December 31, 2015

Mr. Tim Hanley
Senior Vice President West Operations, Exelon
Chairman, BWR Vessel and Internals Project
3420 Hillview Avenue
Palo Alto, CA 94304-1395

SUBJECT: FINAL SAFETY EVALUATION FOR ELECTRIC POWER RESEARCH INSTITUTE TOPICAL REPORT BWRVIP-183, "BWR VESSEL AND INTERNALS PROJECT, TOP GUIDE GRID BEAM INSPECTION AND FLAW EVALUATION GUIDELINES" (TAC NO. ME2178)

Dear Mr. Hanley:

By letter dated January 15, 2008 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML080220430), the Electric Power Research Institute (EPRI) submitted Topical Report (TR) BWRVIP-183, "BWR Vessel and Internals Project, Top Guide Grid Beam Inspection and Flaw Evaluation Guidelines," to the U.S. Nuclear Regulatory Commission (NRC) staff for review.

By letter dated December 13, 2011 (ADAMS Accession No. ML113140259), an NRC draft safety evaluation (SE) regarding our approval of BWRVIP-183 was provided for your review and comment. By letter dated July 24, 2015 (ADAMS Accession No. ML15209A893), you provided your comments on the NRC draft SE. On August 18, 2015, the NRC staff held a teleconference with representatives of the BWRVIP to discuss your comments which were centered mainly on the staff's stated "Conditions" in the draft SE. During the teleconference consensus was reached on the final wording of the Conditions that would appear in the final SE. The final SE, is reflective of the consensus reached regarding the Conditions to topical report (TR) BWRVIP 183. Enclosed is the non-proprietary version of the SE prepared for the public. The NRC staff's disposition of your comments on the draft SE are discussed in the attachment to the enclosure.

The NRC staff has found that TR BWRVIP-183 is acceptable for referencing in licensing applications for nuclear power plants to the extent specified and under the limitations delineated in the TR and in the enclosed final SE. The final SE defines the basis for our acceptance of the TR.

Our acceptance applies only to material provided in the subject TR. We do not intend to repeat our review of the acceptable material described in the TR. When the TR appears as a reference in license applications, our review will ensure that the material presented applies to the specific plant involved. License amendment requests that deviate from this TR will be subject to a plant-specific review in accordance with applicable review standards.

In accordance with the guidance provided on the NRC website, we request that EPRI publish approved proprietary and non-proprietary versions of TR BWRVIP-183 within three months of receipt of this letter. The approved versions shall incorporate this letter and the enclosed final SE after the title page. Also, they must contain historical review information, including NRC requests for additional information and your responses. The approved versions shall include an "-A" (designating approved) following the TR identification symbol.

If future changes to the NRC's regulatory requirements affect the acceptability of this TR, EPRI will be expected to revise the TR appropriately. Licensees referencing this TR would be expected to justify its continued applicability or evaluate their plant using the revised TR.

Sincerely,

/RA K.Hsueh for/

Mirela Gavrilas, Deputy Director
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Project No. 704

Enclosure:
Final Safety Evaluation

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Mirela Gavrilas, Deputy Director
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Project No. 704

Enclosure:
Final Safety Evaluation

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ADAMS Accession No.: ML15309A275 **NRR-106**

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FINAL SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

FOR "BWRVIP-183: BWR VESSEL AND INTERNALS

PROJECT – TOP GUIDE GRID BEAM INSPECTION AND FLAW EVALUATION GUIDELINES"

PROJECT NO. 704

1.0 INTRODUCTION

1.1 Background

By letter dated January 15, 2008 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML080220430), the Boiling Water Reactor (BWR) Vessel Internals Project (BWRVIP) submitted a topical report "BWRVIP-183: BWR Vessel and Internals Project - Top Guide Grid Beam Inspection and Flaw Evaluation Guidelines," which provides the results of an evaluation of the flaw tolerance of top guide grid beams. This is a follow-up report to BWRVIP-26-A, "BWR Top Guide Inspection and Flaw Evaluation Guidelines," which was developed by Electric Power Research Institute after the discovery of top guide grid beam cracking at Oyster Creek Nuclear Generating Station (OCNGS) in 1996. By letter dated December 27, 1996, as supplemented by letter dated November 18, 2004 (ADAMS Accession No. ML043290158), the BWRVIP submitted the BWRVIP-26-A report for staff review. The BWRVIP-26-A report provides generic guidelines intended to present the appropriate inspection recommendations to assure the safety function and integrity of the top guide component. It also provides design information on the top guides, geometries, weld locations, and potential failure locations for the several categories of BWRs (BWR/2 through BWR/6).

