BWRVIP-42NP, Revision 1-A: BWR Vessel and Internals Project

Low Pressure Coolant Injection (LPCI) Coupling Inspection and Flaw Evaluation Guidelines

3002010548NP

Final Report, November 2017

EPRI Project Manager
R. Carter

Work to develop this product was completed under the EPRI Nuclear Quality Assurance Program in compliance with 10 CFR 50, Appendix B and 10 CFR 21,

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NRC SAFETY EVALUATION

In accordance with an NRC request, the NRC Safety Evaluation immediately follows this page. Other pertinent NRC and BWRVIP correspondence are included in appendices.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

August 8, 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 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.

NOTICE: Enclosure transmitted herewith contains SUNSI. When separated from Enclosure, this transmittal document is decontrolled.

OFFICIAL USE ONLY – PROPRIETARY INFORMATION

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

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

Project No. 704

Enclosure:
Final Proprietary SE

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 [inaccessible welds] 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 [plant-specifically]. 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 [all of the remaining locations of the same type] 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 [accessible welds] 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 [2x] 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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Date: August 2016

ACKNOWLEDGEMENTS

This report was prepared by

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This report describes research sponsored by the Electric Power Research Institute (EPRI) and its BWRVIP participating members.

This report is based on the following previously published report:

BWRVIP-42, Revision 1: BWR Vessel and Internals Project, LPCI Coupling Inspection and Flaw Evaluation Guidelines, EPRI, Palo Alto, CA: 2010. 1020999.

This publication is a corporate document that should be cited in the literature in the following manner:

BWRVIP-42NP, Revision 1-A: BWR Vessel and Internals Project: Low Pressure Coolant Injection (LPCI) Coupling Inspection and Flaw Evaluation Guidelines. EPRI, Palo Alto, CA: 2017. 3002010548NP.

ABSTRACT

The Low Pressure Coolant Injection (LPCI) Coupling Inspection and Evaluation (I&E) guidelines contained in this document are generic, and are intended to present the appropriate inspection recommendations and evaluation procedures to assure the integrity of essential safety functions. Design information on the types of LPCI coupling is provided, and potential failure locations such as welds, bolts, and other appurtenances are identified. In determining the potential for failure, intergranular stress corrosion cracking (IGSCC) susceptibility was determined to be the principal failure mechanism. The consequences of each potential failure are also discussed. Based on susceptibility considerations and failure consequences, baseline inspection and reinspection programs are established. Finally, methodologies and suggested load combinations are presented for performing flaw evaluations in the event a flaw is identified during inspection. Guidelines on leakage calculations are also included.

Keywords
BWR Vessel and Internals Project (BWRVIP)
Low pressure coolant injection (LPCI) coupling
Inspection and Flaw Evaluation Guidelines
Leakage calculation

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EXECUTIVE SUMMARY

Deliverable Number: 3002010548NP

Product Type: Technical Report

Product Title: BWRVIP-42NP, Revision 1-A: BWR Vessel and Low Pressure Coolant Injection (LPCI) Coupling Inspection and Flaw Internals Project Evaluation Guidelines

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PRIMARY AUDIENCE: Boiling Water Reactor Vessel Internals Program (BWRVIP) Owners

SECONDARY AUDIENCE: Engineers responsible for defining inspection requirements for LPCI Coupling components in boiling water reactor (BWR) reactor internals

KEY RESEARCH QUESTION

The Boiling Water Reactor Vessel and Internals Project (BWRVIP), formed in June 1994, is an association of utilities focused exclusively on BWR vessel and internals issues. This BWRVIP report provides information on potential failure locations in BWR/4-6 LPCI coupling components, and recommends an inspection program to assure that the integrity of all LPCI safety functions is maintained. A previous version of this report was published as BWRVIP-42-A (EPRI Report 1011470). The report was revised (BWRVIP-42, Revision 1, EPRI Report 1020999) to incorporate the additional inspection requirements for inaccessible LPCI welds based on the methodology contained in BWRVIP-168 (*BWRVIP-168: BWR Vessel and Internals Project, Guidelines for Disposition of Inaccessible Core Spray Piping Welds in BWR Internals*, EPRI Report 1013390). This report, BWRVIP-42, Revision 1-A, incorporates changes requested by the Nuclear Regulatory Commission (NRC) Safety Evaluation of Revision 1 of the report.

