August 5, 2016

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 NON-PROPRIETARY SAFETY EVALUATION OF THE BWRVIP-42, REVISION 1, "LOW PRESSURE COOLANT INJECTION (LPCI) COUPLING INSPECTION AND FLAW EVALUATION GUIDELINES" (TAC NO. MF0363)

Dear Mr. Hanley:

By letter dated December 10, 2012, the Boiling Water Reactor Vessel Internals Project (BWRVIP) submitted, Topical Report (TR) BWRVIP-42, Revision 1, "Low Pressure Coolant Injection (LPCI) Coupling Inspection and Flaw Evaluation Guidelines," dated October 2012 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12349A308), to the U.S. Nuclear Regulatory Commission (NRC) staff for review. The original submittal was supplemented by a letter from the BWRVIP dated September 20, 2015 (ADAMS Package Accession Nos. ML15152A084), in response to requests from the NRC staff for additional information.

By letter dated April 27, 2016 (ADAMS Accession No. ML16074A332), an NRC draft safety evaluation (SE) was provided for your review and comment. By letter dated May 23, 2016 (ADAMS Package Accession No. ML16147A333), the BWRVIP provided comments on the NRC draft SE. The comments provided by the BWRVIP were solely related to the identification of proprietary information in the draft SE.

The NRC staff has found that TR BWRVIP-42, Revision 1 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 proprietary SE. The final proprietary 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-42, Revision 1 within six months of receipt of this letter. The approved versions shall incorporate this letter and the enclosed final proprietary 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.

As an alternative to including the RAIs and RAI responses behind the title page, if changes to the TRs provided to the NRC staff to support the resolution of RAI responses, and the NRC staff reviewed and approved those changes as described in the RAI responses, there are two ways that the accepted version can capture the RAIs:

1. The RAIs and RAI responses can be included as an Appendix to the accepted version.
2. The RAIs and RAI responses can be captured in the form of a table (inserted after the final SE) which summarizes the changes as shown in the approved version of the TR. The table should reference the specific RAIs and RAI responses which resulted in any changes, as shown in the accepted version of the TR.

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

Sincerely,

Kevin Hsueh, Chief **/RA/**
Licensing Processes Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Project No. 704

Enclosure:
Final SE (Non-Proprietary)

In accordance with the guidance provided on the NRC website, we request that EPRI publish approved proprietary and non-proprietary versions of TR BWRVIP-42 within three months of receipt of this letter. The approved versions shall incorporate this letter and the enclosed final proprietary 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.

As an alternative to including the RAIs and RAI responses behind the title page, if changes to the TRs provided to the NRC staff to support the resolution of RAI responses, and the NRC staff reviewed and approved those changes as described in the RAI responses, there are two ways that the accepted version can capture the RAIs:

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

Sincerely,

Kevin Hsueh, Chief **/RA/**
Licensing Processes Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Project No. 704

Enclosure:
Final SE (Non-Proprietary)

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

LICENSING TOPICAL REPORT BWRVIP-42, REVISION 1

"LOW PRESSURE COOLANT INJECTION (LPCI) COUPLING

INSPECTION AND FLAW EVALUATION GUIDELINES"

BOILING WATER REACTOR VESSEL & INTERNALS PROJECT

1.0 INTRODUCTION AND BACKGROUND

In a letter dated December 10, 2012, the Boiling Water Reactor Vessel and Internals Project (BWRVIP) submitted, through the Electric Power Research Institute (EPRI), Licensing Topical Report (LTR) BWRVIP-42, Revision 1, "Low Pressure Coolant Injection (LPCI) Coupling Inspection and Flaw Evaluation Guidelines," dated October 2012 (proprietary: Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML12349A310, -311, and -312; non-proprietary: ML12349A309) to the U.S. Nuclear Regulatory Commission (NRC) for review and approval. LTR BWRVIP-42, Revision 1 provides information on potential failure locations, including consequences and likelihood of the failure, in BWR/4-6 LPCI coupling components due to intergranular stress corrosion cracking (IGSCC) and recommends an inspection program to ensure that the integrity of all LPCI safety functions is maintained.

This review also includes an evaluation of the BWRVIP's response to the NRC staff's request for additional information (RAI), which was provided to the NRC in a BWRVIP letter dated May 20, 2015 (ADAMS Accession No. ML15152A102), and a proposed LTR revision that was transmitted to the NRC staff in an E-mail dated March 3, 2016 (ADAMS Accession No. ML16063A477).

2.0 REGULATORY EVALUATION

The inservice inspection (ISI) of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) Class 1, 2, and 3 components shall be performed in accordance with Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," of the ASME Code and applicable editions and addenda as required by Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(g). When a flaw is detected by inservice volumetric or surface examinations, acceptance of it by an analytical evaluation shall be in accordance with the established procedures in the ASME Code, Section XI, such as that in Subarticle IWB-3600, "Analytical Evaluation of Flaws," to demonstrate that the unit can be safely operated for a specified period of time without repair of the affected component.