Following the issuance of the NRC staff's approval letter dated August 29, 2005 (ADAMS Accession No. ML052490550), for the BWRVIP-26-A report, the NRC staff was concerned that cracking due to irradiation assisted stress corrosion cracking (IASCC) and intergranular stress corrosion cracking (IGSCC) can occur in the top guide grid beams and that it might present a safety concern particularly during the license renewal period. In response, the BWRVIP decided to issue this follow-up report to include an evaluation of flaw tolerance of the top guide grid beams and provide an inspection program for monitoring IASCC.

1.2 Purpose

The NRC staff reviewed the BWRVIP-183 report to determine whether it provides an acceptable level of quality for the inspection and flaw evaluation of the top guide. The review considered the consequences of component failures, potential degradation mechanisms and past service experience, the validity of the structural analyses based on IASCC, the ability of the proposed inspections to detect degradation in a timely manner, and the acceptability of the flaw evaluation and inspection criteria.

1.3 Organization of this Safety Evaluation

A brief summary of the contents of the subject report is given in Section 2.0 of this safety evaluation (SE), with the NRC staff's evaluation presented in Section 3.0. The conditions and limitations are specified in Section 4.0. The conclusions are summarized in Section 5.0. The presentation of the evaluation is structured according to the organization of the topical report.

2.0 SUMMARY OF BWRVIP-183 REPORT

The BWRVIP-183 report contains a discussion of the technical basis for implementing inspection and flaw evaluation guidance for top guide grid beams. This report also provides a description related to design of various top guide grid beams used in BWR/2, 3, 4, 5, and 6 designs, susceptibility and environmental factors that affect the onset of IASCC and IGSCC, and an evaluation of structural integrity of a grid beam that is severed due to extensive flaw growth. In addition, this report discusses the evaluation of loose parts and the effect of fit-up stresses on flaws in top guide grid beams. The aforementioned issues that are addressed in various sections of the BWRVIP-183 report are summarized in the following:

Introduction - Section 1 provides the objective for a regulatorily-accepted, unified industry approach for the design, loading evaluation, and the inspection of the top guide grid beams. This section also provides a brief background review of prior industry inspections of top guide grid beams and their cracking history.

Design and Susceptibility - Section 2 addresses various top guide grid beam designs that are applicable to BWR/2, 3, 4, 5, and 6 designs. This section also addresses the susceptibility of the top guide components to IASCC and IGSCC, which is based on the type of material used, environment, and stress state.

Top Guide Grid Beam Cracking History - Section 3 provides a detailed description of the inspection history and cracking history of the top guide grid beams. This section includes a compilation of historical data (listed in chronological order) related to the date of inspections, the plant being inspected, and the location of any identified cracks.

Top Guide Loadings and Evaluations - Section 4 addresses the loads on the top guide component and flaw evaluation of the top guide grid beams using a fracture mechanics (FM) methodology. The flaw evaluation entails the usage of fracture toughness values which depend on the exposure of the top guide grid beams to the neutron fluence.

Severed Beam Evaluation - Section 5 provides an evaluation when a flaw grows through the entire height of a grid beam, thereby causing beam separation which could affect the insertion of control rods

Multiple Cracks in One Beam - Section 6 provides guidelines for evaluation of the structural integrity of a grid beam that has multiple cracks.

