the BWRVIP positions discussed during the October 29-30, 2001 meeting.

Issue 1:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report uses the "average crack depth" as a parameter for both the inspection and flaw evaluations. The use of average crack depth in the flaw evaluation does not provide adequate conservatism and it is also not consistent with the guidance provided in the BWRVIP-07 report. As approved by the NRC staff, the maximum crack depth should be assumed to ensure a conservative result.

The BWRVIP's May 30, 2001 response [2] stated:

> There are two approaches for the application of average crack depth in BWRVIP-63 (and BWRVIP-76). One approach applies to the screening and acceptance criteria and the second approach applies when performing plant-specific flaw evaluations. These are described in more detail as follows.
>
> The screening and acceptance criteria, presented in Section 3.0 of BWRVIP-63, uses an average crack depth based on the total inspected length. This is appropriate because the models used to develop the screening and acceptance criteria (Section 4.0) are based on conservative LEFM and limit load solutions. The LEFM models assume a uniform depth flaw which is best represented by the average depth. The limit load models are based on the stress condition of the net section remaining, which is also best represented by the average depth. Additional factors of safety, consistent with existing BWRVIP inspection and flaw guidelines, are also included.
>
> The flaw evaluation criteria, presented in Appendices D and F, uses a slightly different approach for determining average crack depth based on only the cracked length, not the total inspected length. However, the guidance provided in BWRVIP-63 (and BWRVIP-76) is stated incorrectly. The BWRVIP intends to clarify only BWRVIP-76 (because BWRVIP-76 supersedes BWRVIP-63) as follows:

Appendix D (page D-1) and Appendix F (page F-11) of BWRVIP-76 presently states "The assumed crack depth in the uninspected region should be set equal to the average crack depth in the inspected region."

BWRVIP-76 should have stated "The assumed crack depth in the uninspected region should be set equal to the average depth of the observed cracks in the inspected region." In other words, the average crack depth should be based on only that portion of the weld that was inspected and found to be cracked. The average crack depth should not be computed based on inspected lengths where no cracking is detected.

The corrected pages of BWRVIP-76 are attached. Note that the example on page F-11 uses the correct crack depth.

Based on the above discussion, the BWRVIP believes that the use of maximum crack depth is excessively conservative whereas the use and application of average crack depth is technically justified and has an adequate level of conservatism.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

Based on discussions the staff has had with the BWRVIP on crack growth rate, the staff finds that, for plants utilizing effective HWC or NMCA, as defined in the staff's SE for the BWRVIP-62 report, the BWRVIP's proposed usage of assumed crack depth in the uninspected region as equal to the average depth of the observed cracks in the inspected region is acceptable. Plants with NWC should use the more conservative maximum crack depth for the uninspected regions. With this revision, the staff considers this item resolved.

Final BWRVIP response:

The BWRVIP continues to disagree with the staff on this issue. There is no information or technical rationale that would indicate cracking in uninspected regions for NWC plants is different than HWC plants. The approach used by the BWRVIP to account for differences in water chemistry is through application of the crack growth rate correlations contained in BWRVIP-14 and BWRVIP-99 for stainless steel materials. These conservative correlations were developed to account for such parameters as ECP, conductivity, stress, fluence, temperature, etc. and have been reviewed by NRC. The BWRVIP believes that use of maximum crack depth for the uninspected regions is overly conservative, regardless of water chemistry conditions. The average crack depth is employed in the screening criteria to determine which welds are to be inspected. It is also used in the acceptance criteria to determine the structural integrity of the welds. Use of maximum depth, as proposed by NRC, will require the BWRVIP to develop a completely revised screening and acceptance criteria based on maximum depth for NWC plants. The BWRVIP continues to believe that sufficient conservatism is included in the BWRVIP-63 methodology to account for the differences in water chemistry. The crack growth rates assumed in the flaw evaluation will be determined based on the water

chemistry conditions, i.e., conductivity and ECP or a stress-intensity-independent based rate will be used.

Issue 2:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 4-1 (Section 4, "Evaluation of Vertical Weld Indications") that "if through-wall cracks in vertical welds were observed during the inspection, leakage from vertical weld cracking must also be evaluated." However, the potential leakage at EOI should also be quantitatively assessed using a conservative evaluation methodology even though through-wall cracks were not detected during the inspection. Therefore, if the cracking is projected to grow through-wall, a leakage assessment should be provided. A similar statement on page 3-4 (Section 3.1.3, "Acceptance Standards for Vertical Welds") should also be revised.

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP recognizes that there is a possibility of through-wall cracking in core shrouds, however, the inspections performed to date have not revealed any through-wall cracking. Furthermore, the issue of leakage through a vertical weld has previously been evaluated. BWRVIP-01, which has been reviewed and approved by the NRC, states that "leakage through a fully cracked vertical weld has also been shown to be acceptably small." Therefore, potential leakage has been evaluated for projected or assumed through-wall flaws and is considered acceptable.
>
> The BWRVIP does believe it is necessary to quantitatively determine the leakage from an actual through-wall flaw as this may have a direct impact on core performance and on the ability to maintain reflood capability.
>
> Therefore, in summary, the BWRVIP believes that only actual through-wall cracks should be evaluated for leakage.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff agrees that actual through-wall cracks should be evaluated for leakage. In addition, if the cracking is not repaired prior to the next operating cycle and the crack is *projected* to grow through-wall, a leakage assessment should also be performed. A similar statement on page 3-4 (Section 3.1.3, "Acceptance Standards for Vertical Welds") should also be revised. With this revision, the staff considers this item closed.

Final BWRVIP response:

> The BWRVIP continues to believe that a requirement to calculate leakage from predicted through-wall cracks is an overly conservative position. Assumptions already embodied in BWRVIP-63 and BWRVIP-76 for postulating the length and depth of flaws are very conservative. These assumptions typically result in an over-predicted amount of cracking

Furthermore, although the crack growth correlations contained in BWRVIP-14 and BWRVIP-99 may predict through-wall cracks, no through-wall cracking has been detected to date in core shrouds. A prediction of through-wall cracks results is an unrealistic prediction of leakage. The BWRVIP has developed conservative methodologies to ensure that structural integrity of the core shroud and other BWR internals is maintained during operating and postulated accident conditions. Assumptions regarding through-wall cracking are invoked to address inspection limitations (i.e, cracks detected by EVT-1 must be assumed through-wall), to simplify the structural analyses and to ensure that the safety margins are robust. To further penalize an owner by requiring the assumption of leakage and potential reduction in unit rating is unwarranted.

As noted above there has been no inspection experience obtained which indicates that through-wall cracks have occurred in the vertical or horizontal core shroud welds. The inspection frequencies contained in BWRVIP-63 and BWRVIP-76 are such that any appreciable through-wall cracks will be detected well before they impact plant operation or structural integrity. The crack growth rates established for stainless steel materials (reported in BWRVIP-14 and BWRVIP-99) are conservative such that the predicted rates bound the inspection data and have added margin to account for unknowns such as weld repairs. The inspection data presented in BWRVIP-99 demonstrates that crack growth rates are slowing substantially as crack depth increases.

Core shroud circumferential welds that have been structurally placed by repair hardware do not require inspections per BWRVIP-76. The design requirement is to assume complete through-wall cracking for each circumferential weld that is structurally replaced. No additional leakage assessments are required by the BWRVIP beyond those considered in the shroud repair design. Therefore, the BWRVIP believes that the requirement to calculate leakage should be only for observed through-wall flaws.

Issue 3:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 4-2 (Section 4, "Evaluation of Vertical Weld Indications") that "K_{IC} = 150 ksi$\sqrt{in}$ based on BWRVIP-01." Elevated fluences on core shroud welds may effect the mechanical properties of the constituent structural materials. Therefore, the material toughness value may vary under high irradiated conditions. Upon availability of relevant data, a fluence threshold should be established for use of this figure in LEFM. When the fluence limit is exceeded, the use of this value should be justified and discussed with the NRC staff.

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP is presently evaluating fracture toughness properties of highly irradiated stainless steel. The BWRVIP expects to submit the results of this work to the NRC in early 2001. The results may indicate that some changes are required to existing BWRVIP guidelines for shroud inspection and flaw evaluation for highly irradiated

welds. However, in the interim, we believe the approach provided in BWRVIP-76, Section D.1.1 is acceptable for evaluating these conditions. If a different method is used by the utility, we agree that it should be justified and discussed with the NRC staff.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> Based on the above, this item remains open and will be addressed in the staff's review of the BWRVIP-76 report.