RESEARCH OVERVIEW

A group of utility and industry experts evaluated available information, including BWR inspection data and information on intergranular stress corrosion cracking (IGSCC), to identify potential failure locations in BWR/4-6 LPCI components. The consequences and likelihood of a failure at each location were evaluated considering component function, plant-specific configuration variations, susceptibility, and inspection history. The project team then made inspection recommendations dependent on BWR type and, where appropriate, plant-specific configuration differences. The NRC Safety Evaluation (SE) of the report, pertinent NRC-BWRVIP correspondence, as well as conditions and limitations specified in the (SE) were added to the report.

KEY FINDINGS

- These guidelines provide design information on the types of LPCI couplings, and identify potential failure locations, such as welds, bolts, and other appurtenances. In determining the inspection strategy, the consequences of a failure in terms of safety and loss of function are the primary considerations.
- The guidelines present a "baseline", as well as a reinspection strategy. The baseline inspection will establish the current condition of the BWR fleet and may result in modifications to the current reinspection schedule.

- The guidelines also provide a methodology, as well as applicable loads and load combinations, for performing flaw evaluations if a flaw is identified during inspection. In addition, leakage calculation methods are outlined.
- The NRC Safety Evaluation (SE) of the report, pertinent NRC-BWRVIP correspondence, as well as conditions and limitations specified in the (SE) were added to the report.

WHY THIS MATTERS

The BWRVIP undertook a large effort to develop a comprehensive set of guides that will provide every member utility with the necessary information to make cost-effective decisions on degradation management for key components in their plant. This series of Inspection and Evaluation (I&E) Guidelines provides BWR owners with NRC-approved tools to answer such questions as: What needs to be inspected, when does it need to be inspected, and what is the technical basis for run-repair decisions when degradation is observed? Utility implementation of these guidelines for safety-critical BWR internals will assure that components have not approached safe limits, and thus confirm their serviceability.

HOW TO APPLY RESULTS

BWR utilities can incorporate the inspection and flaw evaluation guidelines in this report into their plant-specific BWR vessel internals inspection program.

LEARNING AND ENGAGEMENT OPPORTUNITIES

- Boiling Water Reactor Vessel Internals Project (BWRVIP)

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PROGRAM: Boiling Water Reactor Vessel Internals Project (BWRVIP) 41.01.03

IMPLEMENTATION CATEGORY: Category 1

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RECORD OF REVISIONS

Revision Number	Revisions
BWRVIP-42 (TR-108726)	Original Report
BWRVIP-42-A (1011470)	The report as originally published (TR-108726) was revised to incorporate changes proposed by the BWRVIP in responses to NRC Requests for Additional Information, recommendations in the NRC Safety Evaluation (SE), and other necessary revisions identified since the last issuance of the report. All changes except corrections to typographical errors are marked with margin bars. In accordance with a NRC request, the SE is included here as an appendix and the BWRVIP report number includes an "A" indicating the version of the report accepted by the NRC staff. A NRC Final Safety Evaluation accepting this report for referencing in license renewal applications is also included in an appendix. Non-essential format changes were made to comply with the current EPRI publication guidelines. Appendix B added: NRC Final Safety Evaluation of BWRVIP-42. Appendix C added: NRC Acceptance for Referencing Report for Demonstration of Compliance With License Renewal Rule. Details of the revision can be found in Appendix D.
BWRVIP-42, Revision 1 (1020999)	BWRVIP-42-A was revised to incorporate an inspection strategy and leakage evaluation for inaccessible welds. All changes, except corrections to typographical errors, are marked with margins bars. Details of the revision can be found in Appendix E.
BWRVIP-42, Revision 1-A (3002010548)	The previous version of this report (BWRVIP-42, Revision 1) was revised to incorporate changes proposed by the BWRVIP in responses to NRC Requests for Additional Information, recommendations in the NRC Safety Evaluation (SE) on BWRVP-42, Revision 1, and other necessary revisions identified since the last issuance of the report. All changes except corrections to typographical errors are marked with margin bars. In accordance with a NRC request, the SE is included here in the report frontmatter and the BWRVIP report number includes an "A" indicating the version of the report accepted by the NRC staff. Non-essential format changes were made to comply with the current EPRI publication guidelines. Appendices F-H added containing pertinent NRC-BWRVIP Correspondence Details of the revision can be found in Appendix I.