Loose Parts Evaluation: - Section 7 identifies various sizes of possible loose parts and their effects on:

(1) potential for fuel bundle flow blockage,
(2) interference with control rod drive (CRD) operation,
(3) potential for corrosion and reaction with reactor vessel internal materials,
(4) potential for interference with reactor water clean-up (RWCU) or residual heat removal (RHR) valves,
(5) potential for interference with main steam isolation valves (MSIVs), and
(6) potential for damage to the fuel due to fretting.

Inspection Strategy - Section 8 provides inspection guidelines for top guides of various BWR designs, inspection frequency, scope expansion, re-inspection guidelines, and flaw acceptance criteria for continued operation.

Top Guide Grid Beam Evaluation - Appendix A provides details of the flaw evaluation methodology that will be used for evaluating the presence of a flaw in a top guide grid beam.

Fit-up Stress Evaluation - Appendix B addresses a fit-up stress evaluation in which the effects on the top guide performance of possible fit-up stresses that are present during the original fabrication of the top guide are discussed.

3.0 TECHNICAL EVALUATION

The NRC staff evaluation of the BWRVIP-183 report is consistent with the order in which the report was presented. As stated above, Section 1 addresses the introduction to the report and Section 3 includes historical data on the top guide grid beam cracking to date. The data provided in Section 3 of BWRVIP-183 confirmed that, to date, top guide grid beam cracking has only been observed in two U.S. BWRs, OCNGS and Nine Mile Point, Unit 1 (NMP-1). Hence, these two plants were the focus of the BWRVIP's case study evaluations which are discussed in the following sections. The NRC staff has no additional comments on these sections on background information and they are not discussed further in this SE.

3.1 Susceptibility Factors to IASCC and IGSCC

Section 2 of the BWRVIP-183 report adequately addresses various factors that affect the susceptibility of the top guide to IASCC. The factors include: (1) state of stress, (2) reactor coolant system (RCS) environment - which includes oxygen and hydrogen concentrations in the RCS water, level of exposure of the top guide to neutron fluence, and the presence of crevices. For IGSCC, the susceptibility factors include: (1) state of stress, (2) oxygen and hydrogen concentrations in the RCS water, and (3) the presence of crevices. The degree of susceptibility to IASCC and IGSCC increases when the base metals and welds are cold worked and when the weld joints have a sensitized microstructure in the heat affected zone.

Section 2.2.1 of the BWRVIP-183 report states that the top guide projected neutron fluence at the end of 32 effective full power years (EFPY) of operation can reach a value of **[** **]**. Exposure to neutron fluence would affect the fracture toughness and crack growth rates (CGRs) in the top guide grid beams and these properties are used to evaluate the indications in the top guide grid beams. In Section 4.2.2 of the BWRVIP-183 report, the

BWRVIP recommends using a fracture toughness value of **[ ]** for the flaw evaluation methodology for top guide components that are exposed to a neutron fluence value greater than **[ ]**. For a given reactor, the neutron fluence value at the end of 54 EFPY will be greater than the neutron fluence value at the end of 32 EFPY. Section 2.3.3 of the BWRVIP-100-A report, “BWRVIP Vessel and Internals Project: Updated Assessment of the Fracture Toughness of Irradiated Stainless Steel for BWR Core Shrouds,” indicates that the fracture toughness values may drop below **[ ]** at neutron fluence levels above **[ ]**. In this context, in a request for additional information (RAI), RAI 1, by letter dated April 29, 2010, the NRC staff requested that the BWRVIP provide a justification for using a fracture toughness value of **[ ]** for the top guide components through 54 EFPY.

In its RAI response dated March 3, 2011 (ADAMS Accession No. ML110660306), the BWRVIP stated that additional fracture toughness tests conducted by the BWRVIP confirm that the fracture toughness value of **[ ]** is valid for stainless steel materials that are exposed to a maximum neutron fluence value of **[ ]**. The BWRVIP further stated that for the top guide components that are exposed to a neutron fluence value greater than **[ ]**, a justification by the licensee must be provided to assure that proper fracture toughness values will be used for the evaluation of flaws in the top guide grid beams. The BWRVIP agreed to address this issue in its revision to the BWRVIP-183 report. Furthermore, the BWRVIP stated that the BWRVIP-100-A report will be revised to indicate the appropriate fracture toughness values that should be used for materials exposed to a maximum neutron fluence value of **[ ]**. The NRC staff accepts this response as it adequately provides the flaw evaluation guidelines for the top guide grid beams that are exposed to a maximum neutron fluence value of **[ ]**.