Final BWRVIP response:

> BWRVIP-100, "BWR Vessel and Internals Project, Updated Assessment of the Fracture Toughness of Irradiated Stainless Steel for BWR Core Shrouds," EPRI Technical Report 1003016, December 2001 has been submitted to NRC for review and approval. This report provides the relationship of toughness versus fluence for core shroud flaw evaluations. The BWRVIP will use the appropriate fracture toughness limits specified in BWRVIP-100 for evaluation of flaws.

Issue 4:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page B-1 (Appendix B, "Plant Specific Flaw Evaluation Methodology") that "plant-specific analysis may be required if acceptance criteria "c" of Section 3.2 .... cannot be satisfied." Section 3.1.3, "Acceptance Standards for Vertical Welds," should be the correct citation not Section 3.2, "Vertical Welds in Repaired Shrouds."

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP agrees that the citation of Section 3.2 should be corrected to Section 3.1.3.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff finds that these actions adequately addresses this open item.

Final BWRVIP response:

> No changes.

Issue 5:

The Staff's April 18, 2000, Initial SE [3] stated:

The BWRVIP-63 report states on page B-2 (Appendix B, "Plant Specific Flaw Evaluation Methodology") that "submittal to the NRC of these analyses along with the inspection results is required within 90 days of the inspection." The reporting requirements for plant- specific flaw analysis should be consistent with those expressed in the BWRVIP-76 report, which states on page 4-1 (Section 4.3, "Analytical Evaluations of Inspection Results") that the analytical results "shall be reported to the NRC within 30 days after completion of the inspection."

The BWRVIP's May 30, 2001 response [2] stated:

The BWRVIP will provide a response to Item 5 at a later date.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

Based on the above, this item remains open and will be addressed in the staff's review of the BWRVIP-76 report.

Final BWRVIP response:

The BWRVIP has developed reporting requirements which are documented in BWRVIP-94, "BWR Vessel and Internals Project, Program Implementation Guide," EPRI Technical Report 1006288, August 2001. The BWRVIP proposes to delete the specific reporting requirements from all the Inspection and Evaluation Guidelines and reference Section 3.5 of BWRVIP-94 which follows:

> Each utility will inform the NRC of any decision to not fully implement a BWRVIP guideline approved by the NRC staff within 45 days of the report approval. This applies to only those BWRVIP guidelines that have received a Final Safety Evaluation without any exceptions to the report. The NRC should be notified if changes are made to the vessel and internals program that affect implementation of BWRVIP guidelines.
>
> Inspection results and flaw evaluations for components within the scope of the BWRVIP shall be reported as described below.
>
> 1. Licensees shall forward a summary of all inspections, associated results and new repairs to the BWRVIP Program Manager within 120 days following completion of an outage.
>
> 2. Flaw evaluations performed in accordance with the guidance in BWRVIP reports for the acceptance of inspection results do not require submittal to, or approval by, the NRC.
>
> 3. Flaw evaluations that deviate from the guidance in BWRVIP reports (e.g., assumptions, methods, acceptance criteria, etc.) shall be submitted to the NRC for approval. If the flaw evaluation is later revised, the results shall be

communicated to the NRC. The submittal schedule for the analyses will be determined by the licensee and the NRC.

4. If it is determined that implementation cannot be achieved as described in the I&E guidelines, or that meaningful results are not obtained, the user shall notify the BWRVIP with sufficient details to support development of alternative actions. These notifications, as well as planned actions by the BWRVIP, will be summarized and reported to the NRC by the BWRVIP.

5. Modifications to plant operation or configurations that may affect BWRVIP guidance (e.g., power uprate) shall also be reported to the BWRVIP Program Manager.

6. Section XI of the ASME Boiler and Pressure Vessel Code contains rules for inspection, flaw evaluation and repair/replacement of certain components that are also addressed as part of the BWRVIP program. The Code requirements are detailed in Table IWB-2500, Category B-N-2, Welded Core Support Structures and Interior Attachments to Reactor Vessel. In order for BWRVIP I&E Guidelines to be used in lieu of the ASME Code requirements, each licensee must obtain relief from the Code via the process described in 10CFR50.55a. This would best be accomplished by using the technical alternative provision contained in 10CFR50.55a(a)(3)(i).

The form and format of the reporting shall be in accordance with licensee's established procedures. This may include, but is not limited to, submittal by letter or as an attachment to ASME Code required documentation (NIS-1, OAR-1, etc.).

Industry reports are necessary to share information on failure mechanisms, NDE technique applications, repair effectiveness, operating experience, and other items. This experience is shared through the BWRVIP and member utilities. Member utilities agree to share results of assessments outlined in Section 3.4 with the BWRVIP. Deviations from BWRVIP guidance approved by the NRC and documented in accordance with Appendix A shall also be shared with the BWRVIP.

The BWRVIP is also developing a standard template for licensees to follow for submitting a technical alternative to use the BWRVIP I&E Guidelines in lieu of the ASME Code requirements.

Issue 6:

The Staff's April 18, 2000, Initial SE [3] stated:

> The effect of neutron fluence level on the crack growth rate should be consistent with that discussed in the BWRVIP-07 report. When the fluence level exceeds $5x10^{20}n/cm^2$, the appropriate crack growth rate to be used in the flaw evaluation should be discussed with and approved by the NRC staff.

The BWRVIP's May 30, 2001 response [2] stated:

> Until such time as the BWRVIP submits a crack growth evaluation for highly irradiated stainless steel, we agree that when the fluence level exceeds $5x10^{20}$ n/cm^2, the appropriate crack growth rate to be used in plant-specific flaw evaluations will be provided to NRC for concurrence.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff finds that this response adequately addresses this open item.

Final BWRVIP response:

> "BWRVIP-99: BWR Vessel and Internals Project, Crack Growth Rates in Irradiated Stainless Steels in BWR Internal Components," EPRI Technical Report 1003018, December 2001 has been submitted to the NRC for review and approval. The report provides the crack growth rates for stainless steel in the fluence range of $5x10^{20}$ n/cm^2 up to $3x10^{21}$ n/cm^2. The BWRVIP will use the appropriate correlation in this report for evaluation of stainless steel materials subjected to the specified fluence range.

Issue 7:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 3-1(Section 3, "Inspection Recommendations") that "NDE uncertainty does not need to be considered since it is adequately covered by conservatisms in the flaw evaluation methods." BWRVIP-member utilities must determine the measurement uncertainty associated with NDE techniques to be used for inspection of the reactor vessel components consistent with the methodology specified in the BWRVIP-03 report (Section 2.3 "Guidelines for Determining NDE Technique Uncertainty") as approved by the NRC staff, and include the measurement uncertainties in the flaw evaluation consistent with guidance in the BWRVIP-07 report.

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP will provide a response to Item 7 at a later date.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> Based on the above, this item remains open and will be addressed in the staff's review of the BWRVIP-76 report.

Final BWRVIP response:

> The BWRVIP provided a response to Issue 7 in Reference 4.

Issue 8:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 3-3 (Section 3.1.3, "Acceptance Standards for Vertical Welds") that "if the weld has been inspected using a one-sided technique and no cracking was detected then the weld is acceptable for 6 EFPY." In order to verify the weld integrity, the inspection should consist of a two-sided (ID and OD) visual examination. Whenever one-sided visual inspection was performed, the use of its results to determine the reinspection interval should be justified and discussed with the NRC staff. Also, the use of effective full power years (EFPY) as a basis to establish the reinspection interval does not correspond with NRC-approved guidelines. Determination of the acceptable operating time, wherever applicable in the subject report, should be in terms of operating hours or years, not EFPY.