Significant portions of the boiling-water reactor (BWR) reactor vessel internals (RVIs) are not ASME Code Class 1, 2, and 3 components. Therefore, the ISI of these BWR RVIs and the subsequent evaluation of flaws that were found in them during the ISI have been conducted in accordance with inspection and evaluation guidelines established in the numerous approved BWRVIP reports for a variety of BWR RVIs. This LTR provides inspection and flaw evaluation guidelines for BWR/4-6 LPCI coupling components to amend what is lacking in the ASME Code,

Section XI regarding inspection of these RVI components. Once the LTR is approved by the NRC and application of the LTR is confirmed by individual plants through the established process of the BWRVIP, applying the inspection and flaw evaluation guidelines in the LTR to LPCI couplings will be considered by the NRC as essential to maintain integrity of the subject RVI components.

3.0 TECHNICAL EVALUATION

3.1 The BWRVIP's Evaluation

The LTR provides inspection and flaw evaluation guidelines for BWR/4-6 LPCI coupling components. Section 1, "Introduction," provides background, objectives, and scope of this LTR. Section 2, "LPCI Coupling Design and Susceptibility Information," provides (1) detailed schematics of two LPCI coupling designs commonly used in BWR/4-6 plants, and (2) susceptibility factors and potential failure locations. Section 3, "Inspection Strategy," provides specific inspection guidelines for the different locations in the LPCI couplings based on the susceptibility, environment, and safety significance of failure of each location. Section 4, "Loads and Load Combinations," provides loads and load combinations for the various operating conditions, which are identical to those in BWRVIP-42-A (proprietary: ADAMS Accession No. ML050910305; non-proprietary: not in ADAMS). Section 5, "Structural and Leakage Evaluation Methodologies," describes the structural and leak rate evaluation methodologies and computational procedures to evaluate cracks in accessible and inaccessible welds. Appendix A demonstrates compliance with the technical information requirements of the license renewal (LR) rule 10 CFR 54.21.

3.2 The NRC Staff's Evaluation

The NRC staff's review is not limited to only the revised portions of the LTR. It also includes some essential information in BWRVIP-42-A for which the evaluation is not documented in the NRC safety evaluation (SE) dated May 26, 2000 (ADAMS Accession No. ML003719695). BWRVIP-42-A contains this May 26, 2000, SE and the January 9, 2001, SE (ADAMS Accession No. ML010100157), approving use of BWRVIP-42 for LR applications.

3.2.1 Section 1, "Introduction"

Section 1 of the LTR provides background, objectives and scope, and implementation requirements for the establishment of inspection and flaw evaluation guidelines for the LPCI couplings. Since this information is not technical, no evaluation is needed. The new implementation requirements in Section 1 did not exist in BWRVIP-42-A. They are included to identify "needed" sections for potential users of this LTR to focus on, and highlight other sections as "information only."

3.2.2 Section 2, "LPCI Coupling Design and Susceptibility Information"

Section 2 of the LTR first presented various designs for BWR/4-5 and BWR/6 plants, along with 17 schematics showing details of the design configurations. This design information is "factual input" to the inspection and evaluation strategy of the LPCI coupling components, and thus requires no further discussion. The remainder of Section 2 discusses susceptibility information. Section 2.1 of the LTR states, "Degradation in the LPCI coupling components can be due to

intergranular stress corrosion cracking (IGSCC) or fatigue." The LTR later [ ] the effect of fatigue because [
]. The NRC staff considers this justification acceptable because it is supported by analysis (low cyclic stresses) and validated by OE (no detected cracking). Therefore, the NRC staff agrees with the LTRs determination that IGSCC is the dominant degradation mechanism.

For aging embrittlement, Section 2.1.3 of the LTR states, [
]." The NRC issued RAI-2 to request quantitative data to substantiate this claim: specifically, the range of ferrite contents for all LPCI components, the range of neutron fluence values for all LPCI components, and the estimated bounding reduction of fracture toughness for LPCI components based on the quantitative data. RAI-2 also questioned why this reduced level of fracture toughness will not become an issue.

The BWRVIP's response to RAI-2 stated that, "thermal embrittlement is not a concern for LPCI coupling components. The rationale for this position is described in BWRVIP-234 (Reference 1) which is currently under review by the NRC …. However, if the ultimate review of BWRVIP-234 by the NRC determines that thermal embrittlement may be a concern for LPCI components, BWRVIP-42 will be reevaluated to appropriately address the issue." The title of BWRVIP-234 (ADAMS Accession No. ML102570749; package contains, letter, proprietary report, and non-proprietary report) is, "Thermal Aging and Neutron Embrittlement Evaluation of CASS [Cast Austenitic Stainless Steels] for BWR Internals." The NRC staff noted that Sections 2.2.1 and 2.2.2 of the LTR documented all potential LPCI coupling failure locations for BWR/4/5 and BWR/6 plants. Among them, seven locations have CASS materials. The NRC staff found that only two of them (Locations [ ] and [ ] for the BWR/4/5 plants) need to be addressed because the rest are of little concern due to redundancy or negligible impact on functionality. For these two locations, if the scheduled EVT-1 inspections specified in Table 3-1 of the LTR have found flaws away from the weld centerline such that these detected flaws are very likely to be in the CASS materials, the resulting flaw evaluation per LTR Section 5 shall be modified considering the reduced fracture toughness of CASS materials discussed in Appendix A of the SE for BWRVIP-234. This will be imposed as Condition 1 on the flaw evaluation to reflect that the limit load analysis for austenitic stainless steel welds cannot be applied directly to CASS materials without a proper adjustment. It should be noted, however, that although Location [ ] is inaccessible and its routine degradation is assessed through examining designated similar accessible welds, Condition 1 still applies to this location because Location [ ] will eventually be inspected when the designated similar accessible welds have reached a degradation threshold (see evaluation on Inaccessible Welds in Section 3.2.3 of this SE) and the inspection results are evaluated to support continued operation, repair, or replacement.