3.2 Top Guide Loading and Evaluation

Section 4 of the BWRVIP-183 report discusses top guide loadings and flaw evaluation methodology. For the top guide grid beam, the loading consists of dead weight, pressure differential, thermal loads, and dynamic loads for both normal operating and faulted conditions. For the subsequent flaw evaluation methodology, the BWRVIP-183 report employed a methodology which accounts for the variations in fracture toughness and CGR. The CGRs used in this application are from the approved BWRVIP-14-A report, “Evaluation of Crack Growth in BWR Stainless Steel RPV Internals,” and the BWRVIP-99-A report, “Crack Growth Rate in Irradiated Stainless Steels in BWR Internal Components.” The neutron fluence dependent fracture toughness values used in this application are from the approved BWRVIP-100-A report, as modified by the discussion in Section 3.1 above.

The flaw evaluation methodology in the BWRVIP-183 report is based on the methodology of Appendix B of BWRVIP-26-A, where the applied K values were developed from a single edge crack plate model. Use of the single edge-crack plate flaw evaluation model requires that the crack is free from the effect of sudden geometry changes. As such, this methodology is applicable only when the flaws are located at grid beam locations away from notches and slots or close to the symmetric lines of notches and slots. The NRC staff has reflected this limitation on the use of the BWRVIP-183 flaw evaluation methodology in Section 4.0 of this SE as Condition 1 on the use of BWRVIP-183.

With the appropriate fracture toughness and CGR, the BWRVIP calculated the applied stress intensity factors K_I (opening mode) and K_{III} (tearing mode) using the methodology presented in the BWRVIP-26-A report. The applied K values were combined into an equivalent applied J-integral and then compared with J_{IC} to obtain the calculated structural factor (SF) to be evaluated against the allowable SF of 2.77 for normal/upset conditions and 1.39 for emergency/faulted conditions. The overall appropriateness of using the BWRVIP-26-A report flaw evaluation methodology, especially the fracture toughness and CGR, in this application is discussed later after the NRC staff has examined the analytical results from applying this methodology to a real case: the NMP-1 top guide grid beam.

The details of applying the BWRVIP-26-A report flaw evaluation methodology to reported NMP-1 top guide grid beam flaws were presented in Appendix A of the BWRVIP-183 report. The NRC staff issued RAIs, mostly regarding the fidelity of the finite element method (FEM) modeling. The BWRVIP's response, dated March 3, 2011, provided clarification and additional details about the simplifications made in the FEM model, such as the grid beam intersection point connectivity, the interference fit at the grid beam intersections, and the modeling of the gap between the top guide rim and the lower shroud cylinder. With the additional modeling details, the NRC staff concludes that the BWRVIP has demonstrated that reasonable FEM modeling techniques were used to simulate the NMP-1 top guide grid beam with flaw indications consistent with the NMP-1 top guide grid beam inspection history.

Using the CGR under normal water chemistry, the NMP-1 FEM results showed a minimum amount of crack growth for the reported indications that are in the high neutron fluence region during the 10-year period. Based on this, the BWRVIP concluded that "normal operating loads do not create sufficient stresses in the grid beams to promote any significant growth due to IGSCC or IASCC." This BWRVIP conclusion does not seem to support the **[** **]**.

Although the CGR used in the BWRVIP's NMP-1 flaw evaluation example was validated against operating data from the core shroud H4 weld of five plants (see the BWRVIP-99-A report), directly applying this CGR to the top guide grid beam may not be appropriate because **[** **]**, as suggested in Section 8 of the BWRVIP-183 report. In this regard, the BWRVIP-183 report concludes in Section 8 that, **[** **]** That is, the flaw evaluation methodology of BWRVIP-183 which would predict minimal crack growth for a known flaw would, perhaps, predict that the flaw being evaluated should not exist in the first place. The NRC staff is therefore concerned that the BWRVIP-183 flaw evaluation methodology could be underpredicting the expected growth of known flaws. Therefore, Condition 2 in Section 4.0 of this SE limits the use of the BWRVIP-183 flaw evaluation methodology to justifying continued facility operation only for stable flaws. A stable flaw is defined as a flaw with the measured CGR less than the proposed CGR for two consecutive outages.