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INTRODUCTION

1.1 Background

Recently, the BWR Vessel and Internals Project (BWRVIP) prepared a safety assessment of BWR internals [1]. In the evaluation of the LPCI coupling, it was determined that, in the short-term, no action was required to address the low probability occurrences of failures in the coupling and their potential impact on leakage and loss of coolant to the downcomer region. However, for the long-term, the assessment recommended the evaluation of the overall significance of cracking at critical locations and development of inspection and evaluation guidelines to help assure long-term integrity and function.

1.2 Objectives and Scope

The LPCI coupling Inspection and Evaluation (I&E) guidelines contained in this report are generic and are intended to present the appropriate inspection recommendations and evaluation procedures to assure that the integrity of all LPCI safety functions are maintained. Economic and normal operational consequences of cracking are not factored into the recommendations. It is the intent that, for BWRVIP members, these guidelines can be followed in the place of prior SILs (Service Information Letters) and RICSILs (Rapid Information Communication Service Information Letters) to assure the integrity of the essential safety function of the component. The licensee is encouraged, however, to review all applicable SILs and RICSILs to determine any non-safety commercial issues that need to be addressed. The guidelines shall be used consistent with the plant-specific design basis, as appropriate.

The guidelines address the following:

- Component description and identification of LPCI coupling variations by plant type
- Identification of potential failure mechanisms and locations based on geometry, material, environment, susceptibility to stress corrosion cracking, and loads
- Inspection recommendations
- Loads and load combinations for use in flaw evaluations
- Flaw evaluation methodology for potential failure locations requiring inspection

This guideline provides plant-specific information on LPCI coupling configurations and materials of fabrication based on the best available information. Plants are advised to confirm the accuracy of this information to evaluate the applicability of the inspection recommendations.

These guidelines were developed under the applicable provisions of 10CFR50, Appendix B.

1.3 Implementation Requirements

In accordance with the implementation requirements of Nuclear Energy Institute (NEI) 03-08, Guideline for the Management of Materials Issues, Sections 3, 4 and 5 are "needed" and the remainder of the report is provided for information only.

2
LPCI COUPLING DESIGN AND SUSCEPTIBILITY INFORMATION

The low pressure coolant injection (LPCI) system is part of the Boiling Water Reactor (BWR) emergency core cooling system (ECCS). The purpose of this system is to restore and maintain the required water level inside the reactor shroud in the unlikely event of a loss of coolant accident (LOCA). This component is not used during normal operation.

The LPCI coupling is classified as an "essential" component, and is designed to provide a flow path between the reactor vessel nozzle thermal sleeve and the core shroud. LPCI couplings are applicable to newer BWR/4 plants, BWR/5 and BWR/6 plants.

LPCI Coupling in BWR/4 and BWR/5 Plants

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LPCI Coupling in BWR/6 Plants

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While the entire assembly is generally very similar in all plants, there are some differences in the design, fabrication conditions, and materials that exist in the different types of BWRs, as well as between plants of the same BWR type.

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Figure 2-1
Typical LPCI coupling arrangement-BWR/4/5

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Figure 2-2
Typical LPCI coupling -BWR/4/5

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Figure 2-3
LPCI coupling details -BWR/4/5-thermal shield

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EPRI Proprietary Information

Figure 2-4
LPCI coupling details-BWR/4/5-shroud attachment ring

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Figure 2-5
LPCI coupling details-BWR/4/5-sleeve flange-1

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Figure 2-6
LPCI coupling details-BWR/4/5-sleeve flange-2

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Figure 2-7
LPCI coupling details-BWR/4/5-clamp and eye bolt

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Figure 2-8
LPCI coupling details-BWR/4/5-coupling sleeve