Regarding redundancies, Section 2.2 of the LTR states, ["
"] Industry experience indicated that for any components of the same design, although their materials met the same material specifications, the material properties varied from component to component (within a range) and sometimes varied within the component. Therefore, the probability for all LPCI couplings to initiate a crack at the same location and at the same time is extremely low, not to mention that the applied loading also varies among LPCI couplings in an RPV. Based on this observation, the NRC staff agrees with the LTR that the inspection guidelines need not be based on [
].

Regarding potential failure locations, Section 2.2.1 of the LTR contains essentially the same information as in BWRVIP-42-A, except that the inspection strategy for [

] has been modified. Instead of relying on the BWRVIP Inspection Committee to address the development need of the [

] (discussed in Section 3.9 of the LTR) to address the issue before [

]. The NRC staff's evaluation and acceptance of Section 3.9 of the LTR is presented below in Section 3.2.3 of this SE.

In summary, Section 2 contains very limited revised information, and this limited revised information has been accepted based on the above evaluation. The unrevised part of Section 2 of the LTR remains acceptable to the NRC staff because since the issuance of BWRVIP-42-A in 2005, there were no inspection results suggesting that a new degradation mechanism was discovered or new evidence suggesting a revision of the susceptibility information for potential failure locations in the LPCI couplings is needed. As such, with Condition 1, Section 2 of the LTR is acceptable to the NRC staff.

3.2.3 Section 3, "Inspection Strategy"

For this section, the NRC staff only reviewed the proposed revision in the LTR because the approved inspection strategy of BWRVIP-42-A (i.e., the inspection basis, the baseline inspection schedule, and the re-inspection schedule), which remains the same in the LTR, is unlikely to become inadequate, considering the OE before and after the issuance of BWRVIP-42-A in 2005.

Definition of VT-1, Enhanced VT-1 (EVT-1) and VT-3

In the proposed revision, [ ] is defined the same as in the ASME Code, Section XI, and is, therefore, acceptable. [ ] is defined the same as in the latest revision of BWRVIP-03, "Reactor Pressure Vessel and Internals Examination Guidelines," (proprietary: ADAMS Accession No. ML15211A088; non-proprietary: ML15211A085). Since there is no evidence that special requirements or criteria are needed to perform [ ] for LPCI components, using the generic [ ] as defined in BWRVIP-03, which is updated periodically and sometimes reviewed by the NRC, is practical and acceptable. VT-3 is defined in the ASME Code, Section XI as a visual inspection method "to determine the general mechanical and structural condition of components and their supports…and to detect discontinuities and imperfections …." The NRC staff determined that the VT-3 based on BWRVIP-03 as defined in the LTR is consistent with that in the ASME Code, Section XI.

Partially Accessible Welds

For partially accessible welds, Section 3.6 of the LTR states that, "[

]."

This is acceptable if a flaw evaluation based on an appropriately postulated flaw in the inaccessible segment meets established criteria (e.g., ASME Code, Section XI). Discussion on this will be continued when Section 5 of the LTR is discussed and evaluated.

Inaccessible Welds

For LPCI coupling locations classified as High and Low priority, Section 3.7 of the LTR states, “Until an inspection technique becomes available, the priority High and Low (H/L) welds that are completely inaccessible for inspection shall be evaluated using the guidelines in Section 3.9.” Section 3.9.1 provides a two-step process for managing inaccessible welds: (1) to determine the start time of the inspection interval, and (2) to determine [the length] of the inspection interval. For Step 1, the LTR proposed that the start of the inspection interval for the inaccessible weld is the time at which 75% of the similar priority H/L/N plant-specific accessible welds are found to be cracked. For Step 2, the LTR proposed that the length of the inspection interval for inaccessible welds is [the average of the calculated times for the 75 percent population of accessible cracked welds. The NRC staff had concerns regarding both steps and issued RAI-3, requesting justification for establishing the 75% criterion for cracked accessible welds, and for using the average calculated times for the 75% population of cracked accessible welds to determine the next inspection interval.

The BWRVIP’s response to the first part of RAI-3 indicated that (1) all the similar accessible welds are inspected when a crack is detected, providing an accurate representation of the welds of this type, including the hidden welds; (2) the LTR requires all flaws to be evaluated and structural and leakage margins to be maintained to the next inspection; (3) the flaw growth from IGSCC is relatively slow and the flaw sizes and loads needed for stainless steel piping failure are large; (4) leakage from inaccessible welds is to be continually evaluated against plant-specific loss-of-coolant-accident (LOCA) analyses based on assumed through-wall flaws in accessible welds where cracking has been detected; (5) industry inspection results showed no cracking; and (6) the NRC has accepted an identical approach in BWRVIP-18, Revision 1-A, “BWR Core Spray Internals Inspection and Flaw Evaluation Guidelines,” (proprietary: ADAMS No. ML13067A061; non-proprietary: ML13067A063) for managing the core spray system, which is more prone to cracking than the LPCI couplings. Based on the technical justifications stated above and in the interest of regulatory consistency, the NRC staff accepted use of 75% cracking of the similar accessible welds as a criterion for managing inaccessible welds. The BWRVIP did not specifically address the second part of RAI-3. However, Item (6) of the justification for the first part of RAI-3 is sufficient for resolving the second part of RAI-3. RAI-3 is therefore resolved.