The BWRVIP's May 30, 2001 response [2] stated:

> Section 2.2 of BWRVIP-63 specifies that volumetric or two-sided (ID and OD) visual exams are the only acceptable methods for satisfying the acceptance criteria contained in Section 3. This is consistent with the examination guidelines for horizontal welds contained in BWRVIP-76. The beltline region is approximately 75% of the shroud vertical welds and represents a significant two sided or volumetric examination sample. This is considered an adequate sampling to determine if any ID vertical weld cracking exists. However, in some cases a volumetric exam or two-sided visual exam is not possible due to access limitation (obstructions due to hardware, etc.) For these situations, BWRVIP-63 allows for a one-sided exam and states that a maximum EOI of 6 years is acceptable provided that no cracking is detected. If cracks are detected, a plant-specific evaluation must be performed. Therefore, based on the fact that the bulk of the inspections will be volumetric or visual from both the ID and OD, a substantial amount of weld volume will be examined using this criteria. In general, the regions where one-sided visual exams will be employed will be small compared to those examined by volumetric methods. Furthermore, if cracks are detected using one-sided visual exams, analyses must be performed to determine both the structural integrity and future inspection frequency of the vertical weld. If the evaluation performed differs from the acceptable methods described in the report, the evaluation must be submitted to the NRC for approval. Therefore, the BWRVIP believes that one-sided visual examinations are acceptable for certain situations provided that Section 2.2 of the BWRVIP-63 is followed.
>
> The BWRVIP agrees with the NRC that the reinspection intervals should be based on operating years, not EFPY. In fact, this is reflected in the BWRVIP-76 report.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff finds that, with a revision to the BWRVIP-63 report stating that a qualified two-sided EVT-1 type visual exam should encompass *essentially 100 percent* (as defined in 10 CFR 50.55a) of the inspection area, then the EOI criteria, as proposed to be modified,

established in Section 2.2 of the BWRVIP-63 report is acceptable. If a licensee cannot achieve essentially 100 percent coverage utilizing a qualified two-sided EVT-1 type visual exam, or if the licensee utilizes a one-sided EVT-1 type visual exam, then the licensee shall provide a technical justification of the proposed reinspection interval to the NRC staff. With these revisions, and the BWRVIP's agreement regarding operating years vice EFPY, the staff considers this item resolved.

Final BWRVIP response:

The staff position on vertical welds is not consistent with that of the horizontal welds where the NRC has accepted the BWRVIP position of inspecting essentially 100% of all accessible regions with a minimum of 50% in order to justify structural integrity and future reinspection intervals. The same coverage requirements have been applied to the vertical welds. A further point to make is that except for axial welds, located in the beltline region, that might receive an accumulated fluence greater than $1x10^{21}$ n/cm^2, the allowable flaw length exceeds the length of the weld. Regardless of the actual coverage achieved in excess of 50% or the level of fluence, the flaw evaluation criteria defined in BWRVIP-63 will determine if additional inspections are required for the desired period of operation. Thus, the BWRVIP believes that conservative guidance is provided in BWRVIP-63 to assess integrity of the vertical welds.

Issue 9:

The Staff's April 18, 2000, Initial SE [3] stated:

The BWRVIP-63 report states on page 3-5 (Section 3.1.3, "Radial Ring Welds") that "if the location of the welds is known (e.g., from plant drawings), then those specific locations shall be inspected from the OD of the ring." To assure complete integrity of the weld, the inspection should extend the entire length of the weld and not just the outer surface. In addition, the particular NDE technique used to detect any discontinuities within this component should be given (e.g., UT or 2-sided VT).

The BWRVIP's May 30, 2001 response [2] stated:

Inspection of radial ring welds to date has not revealed any significant cracking or structural integrity concerns. The BWRVIP is recommending that the inspection begin at the OD of the rings. If cracking is detected it is expected that additional surfaces will be examined, on an as-needed basis, as input to plant-specific structural evaluations.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

As stated in the staff findings for Issue 8, above, and the staff's April 18, 2000, initial SE, if the licensee is utilizing a visual exam, it should be a qualified two-sided (OD and ID) EVT-1 type visual exam which encompasses *essentially 100 percent* (as defined in 10 CFR 50.55a) of the inspection area. With this revision, the staff considers this item resolved.

Final BWRVIP response:

Radial ring welds have not reveal any significant cracking. Inspections are currently being performed of all accessible areas following the same approach as horizontal and vertical welds. Examination of the ring welds on the ID and bottom surface is generally impractical or not possible because there is either no access or it would require disassembly of the top guide and associated hardware. Therefore, for the same reasons as discussed in the response to Issue 8, the BWRVIP believes that the current guidance specified in BWRVIP-63 is sufficient to detect cracking in the radial ring welds.

References:

1. Letter from William H. Bateman (NRC) to Carl Terry (BWRVIP Chairman), "Final Safety Evaluation of the BWRVIP Vessel and Internals Project, Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63), EPRI Report TR-113170, June 1999 (TAC NO. MA6015)," dated August 20, 2001.
2. Letter from Carl Terry (BWRVIP Chairman) to NRC Document Control Desk, "Project 704 – BWRVIP Response to NRC Safety Evaluation of BWRVIP-63," dated May 30, 2001.
3. Letter from Jack R. Strosnider (NRC) to Carl Terry (BWRVIP Chairman), "Safety Evaluation of the BWRVIP Vessel and Internals Project, Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63), EPRI Report TR-113170, June 1999 (TAC NO. MA6015)," dated April 18, 2000.
4. Letter from Carl Terry (BWRVIP Chairman) to NRC Document Control Desk, "PROJECT NO. 704 -- BWRVIP Partial Response to the NRC Final Safety Evaluation of BWRVIP-63," dated October 22, 2002.

BWRVIP Response to Issues in NRC Final Safety Evaluation of "BWRVIP Vessel And Internals Project, Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63)," EPRI Report TR-113170, June 1999

Below are the issues identified in the NRC Final Safety Evaluation (SE) of the document entitled "Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63)," followed by the BWRVIP response to each issue. The BWRVIP proposes to incorporate staff comments and other changes, where applicable, into a revised BWRVIP-76 report.

The staff's August 20, 2001 Final SE [1] responded to Reference 2. A meeting was held at Argonne National Labs on October 29-30, 2001 to discuss the BWRVIP proposed response to the Final SE. Responses to the Final SE are provided below to document the BWRVIP positions discussed during the October 29-30, 2001 meeting.

Issue 1:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report uses the "average crack depth" as a parameter for both the inspection and flaw evaluations. The use of average crack depth in the flaw evaluation does not provide adequate conservatism and it is also not consistent with the guidance provided in the BWRVIP-07 report. As approved by the NRC staff, the maximum crack depth should be assumed to ensure a conservative result.

The BWRVIP's May 30, 2001 response [2] stated:

> There are two approaches for the application of average crack depth in BWRVIP-63 (and BWRVIP-76). One approach applies to the screening and acceptance criteria and the second approach applies when performing plant-specific flaw evaluations. These are described in more detail as follows.
>
> The screening and acceptance criteria, presented in Section 3.0 of BWRVIP-63, uses an average crack depth based on the total inspected length. This is appropriate because the models used to develop the screening and acceptance criteria (Section 4.0) are based on conservative LEFM and limit load solutions. The LEFM models assume a uniform depth flaw which is best represented by the average depth. The limit load models are based on the stress condition of the net section remaining, which is also best represented by the average depth. Additional factors of safety, consistent with existing BWRVIP inspection and flaw guidelines, are also included.
>
> The flaw evaluation criteria, presented in Appendices D and F, uses a slightly different approach for determining average crack depth based on only the cracked length, not the total inspected length. However, the guidance provided in BWRVIP-63 (and BWRVIP-76) is stated incorrectly. The BWRVIP intends to clarify only BWRVIP-76 (because BWRVIP-76 supersedes BWRVIP-63) as follows:

Appendix D (page D-1) and Appendix F (page F-11) of BWRVIP-76 presently states "The assumed crack depth in the uninspected region should be set equal to the average crack depth in the inspected region."

BWRVIP-76 should have stated "The assumed crack depth in the uninspected region should be set equal to the average depth of the observed cracks in the inspected region." In other words, the average crack depth should be based on only that portion of the weld that was inspected and found to be cracked. The average crack depth should not be computed based on inspected lengths where no cracking is detected.

The corrected pages of BWRVIP-76 are attached. Note that the example on page F-11 uses the correct crack depth.

Based on the above discussion, the BWRVIP believes that the use of maximum crack depth is excessively conservative whereas the use and application of average crack depth is technically justified and has an adequate level of conservatism.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

Based on discussions the staff has had with the BWRVIP on crack growth rate, the staff finds that, for plants utilizing effective HWC or NMCA, as defined in the staff's SE for the BWRVIP-62 report, the BWRVIP's proposed usage of assumed crack depth in the uninspected region as equal to the average depth of the observed cracks in the inspected region is acceptable. Plants with NWC should use the more conservative maximum crack depth for the uninspected regions. With this revision, the staff considers this item resolved.