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Figure 2-9
LPCI coupling details-BWR/4/5-baffle arrangement

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Figure 2-10
LPCI coupling details-BWR/4/5-baffle welds

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Figure 2-11
Typical LPCI coupling-BWR/6

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Figure 2-12
Typical LPCI coupling-BWR/6-general arrangement

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Figure 2-13
LPCI coupling-BWR/6-details

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Figure 2-14
LPCI coupling-BWR/6-thermal shield

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Figure 2-15
LPCI coupling-BWR/6-shroud attachment flange

2.1 Susceptibility Factors

Degradation in the LPCI coupling components can be due to intergranular stress corrosion cracking (IGSCC) or fatigue. Once crack initiation occurs, subsequent crack growth and aging embrittlement can be additional mechanisms that cause degradation. IGSCC includes not only cracking due to material sensitization but also irradiation assisted stress corrosion cracking (IASCC).

2.1.1 Intergranular Stress Corrosion Cracking

There are a number of factors which affect the susceptibility of the LPCI coupling to cracking. The occurrence of IGSCC relies on the simultaneous, combined presence of a corrosive environment, a susceptible material and an applied and/or residual tensile stress greater than some threshold value. A general discussion of susceptibility is provided in the following paragraphs.

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Figure 2-16
LPCI coupling-BWR/6-coupling sleeve

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Figure 2-17
LPCI coupling-BWR/6-flow diverter

2.1.1.1 Environment

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2.1.1.2 Materials

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2.1.1.3 Stress State

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2.1.2 Fatigue

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2.1.3 Aging Embrittlement

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2.2 Potential Failure Locations

This section identifies the potential failure locations in the LPCI coupling assembly. Discussions are included on the failure mechanisms and the resulting safety consequences based on the considerations described below. The discussions lead to the categorization and selection of the appropriate inspection methodology.

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Based on this categorization, and depending upon the nature of the component/failure location, appropriate inspection methodology will be identified in Section 3.

Table 2-1 provides a summary of the potential failure locations for the BWR/4/5 and BWR/6 plants, as applicable. For convenience, the locations are labeled with a prefix of '45' or '6' to denote its applicability to BWR/4/5 or BWR/6, respectively. The variations of the hardware configurations and materials among the BWR plants are summarized in Table 2-2. The materials shown in Table 2-2 are based on the original design and material specifications and on known upgrades. The actual materials should be verified by each plant using this guideline.

Detailed discussion on each potential failure location follows.

Table 2-1
Potential LPCI coupling failure locations

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Table 2-2
Plant type-LPCI coupling type matrix

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2.2.1 Potential Failure Locations-BWR/4/5

This section identifies the potential failure locations in the BWR/4/5 LPCI coupling assemblies. Discussions are included on the failure mechanisms and the resulting safety consequences based on the considerations discussed earlier in paragraph 2.2 as well as the specific susceptibility information identified for each location. The discussions lead to the inspection prioritization of each location. Based on this prioritization, inspection recommendations are made in Section 3.

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2.2.2 Potential Failure Locations-BWR/6

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3
INSPECTION STRATEGY

3.1 Background

Specific inspection guidelines for the different locations in the LPCI couplings are discussed in this section. The guidelines were developed based on the susceptibility, environment, and safety significance of failure of each location as discussed in Section 2.

3.1.1 LPCI Coupling Inspection History

Research of Service Information Letters (SILs) does not identify any SIL related to crack indications in the LPCI coupling(s). The only SIL associated with LPCI is for BWR/6 (SIL No. 401, [10]), according to which in-core instrumentation damage occurred in a plant when, instead of using the feedwater line for RHR cooling function, the emergency core cooling system (LPCI) was inappropriately used as an alternate path for routine, normal shutdown cooling function. Subsequently, flow deflectors were installed inside the shroud at the LPCI discharge inlet to protect the instrumentation and fuel assemblies from potential damage caused by flow impingement.

SIL 401 applies limitations on the use of LPCI for non-emergency/non-accident conditions. Even after the installation of the flow diverter, if repeated use of the LPCI return path is anticipated, planned, or recorded, SIL 401 recommends tracking the usage of LPCI reactor nozzles and components and recommends further evaluation if the design number of cycles is being approached by such applications.