Current OE shows no cracking of accessible similar welds. If 50% and 75% of accessible similar welds become cracked in the future, the NRC staff believes that the OE then, especially related to crack growth rate (CGR), may be very different from the current OE. Therefore, the licensee must inform the NRC Office of Nuclear Reactor Regulation by letter about reaching these two thresholds within 90 days of confirming these events so the NRC staff can reassess the overall inspection strategy and determine the need to review the latest information on OE, flaw evaluation, and leakage assessment for future safe operation of the LPCI couplings. This notification is specified as Condition 2(a) in Section 4.0 and will serve to alert the NRC staff to only potentially important LPCI inspection results. It will also prevent premature or unnecessary audits by the NRC staff of LPCI coupling flaw evaluations.

Determination of Similar Accessible Welds

Section 3.9.2 discussed how similar accessible welds were determined. Section 3.9.2.2 discussed similar accessible welds for Weld 45-12, and Section 3.9.2.3 discussed similar accessible welds for Weld 6-1a. Considering the difficulty in establishing the corresponding

similar accessible welds for the inaccessible welds due to possible large difference between their stresses (applied + residual), the NRC staff requested in RAI-4 justification for the LTRs approach of obtaining information on inaccessible welds (Welds 45-12 and 6-1a) from cracking of designated similar accessible welds.

The BWRVIP's response to RAI-4 stated that, "In the LPCI coupling, as well as most other components, residual stress is the dominant stress that drives crack initiation and growth. It is substantially higher than applied stresses. Consequently, applied stresses do not need to be considered for the purposes of predicting cracking. Given that the residual stress is difficult to predict, no discrimination on stress is possible when developing the population of similar welds." The NRC staff considers this explanation consistent with the OE on IGSCC of BWR components. Further, since Weld [ ] is the only full penetration weld for one BWR design, selecting accessible LPCI [ ] is acceptable, considering that all accessible welds are not full penetration welds and selecting the accessible weld for inspection can only be based on the similar susceptibility category. RAI-4 regarding Weld 45-12 is resolved. By comparison, the LTRs selection of similar accessible welds for Weld [ ] are completely justified because in addition to requiring the weld alloys [ ], both Weld [ ] and the designated similar accessible welds are full penetration welds. RAI-4 regarding Weld 6-1a is resolved.

Repaired Welds

The consideration of repaired welds in the LTR is conservative. The guidelines of Section 3.9.3 for determining the inspection interval for inaccessible welds instruct the applicant to count repaired weld towards the [ ] criterion, even though the repaired welds may not crack again. Inclusion of the repaired welds in the counting will make the [ ] and, eventually, the inspection of [ ] begin sooner, and is, therefore, acceptable.

Scope Expansion for Accessible and Inaccessible Weld Inspection Programs

Section 3.10.1 discussed scope expansion for accessible and partially accessible welds not in an inaccessible weld program. The expansion recommends that, [ ]." Scope expansion to other locations should be determined [ ]. Regarding expansion or additional inspections, IWB-2430 of the ASME Code, Section XI states, "The additional examinations shall be selected from welds, areas, or parts of similar material and service." The LTRs guidance to inspect welds of the same nomenclature on other loops is consistent with IWB-2430. Therefore, the NRC staff determined that the expansion inspections of Section 3.10.1 are acceptable.

Section 3.10.2 discussed scope expansion for accessible welds in an inaccessible weld program. For an inaccessible weld with Priority [ ], if flaws are found in its similar accessible welds during inspection, the expansion recommendation calls for inspection of [ ] in all the LPCI couplings in the plant. This first level of expansion is appropriate because instructing the licensee to inspect [ ] among similar accessible welds during the same refueling outage is responsive and is again consistent with IWB-2430 of the ASME Code, Section XI. If flaws are detected during the first level of expansion, Section 3.10.2 proposed adoption of the second

level of expansion: for the inaccessible weld with Priority [ ], all the [ ] should be inspected; for the Priority [ ] weld, the [ ] should be inspected [ ] during the same refueling outage [ ]. The NRC staff determined that this expansion strategy is appropriate for the Priority [ ] weld for the same reason as stated for the Level 1 expansion. For the Priority [ ] weld, since the selected similar accessible welds are unlikely to crack due to their low priority level, the inspection based on [ ] should be representative of all accessible welds. Further, inspection of the next and the last [ ] will be conducted, pending the inspection findings. The NRC staff accepts this proposed Level 2 expansion because, compared to the expansion inspection scope for the inaccessible welds with Priority [ ], a reasonably relaxed expansion inspection scope for the inaccessible welds with Priority [ ] is appropriate.