Final BWRVIP response:

The BWRVIP continues to disagree with the staff on this issue. There is no information or technical rationale that would indicate cracking in uninspected regions for NWC plants is different than HWC plants. The approach used by the BWRVIP to account for differences in water chemistry is through application of the crack growth rate correlations contained in BWRVIP-14 and BWRVIP-99 for stainless steel materials. These conservative correlations were developed to account for such parameters as ECP, conductivity, stress, fluence, temperature, etc. and have been reviewed by NRC. The BWRVIP believes that use of maximum crack depth for the uninspected regions is overly conservative, regardless of water chemistry conditions. The average crack depth is employed in the screening criteria to determine which welds are to be inspected. It is also used in the acceptance criteria to determine the structural integrity of the welds. Use of maximum depth, as proposed by NRC, will require the BWRVIP to develop a completely revised screening and acceptance criteria based on maximum depth for NWC plants. The BWRVIP continues to believe that sufficient conservatism is included in the BWRVIP-63 methodology to account for the differences in water chemistry. The crack growth rates assumed in the flaw evaluation will be determined based on the water

chemistry conditions, i.e., conductivity and ECP or a stress-intensity-independent based rate will be used.

Issue 2:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 4-1 (Section 4, "Evaluation of Vertical Weld Indications") that "if through-wall cracks in vertical welds were observed during the inspection, leakage from vertical weld cracking must also be evaluated." However, the potential leakage at EOI should also be quantitatively assessed using a conservative evaluation methodology even though through-wall cracks were not detected during the inspection. Therefore, if the cracking is projected to grow through-wall, a leakage assessment should be provided. A similar statement on page 3-4 (Section 3.1.3, "Acceptance Standards for Vertical Welds") should also be revised.

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP recognizes that there is a possibility of through-wall cracking in core shrouds, however, the inspections performed to date have not revealed any through-wall cracking. Furthermore, the issue of leakage through a vertical weld has previously been evaluated. BWRVIP-01, which has been reviewed and approved by the NRC, states that "leakage through a fully cracked vertical weld has also been shown to be acceptably small." Therefore, potential leakage has been evaluated for projected or assumed through-wall flaws and is considered acceptable.
>
> The BWRVIP does believe it is necessary to quantitatively determine the leakage from an actual through-wall flaw as this may have a direct impact on core performance and on the ability to maintain reflood capability.
>
> Therefore, in summary, the BWRVIP believes that only actual through-wall cracks should be evaluated for leakage.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff agrees that actual through-wall cracks should be evaluated for leakage. In addition, if the cracking is not repaired prior to the next operating cycle and the crack is *projected* to grow through-wall, a leakage assessment should also be performed. A similar statement on page 3-4 (Section 3.1.3, "Acceptance Standards for Vertical Welds") should also be revised. With this revision, the staff considers this item closed.

Final BWRVIP response:

> The BWRVIP continues to believe that a requirement to calculate leakage from predicted through-wall cracks is an overly conservative position. Assumptions already embodied in BWRVIP-63 and BWRVIP-76 for postulating the length and depth of flaws are very conservative. These assumptions typically result in an over-predicted amount of cracking

Furthermore, although the crack growth correlations contained in BWRVIP-14 and BWRVIP-99 may predict through-wall cracks, no through-wall cracking has been detected to date in core shrouds. A prediction of through-wall cracks results is an unrealistic prediction of leakage. The BWRVIP has developed conservative methodologies to ensure that structural integrity of the core shroud and other BWR internals is maintained during operating and postulated accident conditions. Assumptions regarding through-wall cracking are invoked to address inspection limitations (i.e, cracks detected by EVT-1 must be assumed through-wall), to simplify the structural analyses and to ensure that the safety margins are robust. To further penalize an owner by requiring the assumption of leakage and potential reduction in unit rating is unwarranted.

As noted above there has been no inspection experience obtained which indicates that through-wall cracks have occurred in the vertical or horizontal core shroud welds. The inspection frequencies contained in BWRVIP-63 and BWRVIP-76 are such that any appreciable through-wall cracks will be detected well before they impact plant operation or structural integrity. The crack growth rates established for stainless steel materials (reported in BWRVIP-14 and BWRVIP-99) are conservative such that the predicted rates bound the inspection data and have added margin to account for unknowns such as weld repairs. The inspection data presented in BWRVIP-99 demonstrates that crack growth rates are slowing substantially as crack depth increases.

Core shroud circumferential welds that have been structurally placed by repair hardware do not require inspections per BWRVIP-76. The design requirement is to assume complete through-wall cracking for each circumferential weld that is structurally replaced. No additional leakage assessments are required by the BWRVIP beyond those considered in the shroud repair design. Therefore, the BWRVIP believes that the requirement to calculate leakage should be only for observed through-wall flaws.

Issue 3:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 4-2 (Section 4, "Evaluation of Vertical Weld Indications") that "K_{IC} = 150 ksi$\sqrt{in}$ based on BWRVIP-01." Elevated fluences on core shroud welds may effect the mechanical properties of the constituent structural materials. Therefore, the material toughness value may vary under high irradiated conditions. Upon availability of relevant data, a fluence threshold should be established for use of this figure in LEFM. When the fluence limit is exceeded, the use of this value should be justified and discussed with the NRC staff.

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP is presently evaluating fracture toughness properties of highly irradiated stainless steel. The BWRVIP expects to submit the results of this work to the NRC in early 2001. The results may indicate that some changes are required to existing BWRVIP guidelines for shroud inspection and flaw evaluation for highly irradiated

welds. However, in the interim, we believe the approach provided in BWRVIP-76, Section D.1.1 is acceptable for evaluating these conditions. If a different method is used by the utility, we agree that it should be justified and discussed with the NRC staff.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> Based on the above, this item remains open and will be addressed in the staff's review of the BWRVIP-76 report.

Final BWRVIP response:

> BWRVIP-100, "BWR Vessel and Internals Project, Updated Assessment of the Fracture Toughness of Irradiated Stainless Steel for BWR Core Shrouds," EPRI Technical Report 1003016, December 2001 has been submitted to NRC for review and approval. This report provides the relationship of toughness versus fluence for core shroud flaw evaluations. The BWRVIP will use the appropriate fracture toughness limits specified in BWRVIP-100 for evaluation of flaws.

Issue 4:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page B-1 (Appendix B, "Plant Specific Flaw Evaluation Methodology") that "plant-specific analysis may be required if acceptance criteria "c" of Section 3.2 .... cannot be satisfied." Section 3.1.3, "Acceptance Standards for Vertical Welds," should be the correct citation not Section 3.2, "Vertical Welds in Repaired Shrouds."

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP agrees that the citation of Section 3.2 should be corrected to Section 3.1.3.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff finds that these actions adequately addresses this open item.

Final BWRVIP response:

> No changes.

Issue 5:

The Staff's April 18, 2000, Initial SE [3] stated:

The BWRVIP-63 report states on page B-2 (Appendix B, "Plant Specific Flaw Evaluation Methodology") that "submittal to the NRC of these analyses along with the inspection results is required within 90 days of the inspection." The reporting requirements for plant- specific flaw analysis should be consistent with those expressed in the BWRVIP-76 report, which states on page 4-1 (Section 4.3, "Analytical Evaluations of Inspection Results") that the analytical results "shall be reported to the NRC within 30 days after completion of the inspection."

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP will provide a response to Item 5 at a later date.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> Based on the above, this item remains open and will be addressed in the staff's review of the BWRVIP-76 report.

Final BWRVIP response:

> The BWRVIP has developed reporting requirements which are documented in BWRVIP-94, "BWR Vessel and Internals Project, Program Implementation Guide," EPRI Technical Report 1006288, August 2001. The BWRVIP proposes to delete the specific reporting requirements from all the Inspection and Evaluation Guidelines and reference Section 3.5 of BWRVIP-94 which follows:
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>> Each utility will inform the NRC of any decision to not fully implement a BWRVIP guideline approved by the NRC staff within 45 days of the report approval. This applies to only those BWRVIP guidelines that have received a Final Safety Evaluation without any exceptions to the report. The NRC should be notified if changes are made to the vessel and internals program that affect implementation of BWRVIP guidelines.
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>> Inspection results and flaw evaluations for components within the scope of the BWRVIP shall be reported as described below.
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>> 1. Licensees shall forward a summary of all inspections, associated results and new repairs to the BWRVIP Program Manager within 120 days following completion of an outage.
>>
>> 2. Flaw evaluations performed in accordance with the guidance in BWRVIP reports for the acceptance of inspection results do not require submittal to, or approval by, the NRC.
>>
>> 3. Flaw evaluations that deviate from the guidance in BWRVIP reports (e.g., assumptions, methods, acceptance criteria, etc.) shall be submitted to the NRC for approval. If the flaw evaluation is later revised, the results shall be

communicated to the NRC. The submittal schedule for the analyses will be determined by the licensee and the NRC.