The BWRVIP inspection and evaluation guidelines are meant to replace safety related inspection guidance in the GE SILs. However, since SIL 401 does not contain safety related inspection guidance, no SILs are superseded by this guideline.

Visual inspections (VT-1, VT-3) have been performed for the LPCI couplings in several plants, as documented in the Vessel Internals Inspection Summary [11], according to which, no indications or cracking in the components/welds have been recorded. However, based on the susceptibility information, and safety/functional significance of potential failures, inspection recommendations are developed below. As inspections are conducted and the actual conditions of the LPCI couplings are better established, the recommendations may be adjusted.

3.2 BWRVIP Inspection Basis

The BWRVIP guidelines are intended to provide flexible options for inspection while assuring that the structural integrity and function of the LPCI coupling, as well as plant safety, are adequately maintained. The guidelines are generic based on the overall understanding of the LPCI design. There may be plant-specific situations where more rigorous inspections are

required or less rigorous inspections are justified due to, for example, plant-specific material information.

As discussed in Section 2.2, several factors were considered in prioritizing the inspections of the potential failure locations. Based on those considerations, the prioritization is as follows:

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Based on this categorization, and depending upon the nature of the component/failure location and susceptibility conditions, appropriate inspection methodologies and strategies are specified.

3.3 Inspection Methods

The typical methods for inspection are described below. Definitions can be found in the latest version of BWRVIP-03 [4].

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3.3.1 Basis for the Recommendation of Specific Inspection Methods

For the purpose of specifying inspection techniques in this guideline, consideration was given to the ability of the techniques to obtain accurate and meaningful data on the flaw. \

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3.4 Baseline Inspection

The baseline inspection recommendations in this guideline are intended to determine the current condition of the LPCI coupling assemblies. In-vessel visual inspections (IVVI) that have been performed for some of the plants may provide valuable information towards early detection of cracking. Such previous inspections that meet the baseline inspection guidelines of this BWRVIP document may qualify as valid "baseline" inspection information, even if it was performed prior to the issuance of the guidelines.

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3.5 Reinspection

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3.5.1 Reinspection Schedule

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3.5.2 Reinspection Schedule for Previously Detected Flaws

In proposed future inspections, the utilities must confirm that the measured CGRs (i.e., the calculated CGR based on the current and 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.

Table 3-1
Inspection guidelines matrix

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Table 3-1 (continued)
Inspection guidelines matrix

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Table 3-1 (continued)
Inspection guidelines matrix

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Table 3-1 (continued)
Inspection guidelines matrix

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Table 3-1 (continued)
Inspection guidelines matrix

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Table 3-1 (continued)
Inspection guidelines matrix

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3.6 Consideration of Un-inspectable Areas in Partially Accessible Welds

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3.7 Inaccessible Welds

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3.8 Inspection Strategy for Accessible and Inaccessible Weld Programs

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3.9 Inspection Program for Inaccessible Welds

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Figure 3-1
Overview of accessible and inaccessible weld inspection programs

3.9.1 Basis for the Allowable Inspection Interval for Inaccessible Welds

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Note: When 50% and then again when 75% of accessible similar welds are found to be cracked in the future, the utility 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.

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3.9.2 Similar Accessible Welds

3.9.2.1 Susceptibility Categories

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3.9.2.2 Similar Accessible Welds for Weld 45-12

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3.9.2.3 Similar Accessible Welds for Weld 6-1a

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3.9.3 Guidelines for Determining the Inspection Interval for Inaccessible Welds

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3.9.4 Example Inspection Interval Determination for Inaccessible Welds

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3.10 Scope Expansion for Accessible and Inaccessible Weld Inspection Programs

3.10.1 Accessible and Partially Accessible Welds

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3.10.2 Inaccessible Welds

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4
LOADS AND LOAD COMBINATIONS

In the event that plant-specific flaw evaluations are required, loads and load combinations are needed for use in the analysis. This section describes the details of the various applicable loads and load combinations (including 'New Loads') which need to be considered in determining the primary and secondary stress levels for the various operating conditions. Any plant-unique loads and load combinations shall also be considered, as applicable. Notwithstanding the recommendations in this section, the loads and load combinations used in analysis should be consistent with the plant design and licensing basis.