Re-inspection of Newly and Previously Detected Flaws

Section 3.5 of the LTR addresses re-inspection of the LPCI coupling components after baseline inspection. However, it did not provide specific inspection guidance for re-inspection of newly and previously detected flaws in LPCI coupling components. In the SE for BWRVIP-18, Revision 2 (proprietary: ADAMS No. ML16008A140; non-proprietary: ML16011A190), the NRC staff imposed a condition regarding re-inspection of newly and previously detected flaws in core spray piping and spargers. In that application, the condition requires re-inspections of newly detected flaws be conducted at every refueling outage until the crack has been stabilized (i.e., the CGR is below the proposed bounding CGR for two consecutive outages). For previously detected flaws, the condition requires re-inspection of these flaws at proposed future inspections for all welds to confirm that the measured CGRs (i.e., the calculated CGR based on the current and the last inspection flaw sizes) for all previously detected flaws are below the proposed CGR.

For LPCI couplings, since OE indicated that no flaws were found in them so far, and the geometry of the LPCI couplings are similar to piping susceptible to IGSCC where the proposed bounding CGR has been successfully applied, the NRC staff does not consider it necessary to impose a condition in this SE for newly detected flaws in LPCI couplings similar to that imposed in the BWRVIP-18, Revision 2 SE. However, the NRC staff still considers it necessary to maintain a slightly relaxed condition in this SE regarding the measured CGRs for previously detected flaws than the one specified in the BWRVIP-18, Revision 2 SE. The basis for imposing this condition is that there is no assurance that the CGR will remain bounded by the proposed bounding CGR many years into the future, considering plant-specific factors due to planned or unanticipated operational changes. Therefore, during proposed future inspections, the applicants must confirm that the measured CGRs (i.e., the calculated CGR based on the current and the last inspection flaw sizes) for all previously detected flaws are below the proposed CGR. If the measured CGR of any previously detected flaw exceeds the proposed CGR, the associated flaw evaluation must use this new CGR. This is Condition 2(b). The proposed inspection schedule will not be affected by this condition. Again, Condition 2(b) represents some relaxation from the corresponding condition in the BWRVIP-18, Revision 2 SE. This adjustment is justified considering the drastically different OE between core spray piping and spargers (BWRVIP-18, Revision 2; many detected flaws) and LPCI couplings (this LTR; no detected flaws).

Based on the above evaluation, the NRC staff determined that, with Condition 2(a) and 2(b), Section 3 of the LTR is acceptable.

3.2.4 Section 4, "Loads and Load Combinations"

Section 4 of the LTR is the only Section in the LTR which is identical to that in BWRVIP-42-A. On June 8, 2009, General Electric-Hitachi issued Safety Communication (SC) 09-01, "Annulus Pressurization Loads Evaluation," related to Annulus Pressurization (AP) loads and the corresponding stresses on the RPV, internals, and containment structures. Hence, RAI-10 requested the BWRVIP to provide additional guidance in Section 4 of this LTR, so that the AP loads can be properly addressed by licensees to reflect the correct hydrodynamic loads in response to SC 09-01.

The BWRVIP's response to RAI-10 stated that, "The potential impact on BWRVIP-42 Revision 1 would be a revision of the flaw analysis method contained in Section 5. However, the inspection requirements, which are not based fundamentally on flaw tolerance, would not be impacted." The NRC staff agrees with BWRVIP that the inspection requirements are not based fundamentally on flaw tolerance. However, considering that the AP loads may affect the flaw evaluation results for detected flaws and may affect the inspection interval for the inaccessible welds, the staff determined that all flaw evaluations to be performed in the future in accordance with Section 5 of this LTR must use the revised AP loads. In an E-mail dated March 3, 2016 (ADAMS Accession No. ML16063A477), the BWRVIP proposed to insert in Section 4.1.6, "Plants should reexamine their AP load calculations and update those calculations, where necessary, considering the potential for increased AP loads as documented in Reference X. (Reference X will be listed in Section 6 as *GE-Hitachi Safety Communication SC 09-01, "Annulus Pressurization Loads Evaluation," June 8, 2009.*)" With this proposed LTR revision, the NRC staff determined that the BWRVIP has provided clear guidance for relevant plants to update their analyses considering AP loads. RAI-10 is resolved, and Section 4 of the LTR is acceptable to the NRC staff.

3.2.5 Section 5, "Structural and Leakage Evaluation Methodologies"

For NDE uncertainty, Section 5.1.1.1 of the LTR indicates that [

]. This is acceptable because the NRC SE dated December 23, 2011 (ADAMS Accession No. ML113110505) resolved the open item on NDE uncertainty specified in the August 20, 2001, SE (ADAMS Accession No. ML012320436) for BWRVIP-63, "Shroud Vertical Weld Inspection and Evaluation Guidelines," which is now superseded by BWRVIP-76-A, "BWR Core Shroud Inspection and Flaw Evaluation Guidelines," (proprietary: ADAMS Accession No. ML101530467; non-proprietary: ML101530466). The NRC staff's acceptance of the BWRVIP's recommendation regarding NDE uncertainty is for all BWR RVIs.