A licensee utilizing the BWRVIP-183 must include in its proposed scheduled inspection, re-inspection of all known top guide grid beam flaws. If new flaws are found, the flaws must be re-inspected in each successive outage until they become stable (i.e., measured CGR is less than the proposed CGR) for two consecutive outages. The proposed inspection schedule may resume after this point. For known top guide grid beam flaws, the purpose of re-inspection is to confirm that the CGR of each flaw is still stable. If the measured CGR (i.e., the calculated CGR based on the current and the last inspection flaw lengths) of any known flaw exceeds the proposed CGR, the flaw must be re-inspected in each successive outage until it becomes stable for two consecutive outages. The proposed inspection schedule may resume after this point. This is Condition 2.

3.3 <u>Severed Beam Evaluation</u>

Section 5 of the BWRVIP-183 report discusses the severed beam evaluation during a dynamic event. Based on a FEM model for the OCNGS top guide with severed beams under a lateral seismic force, the BWRVIP produced a maximum deflection of **[ ]** at one of the two severed locations. The direction of the seismic force was selected to cause the largest deflection for the severed beam segments. The BWRVIP concluded in Section 5.3 that the calculated beam deflections of less than 1 inch at the severed locations would not interfere with CRD operations.

The NRC staff reviewed Section 5 and determined that the severed beam location and the seismic loads to be used are highly plant-specific, hence, the seismic analysis and results presented in this section have very little generic implication. The BWRVIP stated in its response to NRC RAI 3 that, “a plant-specific analysis is required to address the issue of control rod insertion for design basis transients.” The NRC staff thus determined that future plant-specific analyses should be the focus of the NRC staff review, and questions regarding acceptable beam deflections which would not interfere with CRD operations can be deferred to the plant- specific reviews.

The BWRVIP response also included a revised Section 5.3 of the BWRVIP-183 report, providing top-level guidance for such an analysis. Specifically, the report states, “[t]his analysis must take into account the lateral displacement of the core shroud due to all dynamic loads, such as seismic, safety-relief valve blowdown, loss of coolant accident, etc., as well as all plant service conditions. The lateral displacement of the core shroud determined above must be added to that resulting from a severed grid beam subject to similar loading conditions.” Although this only defined the loading to be considered in the plant-specific analysis, it is still helpful to the potential applicants.

The NRC staff considered that evaluation of a postulated severed beam has the benefit of demonstrating defense-in-depth, i.e., even if a completely severed beam should occur (which would not be expected based on the proposed inspection program), it would not be expected to interfere with the ability of the CRD system to insert control rods. This demonstration of defense-in-depth becomes necessary when the flaw evaluation results alone may not adequately justify continued operation (see discussion in Section 3.2 above).

For flaws which are predicted to exceed the acceptance criterion of Section 4.2.1 of the BWRVIP-183 report and for flaws which are predicted to reach a length 75 percent of the beam width prior to the proposed next inspection, a plant-specific severed beam analysis must be performed to demonstrate that even if the beam severed (the worst-case scenario), the CRD operations will not be compromised by the maximum local and global deflection of the top guide grid beams. The applicant must inform the NRC about this event for the NRC staff to determine whether there is a need to review the flaw evaluation report and the plant-specific severed beam analysis report. This is Condition 3.

3.4 Multiple Cracks in One Beam

To verify that the flaw evaluation methodology discussed in Section 3.2 of this SE can be used for the case of multiple flaws in a single top guide grid beam, Section 6 of the BWRVIP-183 report analyzed this special case. The BWRVIP employed a FM model of a semi-infinite space with an infinite number of parallel edge cracks to gain insight into the real case with multiple cracks in one beam. Since the applied K_I associated with the FM model described above is smaller than that for a single edge-cracked plate model, the BWRVIP concluded that multiple cracks in the top guide grid beams can be conservatively evaluated as many single, independent cracks using the flaw evaluation methodology from Section 3.2 of this SE.