4. If it is determined that implementation cannot be achieved as described in the I&E guidelines, or that meaningful results are not obtained, the user shall notify the BWRVIP with sufficient details to support development of alternative actions. These notifications, as well as planned actions by the BWRVIP, will be summarized and reported to the NRC by the BWRVIP.

5. Modifications to plant operation or configurations that may affect BWRVIP guidance (e.g., power uprate) shall also be reported to the BWRVIP Program Manager.

6. Section XI of the ASME Boiler and Pressure Vessel Code contains rules for inspection, flaw evaluation and repair/replacement of certain components that are also addressed as part of the BWRVIP program. The Code requirements are detailed in Table IWB-2500, Category B-N-2, Welded Core Support Structures and Interior Attachments to Reactor Vessel. In order for BWRVIP I&E Guidelines to be used in lieu of the ASME Code requirements, each licensee must obtain relief from the Code via the process described in 10CFR50.55a. This would best be accomplished by using the technical alternative provision contained in 10CFR50.55a(a)(3)(i).

The form and format of the reporting shall be in accordance with licensee's established procedures. This may include, but is not limited to, submittal by letter or as an attachment to ASME Code required documentation (NIS-1, OAR-1, etc.).

Industry reports are necessary to share information on failure mechanisms, NDE technique applications, repair effectiveness, operating experience, and other items. This experience is shared through the BWRVIP and member utilities. Member utilities agree to share results of assessments outlined in Section 3.4 with the BWRVIP. Deviations from BWRVIP guidance approved by the NRC and documented in accordance with Appendix A shall also be shared with the BWRVIP.

The BWRVIP is also developing a standard template for licensees to follow for submitting a technical alternative to use the BWRVIP I&E Guidelines in lieu of the ASME Code requirements.

Issue 6:

The Staff's April 18, 2000, Initial SE [3] stated:

> The effect of neutron fluence level on the crack growth rate should be consistent with that discussed in the BWRVIP-07 report. When the fluence level exceeds $5x10^{20}n/cm^2$, the appropriate crack growth rate to be used in the flaw evaluation should be discussed with and approved by the NRC staff.

The BWRVIP's May 30, 2001 response [2] stated:

> Until such time as the BWRVIP submits a crack growth evaluation for highly irradiated stainless steel, we agree that when the fluence level exceeds $5x10^{20}$ n/cm^2, the appropriate crack growth rate to be used in plant-specific flaw evaluations will be provided to NRC for concurrence.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff finds that this response adequately addresses this open item.

Final BWRVIP response:

> "BWRVIP-99: BWR Vessel and Internals Project, Crack Growth Rates in Irradiated Stainless Steels in BWR Internal Components," EPRI Technical Report 1003018, December 2001 has been submitted to the NRC for review and approval. The report provides the crack growth rates for stainless steel in the fluence range of $5x10^{20}$ n/cm^2 up to $3x10^{21}$ n/cm^2. The BWRVIP will use the appropriate correlation in this report for evaluation of stainless steel materials subjected to the specified fluence range.

Issue 7:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 3-1(Section 3, "Inspection Recommendations") that "NDE uncertainty does not need to be considered since it is adequately covered by conservatisms in the flaw evaluation methods." BWRVIP-member utilities must determine the measurement uncertainty associated with NDE techniques to be used for inspection of the reactor vessel components consistent with the methodology specified in the BWRVIP-03 report (Section 2.3 "Guidelines for Determining NDE Technique Uncertainty") as approved by the NRC staff, and include the measurement uncertainties in the flaw evaluation consistent with guidance in the BWRVIP-07 report.

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP will provide a response to Item 7 at a later date.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> Based on the above, this item remains open and will be addressed in the staff's review of the BWRVIP-76 report.

Final BWRVIP response:

> The BWRVIP provided a response to Issue 7 in Reference 4.

Issue 8:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 3-3 (Section 3.1.3, "Acceptance Standards for Vertical Welds") that "if the weld has been inspected using a one-sided technique and no cracking was detected then the weld is acceptable for 6 EFPY." In order to verify the weld integrity, the inspection should consist of a two-sided (ID and OD) visual examination. Whenever one-sided visual inspection was performed, the use of its results to determine the reinspection interval should be justified and discussed with the NRC staff. Also, the use of effective full power years (EFPY) as a basis to establish the reinspection interval does not correspond with NRC-approved guidelines. Determination of the acceptable operating time, wherever applicable in the subject report, should be in terms of operating hours or years, not EFPY.

The BWRVIP's May 30, 2001 response [2] stated:

> Section 2.2 of BWRVIP-63 specifies that volumetric or two-sided (ID and OD) visual exams are the only acceptable methods for satisfying the acceptance criteria contained in Section 3. This is consistent with the examination guidelines for horizontal welds contained in BWRVIP-76. The beltline region is approximately 75% of the shroud vertical welds and represents a significant two sided or volumetric examination sample. This is considered an adequate sampling to determine if any ID vertical weld cracking exists. However, in some cases a volumetric exam or two-sided visual exam is not possible due to access limitation (obstructions due to hardware, etc.) For these situations, BWRVIP-63 allows for a one-sided exam and states that a maximum EOI of 6 years is acceptable provided that no cracking is detected. If cracks are detected, a plant-specific evaluation must be performed. Therefore, based on the fact that the bulk of the inspections will be volumetric or visual from both the ID and OD, a substantial amount of weld volume will be examined using this criteria. In general, the regions where one-sided visual exams will be employed will be small compared to those examined by volumetric methods. Furthermore, if cracks are detected using one-sided visual exams, analyses must be performed to determine both the structural integrity and future inspection frequency of the vertical weld. If the evaluation performed differs from the acceptable methods described in the report, the evaluation must be submitted to the NRC for approval. Therefore, the BWRVIP believes that one-sided visual examinations are acceptable for certain situations provided that Section 2.2 of the BWRVIP-63 is followed.
>
> The BWRVIP agrees with the NRC that the reinspection intervals should be based on operating years, not EFPY. In fact, this is reflected in the BWRVIP-76 report.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff finds that, with a revision to the BWRVIP-63 report stating that a qualified two-sided EVT-1 type visual exam should encompass *essentially 100 percent* (as defined in 10 CFR 50.55a) of the inspection area, then the EOI criteria, as proposed to be modified,

established in Section 2.2 of the BWRVIP-63 report is acceptable. If a licensee cannot achieve essentially 100 percent coverage utilizing a qualified two-sided EVT-1 type visual exam, or if the licensee utilizes a one-sided EVT-1 type visual exam, then the licensee shall provide a technical justification of the proposed reinspection interval to the NRC staff. With these revisions, and the BWRVIP's agreement regarding operating years vice EFPY, the staff considers this item resolved.

Final BWRVIP response:

The staff position on vertical welds is not consistent with that of the horizontal welds where the NRC has accepted the BWRVIP position of inspecting essentially 100% of all accessible regions with a minimum of 50% in order to justify structural integrity and future reinspection intervals. The same coverage requirements have been applied to the vertical welds. A further point to make is that except for axial welds, located in the beltline region, that might receive an accumulated fluence greater than $1x10^{21}$ n/cm^2, the allowable flaw length exceeds the length of the weld. Regardless of the actual coverage achieved in excess of 50% or the level of fluence, the flaw evaluation criteria defined in BWRVIP-63 will determine if additional inspections are required for the desired period of operation. Thus, the BWRVIP believes that conservative guidance is provided in BWRVIP-63 to assess integrity of the vertical welds.

Issue 9:

The Staff's April 18, 2000, Initial SE [3] stated:

The BWRVIP-63 report states on page 3-5 (Section 3.1.3, "Radial Ring Welds") that "if the location of the welds is known (e.g., from plant drawings), then those specific locations shall be inspected from the OD of the ring." To assure complete integrity of the weld, the inspection should extend the entire length of the weld and not just the outer surface. In addition, the particular NDE technique used to detect any discontinuities within this component should be given (e.g., UT or 2-sided VT).