Regarding consideration of postulated flaws in welds with partial access, Section 5.1.1.2 of the LTR recommends that (a) if the detected flaw length is "x" percent of the inspected length, then assume that [ ] percent of the uninspected length is cracked, or alternatively use a [ ] approach as described in BWRVIP-76-A; (b) if the detected flaw extends into the uninspected region, then assume [ ] the uninspected region is cracked; and (c) for completely inaccessible welds, use evaluation guidelines contained in Section 3.9 of this LTR. The NRC staff confirmed that the BWRVIP's recommendations regarding (a) and (b) above are identical to those in BWRVIP-18, Revision 1-A, and are, therefore, acceptable.

The Section 3.9 guidelines regarding (c) above for flaws in inaccessible welds are also acceptable based on the NRC staff's evaluation in Section 3.2.3 of this SE.

For CGR of a flaw due to the dominant IGSCC mechanism, Section 5.1.1.3 of the LTR recommends the same bounding CGR as that specified in BWRVIP-14-A, "Evaluation of Crack Growth in BWR Stainless Steel Internals," (proprietary: ADAMS Accession No. ML091390009; non-proprietary: ML101880724) and BWRVIP-18, Revision 1-A, both of which were previously found acceptable by the staff. Therefore, the consistent approach outlined in this LTR is also acceptable.

For the structural evaluation using limit load analysis, Section 5.1.2.1 of the LTR proposed to use the limit load analysis described in Appendix C of Section XI of the 1989 to 2001 Editions of the ASME Code as a basis, plus some additional features. The 2004 and later Edition of the ASME Code redefined flow stress, σ_f, for the piping materials and used a new set of structural factors (or safety factors) for applied loads. Since these elements have not been incorporated in the proposed limit load methodology of Section 5.1.2.1, RAI-6 requested BWRVIP revise the LTRs methodology to be consistent with the 2004 and later Editions of the ASME Code, Section XI, Appendix C.

The BWRVIP's response to RAI-6 provided a thorough evaluation of these two variations of the ASME Code, Section XI, Appendix C methodology. This evaluation is almost identical to the RAI response related to the BWRVIP-18, Revision 2 review. Based on the BWRVIP-18, Revision 2 SE, accepting the BWRVIP's limit load analysis without the two 2004 Edition revisions, the NRC staff accepts the proposed limit load analysis for LPCI piping. Therefore, RAI-6 is resolved.

Other important features in the 2004 and later Edition of the ASME Code, Section XI, Appendix C have been, however, incorporated in Section 5.1.2.1.1 of the LTR. They are (1) use of the same Z factor (a factor to correlate elastic plastic fracture mechanics results to limit load analysis results) for austenitic stainless steel shielded metal arc welds (SMAW) and submerged arc welds (SAW); and (2) use of new Z factors for Alloy 600 materials and the 82/182 welds. Both have been reviewed and accepted by the NRC, as indicated in 10 CFR 50.55a incorporating by reference the 2008 Edition of the ASME code for the former and the proposed Rule incorporating by reference the 2009 Edition of the ASME Code for the latter (80 FR 56820; September 18, 2015).

If multiple indications are detected during the inspection at a location, Section 5.1.2.1.2 of the LTR proposed to combine two flaws into one if the distance between them is less than [ ] the pipe thickness. This is more conservative than that approved in BWRVIP-158-A, "Flaw Proximity Rules for Assessment of BWR Internals," (proprietary: ADAMS Accession No. ML12349A339; non-proprietary: ML12349A070) and is, therefore, acceptable.

Regarding the proposed limit load methodology for multiple circumferential indications, Section 5.1.2.1.3 of the LTR proposed to [ ] and consider them as one indication. This is conservative and acceptable. In addition, the LTR proposed to use the limit load methodology described in BWRVIP-76-A as an alternative. Since the July 27, 2006, SE enclosed in BWRVIP-76-A did not evaluate any limit load methodology, RAI-7 requested BWRVIP confirm that "the limit load methodology described in BWRVIP-76-A" refers to the specific limit load

methodology of the Distributed Ligament Length (DLL) computer code presented in Appendix D of BWRVIP-76-A.

The BWRVIP's response to RAI-7 confirmed the above, which provides basis for the NRC staff's acceptance of this alternative contained in Appendix D of BWRVIP-76-A. Although the DLL limit load methodology was not discussed in the July 27, 2006, SE enclosed in BWRVIP-76-A, it was briefly discussed in the SE dated October 31, 2001, for Nine Mile Point, Unit 1 (ADAMS Accession No. ML012990403) and the SE dated October 30, 2000, for Nine Mile Point, Unit 2 (ADAMS Accession No. ML003747597). Therefore, the alternative DLL limit load methodology has already been accepted by the NRC, and RAI-7 is resolved.

Section 5.1.2.1.5 of the LTR provides an equation to calculate the time to reach the minimum acceptable structural margin based on the allowable flaw size that was determined by the proposed limit load analysis. However, the LTR does not state that for a detected flaw, the calculated time must be greater than or equal to the time to the next proposed scheduled inspection. In the March 3, 2016 E-mail, the BWRVIP proposed to insert in Section 5.1.2.1.5, "The calculated time to reach the minimum allowable structural margin must be greater than or equal to the time to the next proposed scheduled inspection. Otherwise, the inspection interval must be reduced." With this proposed LTR revision, the NRC staff determined that the BWRVIP has provided an appropriate acceptance criterion for the flaw evaluation of Section 5 of the LTR.