The NRC staff considers this acceptable because **[**

] From this semi-infinite space model, it can be inferred that a single crack in an infinite long plate with a finite width will also have the highest applied K_I when compared with the case of multiple parallel cracks in the same finite-width infinite long plate. Hence, the NRC staff has concluded that the BWRVIP-183, Section 3.2 flaw evaluation methodology is generically applicable to the case of multiple flaws in a single top guide grid beam.

However, as implied in the BWRVIP-183 report, although the multiple cracks in the top guide grid beams can be treated individually in the flaw evaluation, certain aspects of the multiple cracks still need to be considered. The multiple cracks could intersect one another or fracture through the beam and produce loose beam segments. This scenario is evaluated in Section 7 of the BWRVIP-183 report.

3.5 Loose Parts Evaluation

The NRC staff reviewed Section 7 of the BWRVIP-183 report which discusses the evaluation of postulated loose parts from the top guide component, the NRC staff concludes that this section is acceptable based on the following:

(1) The evaluation of postulated loose parts from the top guide component is consistent with the guidelines that are provided in the staff-approved version of BWRVIP-06-A, "BWR Vessel Internals Project, Safety Assessment of BWR Reactor Internals." These guidelines provide necessary information with regards to the evaluation of the effects of loose parts on the safety and operational concerns of the reactor.

(2) The BWRVIP adequately addressed six concerns related to the safety and operation of the reactor. These six concerns are addressed in Section 7 of the BWRVIP-183 report and these concerns are related to the presence of postulated loose parts from the top guide component. In its evaluation, the BWRVIP took into account the characteristics of each scenario associated with each concern and they are related

to CRD operation, flow blockage in the fuel bundle, and interference with RWCU, RHR, and MSIV valves. This evaluation is consistent with the BWRVIP-06-A guidelines, and it provides reasonable assurance that the safety of the reactor will not be compromised with the presence of postulated loose parts.

3.6 Inspection Strategy

Section 8 of the BWRVIP-183 report provides adequate details regarding the inspection strategy for all BWR fleet top guide grid beams. This section also includes the inspection techniques, inspection frequency, the locations of grid beams that are more susceptible to IASCC, and the re-inspection frequency. Adequate guidelines are provided for the scope expansion strategy for all BWR units. Based on the past inspection results BWRVIP identified various susceptible cell locations of the top guide grid beams which have high stress and high neutron exposure. The NRC staff accepts the proposed inspection frequency for the top guide grid beams because the inspection frequency is consistent with the one addressed in aging management program (AMP) XI.M9 in NUREG-1801, “Generic Aging Lessons Learned (GALL) Report,” Revision 2. The scope expansion strategy for the inspection of top guide grid beams is very effective because it takes into account the critical flaw size for establishing the additional inspection criteria. The NRC staff accepts the re-inspection guidelines because the re-inspection sampling includes a mix of additional areas including central and peripheral locations around the top guide, where possible, which are also susceptible to IASCC and IGSCC. In Section 8.3 of the BWRVIP-183 report, with reference to the selection of the re-inspection sample, the BWRVIP uses a term “rotating inspection sample.” The NRC staff recommends that this term should be clarified in the BWRVIP-183-A report.

3.7 Top Guide Grid Beam Flaw Evaluation

Appendix A of the BWRVIP-183 report contains an example of applying the top guide flaw evaluation methodology presented in Section 4 of the report to the NMP-1 top guide with detected flaws. The NRC staff’s evaluation of this analysis was discussed in Section 3.2 of this SE and will not be repeated here.