The BWRVIP's May 30, 2001 response [2] stated:

Inspection of radial ring welds to date has not revealed any significant cracking or structural integrity concerns. The BWRVIP is recommending that the inspection begin at the OD of the rings. If cracking is detected it is expected that additional surfaces will be examined, on an as-needed basis, as input to plant-specific structural evaluations.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

As stated in the staff findings for Issue 8, above, and the staff's April 18, 2000, initial SE, if the licensee is utilizing a visual exam, it should be a qualified two-sided (OD and ID) EVT-1 type visual exam which encompasses *essentially 100 percent* (as defined in 10 CFR 50.55a) of the inspection area. With this revision, the staff considers this item resolved.

Final BWRVIP response:

Radial ring welds have not reveal any significant cracking. Inspections are currently being performed of all accessible areas following the same approach as horizontal and vertical welds. Examination of the ring welds on the ID and bottom surface is generally impractical or not possible because there is either no access or it would require disassembly of the top guide and associated hardware. Therefore, for the same reasons as discussed in the response to Issue 8, the BWRVIP believes that the current guidance specified in BWRVIP-63 is sufficient to detect cracking in the radial ring welds.

References:

1. Letter from William H. Bateman (NRC) to Carl Terry (BWRVIP Chairman), "Final Safety Evaluation of the BWRVIP Vessel and Internals Project, Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63), EPRI Report TR-113170, June 1999 (TAC NO. MA6015)," dated August 20, 2001.
2. Letter from Carl Terry (BWRVIP Chairman) to NRC Document Control Desk, "Project 704 – BWRVIP Response to NRC Safety Evaluation of BWRVIP-63," dated May 30, 2001.
3. Letter from Jack R. Strosnider (NRC) to Carl Terry (BWRVIP Chairman), "Safety Evaluation of the BWRVIP Vessel and Internals Project, Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63), EPRI Report TR-113170, June 1999 (TAC NO. MA6015)," dated April 18, 2000.
4. Letter from Carl Terry (BWRVIP Chairman) to NRC Document Control Desk, "PROJECT NO. 704 -- BWRVIP Partial Response to the NRC Final Safety Evaluation of BWRVIP-63," dated October 22, 2002.

BWRVIP Response to Issues in NRC Final Safety Evaluation of "BWRVIP Vessel And Internals Project, Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63)," EPRI Report TR-113170, June 1999

Below are the issues identified in the NRC Final Safety Evaluation (SE) of the document entitled "Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63)," followed by the BWRVIP response to each issue. The BWRVIP proposes to incorporate staff comments and other changes, where applicable, into a revised BWRVIP-76 report.

The staff's August 20, 2001 Final SE [1] responded to Reference 2. A meeting was held at Argonne National Labs on October 29-30, 2001 to discuss the BWRVIP proposed response to the Final SE. Responses to the Final SE are provided below to document the BWRVIP positions discussed during the October 29-30, 2001 meeting.

Issue 1:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report uses the "average crack depth" as a parameter for both the inspection and flaw evaluations. The use of average crack depth in the flaw evaluation does not provide adequate conservatism and it is also not consistent with the guidance provided in the BWRVIP-07 report. As approved by the NRC staff, the maximum crack depth should be assumed to ensure a conservative result.

The BWRVIP's May 30, 2001 response [2] stated:

> There are two approaches for the application of average crack depth in BWRVIP-63 (and BWRVIP-76). One approach applies to the screening and acceptance criteria and the second approach applies when performing plant-specific flaw evaluations. These are described in more detail as follows.
>
> The screening and acceptance criteria, presented in Section 3.0 of BWRVIP-63, uses an average crack depth based on the total inspected length. This is appropriate because the models used to develop the screening and acceptance criteria (Section 4.0) are based on conservative LEFM and limit load solutions. The LEFM models assume a uniform depth flaw which is best represented by the average depth. The limit load models are based on the stress condition of the net section remaining, which is also best represented by the average depth. Additional factors of safety, consistent with existing BWRVIP inspection and flaw guidelines, are also included.
>
> The flaw evaluation criteria, presented in Appendices D and F, uses a slightly different approach for determining average crack depth based on only the cracked length, not the total inspected length. However, the guidance provided in BWRVIP-63 (and BWRVIP-76) is stated incorrectly. The BWRVIP intends to clarify only BWRVIP-76 (because BWRVIP-76 supersedes BWRVIP-63) as follows:

Appendix D (page D-1) and Appendix F (page F-11) of BWRVIP-76 presently states "The assumed crack depth in the uninspected region should be set equal to the average crack depth in the inspected region."

BWRVIP-76 should have stated "The assumed crack depth in the uninspected region should be set equal to the average depth of the observed cracks in the inspected region." In other words, the average crack depth should be based on only that portion of the weld that was inspected and found to be cracked. The average crack depth should not be computed based on inspected lengths where no cracking is detected.

The corrected pages of BWRVIP-76 are attached. Note that the example on page F-11 uses the correct crack depth.

Based on the above discussion, the BWRVIP believes that the use of maximum crack depth is excessively conservative whereas the use and application of average crack depth is technically justified and has an adequate level of conservatism.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

Based on discussions the staff has had with the BWRVIP on crack growth rate, the staff finds that, for plants utilizing effective HWC or NMCA, as defined in the staff's SE for the BWRVIP-62 report, the BWRVIP's proposed usage of assumed crack depth in the uninspected region as equal to the average depth of the observed cracks in the inspected region is acceptable. Plants with NWC should use the more conservative maximum crack depth for the uninspected regions. With this revision, the staff considers this item resolved.

Final BWRVIP response:

The BWRVIP continues to disagree with the staff on this issue. There is no information or technical rationale that would indicate cracking in uninspected regions for NWC plants is different than HWC plants. The approach used by the BWRVIP to account for differences in water chemistry is through application of the crack growth rate correlations contained in BWRVIP-14 and BWRVIP-99 for stainless steel materials. These conservative correlations were developed to account for such parameters as ECP, conductivity, stress, fluence, temperature, etc. and have been reviewed by NRC. The BWRVIP believes that use of maximum crack depth for the uninspected regions is overly conservative, regardless of water chemistry conditions. The average crack depth is employed in the screening criteria to determine which welds are to be inspected. It is also used in the acceptance criteria to determine the structural integrity of the welds. Use of maximum depth, as proposed by NRC, will require the BWRVIP to develop a completely revised screening and acceptance criteria based on maximum depth for NWC plants. The BWRVIP continues to believe that sufficient conservatism is included in the BWRVIP-63 methodology to account for the differences in water chemistry. The crack growth rates assumed in the flaw evaluation will be determined based on the water

chemistry conditions, i.e., conductivity and ECP or a stress-intensity-independent based rate will be used.

Issue 2:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 4-1 (Section 4, "Evaluation of Vertical Weld Indications") that "if through-wall cracks in vertical welds were observed during the inspection, leakage from vertical weld cracking must also be evaluated." However, the potential leakage at EOI should also be quantitatively assessed using a conservative evaluation methodology even though through-wall cracks were not detected during the inspection. Therefore, if the cracking is projected to grow through-wall, a leakage assessment should be provided. A similar statement on page 3-4 (Section 3.1.3, "Acceptance Standards for Vertical Welds") should also be revised.

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP recognizes that there is a possibility of through-wall cracking in core shrouds, however, the inspections performed to date have not revealed any through-wall cracking. Furthermore, the issue of leakage through a vertical weld has previously been evaluated. BWRVIP-01, which has been reviewed and approved by the NRC, states that "leakage through a fully cracked vertical weld has also been shown to be acceptably small." Therefore, potential leakage has been evaluated for projected or assumed through-wall flaws and is considered acceptable.
>
> The BWRVIP does believe it is necessary to quantitatively determine the leakage from an actual through-wall flaw as this may have a direct impact on core performance and on the ability to maintain reflood capability.
>
> Therefore, in summary, the BWRVIP believes that only actual through-wall cracks should be evaluated for leakage.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff agrees that actual through-wall cracks should be evaluated for leakage. In addition, if the cracking is not repaired prior to the next operating cycle and the crack is *projected* to grow through-wall, a leakage assessment should also be performed. A similar statement on page 3-4 (Section 3.1.3, "Acceptance Standards for Vertical Welds") should also be revised. With this revision, the staff considers this item closed.