4.1 Loads

The applicable significant loads are defined in this section.

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4.1.1 Normal Load

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4.1.2 Differential Pressure

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4.1.3 Seismic Loads

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4.1.4 Fluid Drag

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4.1.5 Safety/Relief Valve Discharge Hydrodynamic Loads

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4.1.6 Loss-of-Coolant Accident (LOCA) Hydrodynamic Loads

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Plants should reexamine their AP load calculations and update those calculations, where necessary, considering the potential for increased AP loads documented in Reference 14.

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4.1.7 Application of Hydrodynamic Loads

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4.1.8 Thermal Loads

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4.1.9 Flow Induced Vibration

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4.2 Load Combinations

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4.3 Consideration of Shroud Repair

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5
STRUCTURAL AND LEAKAGE EVALUATION METHODOLOGIES

Structural and leak rate evaluations must be performed to ensure that adequate structural and leakage margins are maintained for cracked LPCI coupling components during operation. This section describes the structural and leak rate evaluation methodologies and computational procedures needed to evaluate cracks in both accessible and inaccessible welds. Crack growth considerations also are provided.

The structural and leakage evaluation approaches for pressure retaining welds are presented in Section 5.1. Different evaluation approaches are used for the attachments, such as the strut and attachment ring welds, and are described separately in Section 5.2.

Note: For locations [ ] and [ ], if scheduled EVT-1 inspections specified in Table 3-1 identify flaws away from the weld centerline such that the detected flaws are very likely to be in the CASS material (LPCI sleeve flange or shroud attachment ring if CASS), the resulting flaw evaluation per Section 5.0 shall be modified considering the reduced fracture toughness of CASS materials discussed in Appendix A of the SE for BWRVIP-234 (See BWRVIP-234-A).

5.1 Pressure Retaining Weld Locations

This section provides methods for evaluating the acceptability of flaws in pressure retaining welds in the LPCI coupling assembly.

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5.1.1 Flaw Characterization

5.1.1.1 NDE Uncertainty

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5.1.1.2 Consideration of Welds with Partial Inspection Access

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5.1.1.3 Crack Growth

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For cracks in the circumferential direction, a crack growth rate of $5x10^{-5}$ inch/hot hour should be used in the evaluation of the LPCI coupling. However, a lower crack growth rate can be used, if technically justified and documented in a deviation disposition in accordance with BWRVIP-94 Revision 2 [15].

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5.1.2 Structural Evaluation

5.1.2.1 Limit Load Evaluation Methodology

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Figure 5-1
Stress distribution in a cracked pipe at limit load

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5.1.2.1.2 Flaw Proximity Considerations

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5.1.2.1.3 Limit Load Methodology for Multiple Circumferential Indications

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5.1.2.1.4 Allowable Flaw Size Determination

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5.1.2.1.5 Time to Reach the Minimum Acceptable Structural Margin

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5.1.3 Leakage Considerations

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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 that the plant remains within their design basis. The leakage assessment should include all applicable references regarding the determination of calculated and allowable leakage.

5.1.4 Leak Rate Calculation Methods

5.1.4.1 Leak Rate from Cracks Detected in Accessible and Partially Accessible Welds

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5.1.4.2 Leak Rate from Cracks in Inaccessible Welds

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5.1.4.2.1 Example Applications

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Table 5-1
Calculated leak rate distribution for eight similar accessible welds with through-wall flaws

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Figure 5-2
Plot of the leak rate distribution for similar accessible welds and the estimated leak rates for inaccessible welds

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Table 5-2
Calculated leak rate distribution for three similar accessible welds with through-wall flaws

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5.2 Flaw Evaluation of Other Weld Locations

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13. Board Approved ASME Section XI Standards Committee Record Number 07-2010, Incorporate Procedures for Evaluation of Flaws in Alloy 600/82/182/132 Piping and Welds into Appendix C of Section XI, to be published in the 2009 Addenda of the ASME Boiler and Pressure Vessel Code, Section XI.
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A