3.8 Fit-Up Stress Evaluation

Appendix B presents a study of the effect of possible fit-up stresses caused by re-rounding of the top guide using a clamping device to correct the out-of-roundness configuration of the top guide before installation. After the installation, the clamping device is removed. **[**

] The NRC staff considers use of the NMP-1 FEM model adequate because it is a general FEM model having sufficient structures around the top guide modeled. The results are also reasonable considering the stresses that could be induced by the small displacement loading. Again, this exercise is highly plant-specific and indicated that even when this out-of-roundness of the top guide is considered along with the normal operating loads, the stresses in the grid beams will not cause significant crack growth.

4.0 CONDITIONS AND LIMITATIONS

Depending on the inspection findings of the top guide grid beams, licensees may need to perform certain plant-specific evaluations in accordance with the BWRVIP-183 report. For beams with stable flaws, the proposed flaw evaluation, as limited by Condition 1, may be used to demonstrate continued operation to the proposed next inspection.

NRC SE Condition 1

Condition 1 – Use of the flaw evaluation methodology in BWRVIP-183, Section 4 may only be applied when a detected flaw is sufficiently far from geometric discontinuities like notches or slots or close to the symmetric lines of notches and slots such that the stress condition in the vicinity of the flaw and the cracked beam geometry is consistent with that for a single edge-cracked plate. Applicants must demonstrate that any detected flaws being evaluated using the flaw evaluation methodology of Section 4 of BWRVIP-183 meet this criterion. If this cannot be demonstrated, appropriate applied K values which account for the effects of geometric discontinuities must be used and justified in the flaw evaluation.

NRC SE Condition 2

As stated in Section 3.2, the NRC staff is concerned that the BWRVIP-183 flaw evaluation methodology could be underpredicting the expected growth of known flaws. Therefore, Condition 2 is imposed to address the difference between the analytical predictions of insignificant growth of grid beam flaws and the operating experience showing long flaws.

Condition 2 – Use of the BWRVIP-183, Section 4 flaw evaluation methodology may be applied to justify continued facility operation to the next proposed inspection date in accordance with the BWRVIP-183 report only for stable flaws. In addition, if new flaws are found during inspection, the flaws must be re-inspected in each successive outage until they become stable for two consecutive outages. The proposed inspection schedule may resume after this point. This inspection must also confirm that the measured CGRs for all known top guide grid beam flaws are below the proposed CGR. If the measured CGR of any known flaw exceeds the proposed CGR, the flaw must be re-inspected in each successive outage until they become stable for two consecutive outages. The proposed inspection schedule may resume after this point.

NRC SE Condition 3

The NRC staff reviewed Section 5 and determined that the severed beam location and the seismic loads to be used are highly plant-specific, hence, the seismic analysis and results presented in this section have very little generic implication. The BWRVIP stated in its response to NRC RAI 3 that, “a plant-specific analysis is required to address the issue of control rod insertion for design basis transients.” The NRC staff thus determined that future plant-specific analyses should be the focus of the NRC staff review, and questions regarding acceptable beam deflections which would not interfere with CRD operations can be deferred to the plant-specific reviews.

Condition 3 – For flaws which are predicted to exceed the acceptance criterion of Section 4.2.1 of the BWRVIP-183 report and for flaws which are predicted to reach a length 75 percent of the beam width prior to the proposed next inspection, the licensee must also perform a severed beam evaluation consistent with BWRVIP-183, Section 5. The severed beam analysis is needed to demonstrate that even if a completely severed beam were to occur, it would not be expected to interfere with the ability of the CRD system to insert control rods. The applicant must inform the NRC Office of Nuclear Reactor Regulation by letter about this event within 90 days of completion of the flaw evaluation report or the severed beam analysis report for the NRC staff to determine whether there is a need to review the flaw evaluation report and the plant-specific severed beam analysis report.

5.0 CONCLUSION

The NRC staff has reviewed the BWRVIP-183 report and the supplemental information that was submitted to the NRC staff by the RAI response letter dated March 3, 2011. Based on its review, the NRC staff concluded that the conditions as described in Section 4.0 of this SE shall be incorporated in the -A version of the BWRVIP-183 report.