Final BWRVIP response:

> The BWRVIP continues to believe that a requirement to calculate leakage from predicted through-wall cracks is an overly conservative position. Assumptions already embodied in BWRVIP-63 and BWRVIP-76 for postulating the length and depth of flaws are very conservative. These assumptions typically result in an over-predicted amount of cracking

Furthermore, although the crack growth correlations contained in BWRVIP-14 and BWRVIP-99 may predict through-wall cracks, no through-wall cracking has been detected to date in core shrouds. A prediction of through-wall cracks results is an unrealistic prediction of leakage. The BWRVIP has developed conservative methodologies to ensure that structural integrity of the core shroud and other BWR internals is maintained during operating and postulated accident conditions. Assumptions regarding through-wall cracking are invoked to address inspection limitations (i.e, cracks detected by EVT-1 must be assumed through-wall), to simplify the structural analyses and to ensure that the safety margins are robust. To further penalize an owner by requiring the assumption of leakage and potential reduction in unit rating is unwarranted.

As noted above there has been no inspection experience obtained which indicates that through-wall cracks have occurred in the vertical or horizontal core shroud welds. The inspection frequencies contained in BWRVIP-63 and BWRVIP-76 are such that any appreciable through-wall cracks will be detected well before they impact plant operation or structural integrity. The crack growth rates established for stainless steel materials (reported in BWRVIP-14 and BWRVIP-99) are conservative such that the predicted rates bound the inspection data and have added margin to account for unknowns such as weld repairs. The inspection data presented in BWRVIP-99 demonstrates that crack growth rates are slowing substantially as crack depth increases.

Core shroud circumferential welds that have been structurally placed by repair hardware do not require inspections per BWRVIP-76. The design requirement is to assume complete through-wall cracking for each circumferential weld that is structurally replaced. No additional leakage assessments are required by the BWRVIP beyond those considered in the shroud repair design. Therefore, the BWRVIP believes that the requirement to calculate leakage should be only for observed through-wall flaws.

Issue 3:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 4-2 (Section 4, "Evaluation of Vertical Weld Indications") that "K_{IC} = 150 ksi$\sqrt{in}$ based on BWRVIP-01." Elevated fluences on core shroud welds may effect the mechanical properties of the constituent structural materials. Therefore, the material toughness value may vary under high irradiated conditions. Upon availability of relevant data, a fluence threshold should be established for use of this figure in LEFM. When the fluence limit is exceeded, the use of this value should be justified and discussed with the NRC staff.

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP is presently evaluating fracture toughness properties of highly irradiated stainless steel. The BWRVIP expects to submit the results of this work to the NRC in early 2001. The results may indicate that some changes are required to existing BWRVIP guidelines for shroud inspection and flaw evaluation for highly irradiated

welds. However, in the interim, we believe the approach provided in BWRVIP-76, Section D.1.1 is acceptable for evaluating these conditions. If a different method is used by the utility, we agree that it should be justified and discussed with the NRC staff.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> Based on the above, this item remains open and will be addressed in the staff's review of the BWRVIP-76 report.

Final BWRVIP response:

> BWRVIP-100, "BWR Vessel and Internals Project, Updated Assessment of the Fracture Toughness of Irradiated Stainless Steel for BWR Core Shrouds," EPRI Technical Report 1003016, December 2001 has been submitted to NRC for review and approval. This report provides the relationship of toughness versus fluence for core shroud flaw evaluations. The BWRVIP will use the appropriate fracture toughness limits specified in BWRVIP-100 for evaluation of flaws.

Issue 4:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page B-1 (Appendix B, "Plant Specific Flaw Evaluation Methodology") that "plant-specific analysis may be required if acceptance criteria "c" of Section 3.2 .... cannot be satisfied." Section 3.1.3, "Acceptance Standards for Vertical Welds," should be the correct citation not Section 3.2, "Vertical Welds in Repaired Shrouds."

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP agrees that the citation of Section 3.2 should be corrected to Section 3.1.3.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff finds that these actions adequately addresses this open item.

Final BWRVIP response:

> No changes.

Issue 5:

The Staff's April 18, 2000, Initial SE [3] stated:

The BWRVIP-63 report states on page B-2 (Appendix B, "Plant Specific Flaw Evaluation Methodology") that "submittal to the NRC of these analyses along with the inspection results is required within 90 days of the inspection." The reporting requirements for plant- specific flaw analysis should be consistent with those expressed in the BWRVIP-76 report, which states on page 4-1 (Section 4.3, "Analytical Evaluations of Inspection Results") that the analytical results "shall be reported to the NRC within 30 days after completion of the inspection."

The BWRVIP's May 30, 2001 response [2] stated:

The BWRVIP will provide a response to Item 5 at a later date.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

Based on the above, this item remains open and will be addressed in the staff's review of the BWRVIP-76 report.

Final BWRVIP response:

The BWRVIP has developed reporting requirements which are documented in BWRVIP-94, "BWR Vessel and Internals Project, Program Implementation Guide," EPRI Technical Report 1006288, August 2001. The BWRVIP proposes to delete the specific reporting requirements from all the Inspection and Evaluation Guidelines and reference Section 3.5 of BWRVIP-94 which follows:

> Each utility will inform the NRC of any decision to not fully implement a BWRVIP guideline approved by the NRC staff within 45 days of the report approval. This applies to only those BWRVIP guidelines that have received a Final Safety Evaluation without any exceptions to the report. The NRC should be notified if changes are made to the vessel and internals program that affect implementation of BWRVIP guidelines.
>
> Inspection results and flaw evaluations for components within the scope of the BWRVIP shall be reported as described below.
>
> 1. Licensees shall forward a summary of all inspections, associated results and new repairs to the BWRVIP Program Manager within 120 days following completion of an outage.
>
> 2. Flaw evaluations performed in accordance with the guidance in BWRVIP reports for the acceptance of inspection results do not require submittal to, or approval by, the NRC.
>
> 3. Flaw evaluations that deviate from the guidance in BWRVIP reports (e.g., assumptions, methods, acceptance criteria, etc.) shall be submitted to the NRC for approval. If the flaw evaluation is later revised, the results shall be

communicated to the NRC. The submittal schedule for the analyses will be determined by the licensee and the NRC.

4. If it is determined that implementation cannot be achieved as described in the I&E guidelines, or that meaningful results are not obtained, the user shall notify the BWRVIP with sufficient details to support development of alternative actions. These notifications, as well as planned actions by the BWRVIP, will be summarized and reported to the NRC by the BWRVIP.

5. Modifications to plant operation or configurations that may affect BWRVIP guidance (e.g., power uprate) shall also be reported to the BWRVIP Program Manager.

6. Section XI of the ASME Boiler and Pressure Vessel Code contains rules for inspection, flaw evaluation and repair/replacement of certain components that are also addressed as part of the BWRVIP program. The Code requirements are detailed in Table IWB-2500, Category B-N-2, Welded Core Support Structures and Interior Attachments to Reactor Vessel. In order for BWRVIP I&E Guidelines to be used in lieu of the ASME Code requirements, each licensee must obtain relief from the Code via the process described in 10CFR50.55a. This would best be accomplished by using the technical alternative provision contained in 10CFR50.55a(a)(3)(i).

The form and format of the reporting shall be in accordance with licensee's established procedures. This may include, but is not limited to, submittal by letter or as an attachment to ASME Code required documentation (NIS-1, OAR-1, etc.).

Industry reports are necessary to share information on failure mechanisms, NDE technique applications, repair effectiveness, operating experience, and other items. This experience is shared through the BWRVIP and member utilities. Member utilities agree to share results of assessments outlined in Section 3.4 with the BWRVIP. Deviations from BWRVIP guidance approved by the NRC and documented in accordance with Appendix A shall also be shared with the BWRVIP.

The BWRVIP is also developing a standard template for licensees to follow for submitting a technical alternative to use the BWRVIP I&E Guidelines in lieu of the ASME Code requirements.

Issue 6:

The Staff's April 18, 2000, Initial SE [3] stated:

> The effect of neutron fluence level on the crack growth rate should be consistent with that discussed in the BWRVIP-07 report. When the fluence level exceeds $5x10^{20}n/cm^2$, the appropriate crack growth rate to be used in the flaw evaluation should be discussed with and approved by the NRC staff.