BWR LPCI COUPLING—DEMONSTRATION OF COMPLIANCE WITH THE TECHNICAL INFORMATION REQUIREMENTS OF THE LICENSE RENEWAL RULE (10 CFR 54.21)

The purpose of Appendix A is to demonstrate that this report provides the necessary information to comply with the technical information requirements pursuant to paragraphs 54.21 [a] and [c], and 54.22, and the NRC's findings under 54.29 [a] of the license renewal rule [A-1]. It is intended that the NRC's review and approval of Appendix A will allow utilities the option to incorporate the report and Appendix by reference in a plant-specific integrated plant assessment (IPA) and time-limited aging analysis (TLAA) evaluation. If a license renewal applicant confirms that this report applies to their plant's current licensing basis (CLB) and that the results of the Appendix A IPA and TLAA evaluation are in effect at their plant, then no further review by the NRC of the matters described herein is needed.

A.1 Description of the BWR LPCI Coupling and Intended Functions

The low pressure coolant injection (LPCI) system is part of the Boiling Water Reactor (BWR) emergency core cooling system (ECCS). The purpose of this system is to restore and maintain the desired water level inside the reactor shroud in the unlikely event of a loss of coolant accident (LOCA). For the newer BWR/4 plants, and BWR/5 and BWR/6 plants, the coolant is injected into the core through the LPCI coupling. The coupling provides a flow path between the reactor vessel LPCI nozzle safe end/thermal sleeve and the core shroud cylinder. This flow path is not used during normal operation A description of the coupling assemblies in each type of plant is provided in the following paragraphs. Differences in design, fabrication and materials for the different types of BWRs, as well as between plants of the same BWR type, are identified in Table 2-2.

A.1.1 LPCI Coupling in BWR/4 and BWR/5 Plants

The newer BWR/4 and the BWR/5 plants have essentially identical couplings. Typical coupling arrangement and details are shown in Figures 2-1 to 2-10. There are four coupling assemblies per newer BWR/4 plant and three coupling assemblies per BWR/5 plant. The piping arrangement in these plants discharges the flow into the shroud in the upper shroud region, at the top elevation. The coupling extends horizontally from the vessel to the shroud. The sleeve type coupling is designed to be removable and is attached by V-groove band clamps to flanges fixed at the shroud and at the Reactor Pressure Vessel (RPV) nozzle safe end/thermal sleeve. A slip joint is designed at each end of the coupling sleeve. Piston ring seals are included at the flange/sleeve slip joints to minimize leakage flow. Stellite #6 is applied to the contact surface of the sleeve and the flange to provide hard contact surface and facilitate relative motion. A baffle/channel arrangement exists

inside the shroud which serves to direct the flow under the top guide and into the core area. A typical baffle arrangement is shown in Figures 2-9 and 2-10.

Bellow-type couplings are used in two plants outside of the United States. This report and Appendix does not apply to plants with bellow-type coupling assemblies.

A.1.2 LPCI Coupling in BWR/6 Plants

There are three coupling assemblies per BWR/6 plant. Typical coupling arrangement and details are shown in Figures 2-11 to 2-17. The arrangement in the RPV-shroud annulus consists of two elbows, the upper one connected to the RPV safe end and the lower one connected to the shroud, just below the flange which seats the top guide. The components connecting the two elbows include: a fitting welded to the ends of the elbows, a sleeve coupling interface between the elbows, with its ends housed inside collars which are threaded to the fittings. This provides a slip joint at each end of the sleeve. Piston ring seals are included at the collar/sleeve slip joints to minimize leakage flow. Stellite #6 is applied to the contact surface of the sleeve and the collar to provide hard contact surface and facilitate relative motion. In order to minimize flow-induced vibration effects, a strut is welded to the lower elbow, bracing it to the shroud. The injection point inside shroud is directed to a location below the grid. A flow diverter exists at the inlet inside the shroud, which consists of a splash plate welded to the shroud inner wall by four legs. A typical flow diverter is shown in Figure 2-17.