Section 5.1.3 of the LTR provides a limit on the leakage rate, [

].”
Accordingly, the leakage from all detected flaws in the accessible welds and assumed flaws in the inaccessible welds for a [ ] plant needs be limited to [ ] of normal core flow. The limit was established by the acceptable increase in the calculated value of [ ], which is a part of the plant-specific LOCA analysis. In the March 3, 2016 E-mail, the BWRVIP proposed to insert in Section 5.1.3, "In summary, plant leakage assessments must consider leakage from all potential sources. The total calculated leakage must be less than the allowable leakage to ensure the plant remains within their design basis. The leakage assessment should include all applicable references regarding the determination of calculated and allowable leakage." With this proposed LTR revision, the NRC staff determined that the BWRVIP has provided an appropriate acceptance criterion for the leakage evaluation of Section 5 of the LTR.

As in BWRVIP-18, Revision 1-A, BWRVIP-18, Revision 2, and BWRVIP-42-A, Section 5.1.4.1 of the LTR proposes the same simple formula for incompressible flow through an opening and, alternatively, the PICEP methodology (EPRI NP-3596-SR, "PICEP: Pipe Crack Evaluation Program (Revision 1)") based on a two-phase flow model for calculating the leak rate from cracks detected in accessible and partially accessible welds. The proposed leakage calculation is identical to the approved methodology, and, therefore, continues to be acceptable. Section 5.1.4.2 of the LTR also proposed steps to predict leak rates from inaccessible welds. In RAI-8, the NRC staff requested clarification regarding two of the ten steps and received satisfactory responses.

Based on the above evaluation, the NRC staff determined that Section 5 of this LTR is acceptable.

3.2.6 Appendix A, "BWR LPCI Coupling – Demonstration of Compliance with the Technical Information Requirements of the License Renewal Rule (10 CFR 54.21)"

Appendix A of the LTR is provided for LR applicants. Since Appendix A is identical to that evaluated in the NRC SE dated January 9, 2001, on BWRVIP-42, all approved technical and regulatory items remain acceptable in this SE. The added structural and leakage evaluation methodologies, as discussed in Section 3.2.5 of this SE, remain acceptable during the LR period because these methodologies are not affected by the additional 20 years of operation. However, to minimize the number of action items specified in the January 9, 2001, SE, RAI-9 requested the BWRVIP to address these action items so that they can be removed or simplified.

Action Item 1 requires the LR applicant to (1) verify that its plant is bounded by the BWRVIP-42 report; (2) commit to programs described as necessary in the BWRVIP-42 report to manage the effects of aging on the functionality of the LPCI coupling during the period of extended operation, and commit to follow the guidance in the approved BWRVIP-56 report, "LPCI Coupling Repair Design Criteria," if corrective actions are necessary; and (3) identify all deviations from the aging management programs referenced within the BWRVIP-42 report. Action Item 1(1) is addressed separately in the BWRVIP's response to RAI-1, which indicated that the two categorizations of LPCI couplings were developed after careful examination of generic and plant specific drawings, and it is believed that the categorizations are comprehensive and applicable to all BWR/4, /5 and /6 plants. Since the inspection guidelines are based on the general understanding of the LPCI design (as opposed to specific dimensions of the LPCI coupling components), and the proposed structural and leakage evaluation methodologies are generic and applicable to all BWR/4, /5 and /6 plants, it becomes unnecessary for the LTR to be bounding. The NRC staff agrees with this explanation, and Action Item 1(1) is resolved. Regarding Action Item 1(2), the BWRVIP's response to RAI-9 states, "With regard to commitments to follow BWRVIP guidance for LPCI couplings, in accordance with the NEI 03-08 Materials Initiative, all plants are required to follow the guidance in BWRVIP-42 and its companion repair design criteria, BWRVIP-56-A." Hence, Action Item 1(2) is resolved. Regarding Action Item 1(3), the BWRVIP proposed to add a new paragraph at the end of paragraph A.3.c:

> *If an applicant for license renewal will need to deviate from the requirements of BWRVIP-42 during the period of extended operation, the deviations and technical justifications will have to be identified by the renewal applicant and evaluated on a plant-specific basis in accordance with 10 CFR 54.21(a)(3) and (c)(1).*

With this new guidance on deviation from the requirements of the LTR, Action Item 1(3) is resolved. In summary, all aspects of Action Item 1 are addressed satisfactorily by the BWRVIP and Action Item 1 is no longer required by this SE for BWRVIP-42, Revision 1.

Action Item 2 requires the applicants for LR referencing BWRVIP-42 ensure that the programs and activities specified as necessary in the BWRVIP-42 report be summarily described in the final safety analysis report (FSAR) supplement. To address this issue, the BWRVIP's response to RAI-9 proposed to add a new paragraph to Appendix A:

A.6 Description of Aging Management Program in the License Renewal Supplement of the Final Safety Analysis Report (54.21(d))

If an applicant for license renewal has low pressure coolant injection (LPCI) couplings, the inspection and evaluation guidelines of BWR VIP-42 shall be summarily described in the Final Safety Analysis Report license renewal supplement in accordance with 10 CFR [54.21 (d)].

With this addition, Action Item 2 is addressed satisfactorily and needs not be specified as an action item in this SE for BWRVIP-42, Revision 1.