The BWRVIP's May 30, 2001 response [2] stated:

> Until such time as the BWRVIP submits a crack growth evaluation for highly irradiated stainless steel, we agree that when the fluence level exceeds $5x10^{20}$ n/cm^2, the appropriate crack growth rate to be used in plant-specific flaw evaluations will be provided to NRC for concurrence.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff finds that this response adequately addresses this open item.

Final BWRVIP response:

> "BWRVIP-99: BWR Vessel and Internals Project, Crack Growth Rates in Irradiated Stainless Steels in BWR Internal Components," EPRI Technical Report 1003018, December 2001 has been submitted to the NRC for review and approval. The report provides the crack growth rates for stainless steel in the fluence range of $5x10^{20}$ n/cm^2 up to $3x10^{21}$ n/cm^2. The BWRVIP will use the appropriate correlation in this report for evaluation of stainless steel materials subjected to the specified fluence range.

Issue 7:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 3-1(Section 3, "Inspection Recommendations") that "NDE uncertainty does not need to be considered since it is adequately covered by conservatisms in the flaw evaluation methods." BWRVIP-member utilities must determine the measurement uncertainty associated with NDE techniques to be used for inspection of the reactor vessel components consistent with the methodology specified in the BWRVIP-03 report (Section 2.3 "Guidelines for Determining NDE Technique Uncertainty") as approved by the NRC staff, and include the measurement uncertainties in the flaw evaluation consistent with guidance in the BWRVIP-07 report.

The BWRVIP's May 30, 2001 response [2] stated:

> The BWRVIP will provide a response to Item 7 at a later date.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> Based on the above, this item remains open and will be addressed in the staff's review of the BWRVIP-76 report.

Final BWRVIP response:

> The BWRVIP provided a response to Issue 7 in Reference 4.

Issue 8:

The Staff's April 18, 2000, Initial SE [3] stated:

> The BWRVIP-63 report states on page 3-3 (Section 3.1.3, "Acceptance Standards for Vertical Welds") that "if the weld has been inspected using a one-sided technique and no cracking was detected then the weld is acceptable for 6 EFPY." In order to verify the weld integrity, the inspection should consist of a two-sided (ID and OD) visual examination. Whenever one-sided visual inspection was performed, the use of its results to determine the reinspection interval should be justified and discussed with the NRC staff. Also, the use of effective full power years (EFPY) as a basis to establish the reinspection interval does not correspond with NRC-approved guidelines. Determination of the acceptable operating time, wherever applicable in the subject report, should be in terms of operating hours or years, not EFPY.

The BWRVIP's May 30, 2001 response [2] stated:

> Section 2.2 of BWRVIP-63 specifies that volumetric or two-sided (ID and OD) visual exams are the only acceptable methods for satisfying the acceptance criteria contained in Section 3. This is consistent with the examination guidelines for horizontal welds contained in BWRVIP-76. The beltline region is approximately 75% of the shroud vertical welds and represents a significant two sided or volumetric examination sample. This is considered an adequate sampling to determine if any ID vertical weld cracking exists. However, in some cases a volumetric exam or two-sided visual exam is not possible due to access limitation (obstructions due to hardware, etc.) For these situations, BWRVIP-63 allows for a one-sided exam and states that a maximum EOI of 6 years is acceptable provided that no cracking is detected. If cracks are detected, a plant-specific evaluation must be performed. Therefore, based on the fact that the bulk of the inspections will be volumetric or visual from both the ID and OD, a substantial amount of weld volume will be examined using this criteria. In general, the regions where one-sided visual exams will be employed will be small compared to those examined by volumetric methods. Furthermore, if cracks are detected using one-sided visual exams, analyses must be performed to determine both the structural integrity and future inspection frequency of the vertical weld. If the evaluation performed differs from the acceptable methods described in the report, the evaluation must be submitted to the NRC for approval. Therefore, the BWRVIP believes that one-sided visual examinations are acceptable for certain situations provided that Section 2.2 of the BWRVIP-63 is followed.
>
> The BWRVIP agrees with the NRC that the reinspection intervals should be based on operating years, not EFPY. In fact, this is reflected in the BWRVIP-76 report.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

> The staff finds that, with a revision to the BWRVIP-63 report stating that a qualified two-sided EVT-1 type visual exam should encompass *essentially 100 percent* (as defined in 10 CFR 50.55a) of the inspection area, then the EOI criteria, as proposed to be modified,

established in Section 2.2 of the BWRVIP-63 report is acceptable. If a licensee cannot achieve essentially 100 percent coverage utilizing a qualified two-sided EVT-1 type visual exam, or if the licensee utilizes a one-sided EVT-1 type visual exam, then the licensee shall provide a technical justification of the proposed reinspection interval to the NRC staff. With these revisions, and the BWRVIP's agreement regarding operating years vice EFPY, the staff considers this item resolved.

Final BWRVIP response:

The staff position on vertical welds is not consistent with that of the horizontal welds where the NRC has accepted the BWRVIP position of inspecting essentially 100% of all accessible regions with a minimum of 50% in order to justify structural integrity and future reinspection intervals. The same coverage requirements have been applied to the vertical welds. A further point to make is that except for axial welds, located in the beltline region, that might receive an accumulated fluence greater than $1x10^{21}$ n/cm^2, the allowable flaw length exceeds the length of the weld. Regardless of the actual coverage achieved in excess of 50% or the level of fluence, the flaw evaluation criteria defined in BWRVIP-63 will determine if additional inspections are required for the desired period of operation. Thus, the BWRVIP believes that conservative guidance is provided in BWRVIP-63 to assess integrity of the vertical welds.

Issue 9:

The Staff's April 18, 2000, Initial SE [3] stated:

The BWRVIP-63 report states on page 3-5 (Section 3.1.3, "Radial Ring Welds") that "if the location of the welds is known (e.g., from plant drawings), then those specific locations shall be inspected from the OD of the ring." To assure complete integrity of the weld, the inspection should extend the entire length of the weld and not just the outer surface. In addition, the particular NDE technique used to detect any discontinuities within this component should be given (e.g., UT or 2-sided VT).

The BWRVIP's May 30, 2001 response [2] stated:

Inspection of radial ring welds to date has not revealed any significant cracking or structural integrity concerns. The BWRVIP is recommending that the inspection begin at the OD of the rings. If cracking is detected it is expected that additional surfaces will be examined, on an as-needed basis, as input to plant-specific structural evaluations.

The Staff's August 20, 2001 evaluation of BWRVIP response [1] stated:

As stated in the staff findings for Issue 8, above, and the staff's April 18, 2000, initial SE, if the licensee is utilizing a visual exam, it should be a qualified two-sided (OD and ID) EVT-1 type visual exam which encompasses *essentially 100 percent* (as defined in 10 CFR 50.55a) of the inspection area. With this revision, the staff considers this item resolved.

Final BWRVIP response:

Radial ring welds have not reveal any significant cracking. Inspections are currently being performed of all accessible areas following the same approach as horizontal and vertical welds. Examination of the ring welds on the ID and bottom surface is generally impractical or not possible because there is either no access or it would require disassembly of the top guide and associated hardware. Therefore, for the same reasons as discussed in the response to Issue 8, the BWRVIP believes that the current guidance specified in BWRVIP-63 is sufficient to detect cracking in the radial ring welds.

References:

1. Letter from William H. Bateman (NRC) to Carl Terry (BWRVIP Chairman), "Final Safety Evaluation of the BWRVIP Vessel and Internals Project, Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63), EPRI Report TR-113170, June 1999 (TAC NO. MA6015)," dated August 20, 2001.
2. Letter from Carl Terry (BWRVIP Chairman) to NRC Document Control Desk, "Project 704 – BWRVIP Response to NRC Safety Evaluation of BWRVIP-63," dated May 30, 2001.
3. Letter from Jack R. Strosnider (NRC) to Carl Terry (BWRVIP Chairman), "Safety Evaluation of the BWRVIP Vessel and Internals Project, Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63), EPRI Report TR-113170, June 1999 (TAC NO. MA6015)," dated April 18, 2000.
4. Letter from Carl Terry (BWRVIP Chairman) to NRC Document Control Desk, "PROJECT NO. 704 -- BWRVIP Partial Response to the NRC Final Safety Evaluation of BWRVIP-63," dated October 22, 2002.