The NRC staff finds that the BWRVIP-183 report, as modified and clarified to incorporate the NRC staff's conditions, provides an acceptable technical justification with respect to the proposed inspections and flaw evaluation guidelines for the BWR top guide hardware. The BWRVIP-183 report is considered by the NRC staff to be acceptable for licensee usage, as modified by the NRC staff requirements and recommendations given above, at any time during either a facility's current operating term or extended license period.

Attachment: Resolution of Comments

Principal Contributors: G. Cheruvenki
S. Sheng

Date: December 31, 2015

RESOLUTION OF COMMENTS FOR

"BWRVIP-183: BWR VESSEL AND INTERNALS

PROJECT – TOP GUIDE GRID BEAM INSPECTION AND FLAW

EVALUATION GUIDELINES"

Nuclear Regulatory Commission (NRC) Safety Evaluation (SE) Condition 1 Comments and Resolution:

The flaw evaluation methodology in BWRVIP-183 is based on the methodology of Appendix B of BWRVIP-26-A, where the applied K values were developed from a single edge-cracked plate model. Use of the single edge-cracked plate flaw evaluation model requires that the crack is free from the effect of sudden geometry changes. The NRC staff proposed SE Condition 1 stated that as such, this methodology should be applicable only when the flaws are located at grid beam locations away from notches and slots.

The BWRVIP responded, with reasoning, that the single edge cracked plate model proposed in BWRVIP-183 can, in fact, be conservatively used at a notch or any other crack location. The NRC staff did not agree with the justification provided and retained Condition 1 with added clarification.

NRC SE Condition 2 Comments and Resolution:

The NRC staff had a concern that the BWRVIP-183 flaw evaluation methodology could be under-predicting the expected growth of known flaws. For this reason the NRC staff included SE Condition 2. The NRC staff proposed SE Condition 2. SE Condition 2 stipulated that the BWRVIP-183, Section 4, flaw evaluation methodology may be applied to justify continued facility operation on a cycle-by-cycle basis and that once a licensee acquired sufficient plant operating experience, it could and would need to request NRC approval to apply the BWRVIP-183, Section 4 methodology to justify plant operation for more than one cycle at a time.

The BWRVIP responded stating that inspections every outage are not necessary. The BWRVIP provided reasoning for this position which included favorable plant operating experience and the commitment to add re-inspection guidance based on new information gained from BWRVIP-183 inspections. The NRC staff accepted this commentary and modified Condition 2 to permit the use of BWRVIP-183, Section 4, flaw evaluation methodology to justify continued facility operation to the next scheduled inspection date with the stipulation that it be applied for stable flaws only and defined criteria for what constitutes a stable flaw. This modification negates the need for BWRVIP to seek NRC approval to apply the BWRVIP-183, Section 4, methodology to justify plant operation for more than one cycle at a time as was initially stipulated.

NRC SE Condition 3 Comments and Resolution:

The NRC staff proposed the condition that for any application demonstrating that a flawed beam will not become a severed beam during the proposed period of operation, a plant-specific severed beam analysis be performed and submitted for staff review to demonstrate that even if the beam severed, the CRD operations would not be compromised by the maximum local and global deflection of the top guide grid beams. The BWRVIP responded stating that imposing a requirement to assume a severed beam for all flaws when plant-specific flaw evaluations do not predict the critical flaw size will be reached could potentially require unnecessary repairs. The BWRVIP stated it will include guidance to consider CRD insertion in all severed beam evaluations. With the addition of this guidance the BWRVIP considers that the NRC's concern is addressed and, similar to other BWRVIP I&E guidelines, plants should not be required to submit their flaw evaluations to the NRC unless they deviate from the BWRVIP I&E guidelines.

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The NRC staff accepted the assertion concerning consensus on not reviewing flaw evaluation reports for activities not required by the American Society of Mechanical Engineers Code but still considers it necessary for licensees to inform the NRC of critical events, such as when flaws are predicted to crack 75 percent of the beam width prior to the proposed next inspection. Condition 3 therefore was modified to require the applicant to inform the NRC of the event in order to determine whether the NRC considers the event to be of a nature such that there is a need to review the flaw evaluation report and the plant-specific severed beam analysis report.