Action Item 3 requires the applicants for LR referencing BWRVIP-42 ensure that the inspection strategy described in the BWRVIP-42 report does not conflict with or result in any changes to their technical specifications. To address this, the BWRVIP's response to RAI-9 proposed to revise paragraph A.6 as follows:

Technical Specifications (TS) typically do not address inspection and evaluation requirements for LPCI couplings, thus there would be no changes or additions to the TS associated with LPCI couplings as a result of implementation of BWRVIP-42. If LPCI couplings are addressed in a plant's TS, the requirements of the TS supersede those of BWRVIP-42.

This is acceptable because the BWRVIP confirmed that, according to common industry practice, it is unlikely there would be changes or additions to the TS associated with LPCI couplings as a result of implementation of BWRVIP-42. Further, in the unlikely case that LPCI couplings are addressed in a plant's TS, the requirements of the TS supersede those of BWRVIP-42. This ensures that LR applicant will not use the approved version of BWRVIP-42, Revision 1 to replace TS requirements regarding LPCI. Therefore, Action Item 3 is addressed satisfactorily and needs not be specified as an action item in this SE for BWRVIP-42, Revision 1.

Action Item 4 requires the applicants referencing BWRVIP-42 for LR identify and evaluate any potential Time-Limited Aging Analysis (TLAA) issues which may impact the structural integrity of the subject RPV internal components. Paragraph A.4 of BWRVIP-42, Revision 1 is consistent with this requirement, except that this paragraph also states, "Alternatively, Section 5.0 also allows use of measured CGRs or plant-specific information in predicting the CGR." The BWRVIP's response to RAI-9 proposed to revise paragraph A.4 to include, "a lower crack growth rate may be used if….it is provided in the license renewal application for NRC review and approval." With this statement, Action Item 4 is addressed satisfactorily and needs not be specified as an action item in this SE for BWRVIP-42, Revision 1.

4.0 CONDITIONS AND LIMITATIONS

As stated in Section 3.2.2 of this SE, if the scheduled EVT-1 inspections specified in Table 3-1 of the LTR for Locations [ ] and [ ] have found flaws away from the weld centerline such that the detected flaws are very likely to be in the CASS material, the resulting flaw evaluation per LTR Section 5 shall be modified considering the reduced fracture toughness of CASS materials discussed in Appendix A of the SE for BWRVIP-234. This is imposed as Condition 1 on the applicants' use of the LTR regarding flaw evaluation for LPCI Coupling CASS Components. The staff recognized that because Locations [ ] is inaccessible, there will be only one or two inspections and associated flaw evaluations for it.

Condition 1 for Flaws in CASS Locations:

> For Locations [ ] and [ ], if the scheduled EVT-1 inspections specified in Table 3-1 of the LTR have found flaws away from the weld centerline such that these detected flaws are very likely to be in the CASS materials, the resulting flaw evaluation per LTR Section 5 shall be modified considering the reduced fracture toughness of CASS materials discussed in Appendix A of the SE for BWRVIP-234.

Section 3.2.3 of the LTR accepts use of 75% cracking of the similar accessible welds as a criterion for managing inaccessible welds. Due to the concern that if 50% and 75% of accessible similar welds become cracked in the future, the OE then, especially CGR, may be very different from the current OE where no cracking has been observed, the NRC staff imposed Condition 2(a) requiring applicants inform the NRC when these thresholds are reached so the NRC staff can reassess the overall inspection strategy and determine the need to review the latest information on OE, flaw evaluation, and leakage assessment for future safe operation of the LPCI couplings. Further, to ensure that the actual CGR is less than the bounding CGR assumed in the LTR, Section 3.2.3 imposed Condition 2(b) regarding re-inspections of previously detected cracks.

Condition 2(a) for Reporting Extensive Cracking:

> When 50% and 75% of accessible similar welds are cracked in the future, the applicant must inform the NRC Office of Nuclear Reactor Regulation by letter about reaching these two thresholds within 90 days of confirming these events so the NRC staff can reassess the overall inspection strategy and determine the need to review the latest information on OE, flaw evaluation, and leakage assessment for future safe operation of the LPCI couplings.

Condition 2(b) for Re-inspection of Previously Detected Flaws:

> In proposed future inspections, the applicants must confirm that the measured CGRs (i.e., the calculated CGR based on the current and the last inspection flaw sizes) for all previously detected flaws are below the proposed bounding CGR. If the measured CGR of any previously detected flaw exceeds the proposed CGR, the associated flaw evaluation must use this new CGR.

5.0 CONCLUSION

The NRC staff has reviewed the LTR and the supplemental information that was transmitted to the NRC staff by letter dated May 20, 2015 and E-mail dated March, 3, 2016. Based on its review, the NRC staff concluded that the BWRVIP's proposed inspection plan is acceptable with the Conditions addressed in Section 4.0 of this SE.

The NRC staff finds that the LTR, as modified to incorporate the NRC staff's conditions, provides an acceptable technical justification with respect to the proposed guidelines on inspections, flaw evaluations, and leakage assessments for the BWR LPCI coupling components. The LTR is considered by the NRC staff to be acceptable, in part, for licensee usage, as modified by the NRC staff requirements and recommendations given above, during either a facility's current operating term or extended license period.

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