A.1.3 LPCI Coupling Intended Function

The LPCI coupling is required to ensure the capability to shut down the reactor and maintain it in a safe-shut down condition (54.4(a)(1)(ii)) and prevent or mitigate the consequences of accidents that could result in potential offsite exposure comparable to 10 CFR 100 guidelines (54.4(a)(l)(iii)). Therefore, the intended function for the LPCI coupling is to provide a flow path between the RPV nozzle safe end, thermal sleeve and the core shroud cylinder so that the LPCI system can restore and maintain the desired level inside the core shroud in the event of loss coolant accident.

The intended function is preserved under normal, upset, emergency, and faulted conditions. Section 4.0 describes the details of the various loading and load combinations that need to be considered to determine that stress levels for the various operating conditions are consistent with the CLB.

A.2 LPCI Coupling Components Subject to Aging Management Review

Paragraph 54.21(a)(l) of the rule provides the requirements for identifying the LPCI coupling components that are subject to aging management review. To satisfy the requirements of 54.21(a)(l), the guidance provided in the NEI industry guideline [A-2] was used to identify passive components and then to identify those that are long-lived. For the LPCI coupling, a screening methodology was not needed to make this determination. All of the components in the LPCI coupling are passive and long-lived and are subject to aging management review.

A.3 Management of Aging Effects (54.21[a][3])

a. Description of Aging Effects

   The BWR Reactor Pressure Vessel Internals Industry Report [A-3] and the resolution to the NRC's questions on the Industry Report are used to identify the aging mechanisms for the

reactor vessel internals. Aging mechanisms are the causes of the aging effects. The NUREG 1557 [A-4] is used to establish the correlation between the aging effects and their associated aging mechanisms. The LPCI coupling is not specifically addressed in the industry report, however the mechanisms affecting the coupling are described and evaluated. Using the susceptibility assessment provided in Section 2.0 and the industry report assessment of the age-related degradation mechanisms, it was determined that crack initiation and growth is the aging effect that requires aging management review for the LPCI coupling. The industry report concludes that internals components are not susceptible to thermal aging embrittlement provided the materials of construction are wrought austenitic stainless or Ni-Cr-Fe alloy. Since some of the LPCI coupling components are constructed using cast materials, thermal embrittlement is a potential degradation mechanism. Cast components with high ferrite contents are susceptible to thermal embrittlement; however, this condition does not cause cracking. Thermal embrittlement results in a lower fracture toughness. Fracture toughness was not a limiting condition in the design of the LPCI coupling cast components, because the applied stresses are relatively low at all operating conditions. The components would not be susceptible to IGSCC because low ferrite conditions are required to promote IGSCC. Therefore, the effects of thermal embrittlement on the LPCI coupling are determined to be insignificant and will not be subject to aging management review for license renewal. Fatigue was also evaluated, as shown in Section 2.0, and was determined not to be a significant aging mechanism. Since relative motion occurs between the sleeve and flange, wear was also evaluated as a potential aging mechanism. Based on the original design analysis, the relative motion of the sleeve to flange joint is small, and the wear surfaces are hardened; therefore, wear is not considered a significant aging mechanism in the period of extended operation, and will not be subject to aging management review. Similarly, the piston ring seal undergoes small relative motion, and wear is not considered a significant aging mechanism. These conclusions are consistent with the scope and intent of this report.

The causes of crack initiation and growth and a susceptibility assessment for the LPCI coupling are provided in Section 2.0. The susceptibility factors of environment, materials, and stress state are discussed in Section 2.1. A discussion of the potential failure locations is presented for each of the LPCI coupling locations which are discussed individually in Section 2.2. In general, it was determined that:

1. many locations in the LPCI coupling are subjected to an aggressive environment and within a region of high electrochemical corrosion potential (ECP),
2. LPCI coupling materials at locations where a heat affected zone or excessive cold work exists may be susceptible to crack initiation and growth due to SCC,
3. based on the configuration, most LPCI coupling components regardless of the grade of material are potentially susceptible to crack initiation and growth, and
4. regions with the highest expected crack initiation and growth susceptibility are the creviced locations, especially those creviced regions subject to high weld residual stresses. Some of the welds in the LPCI coupling are creviced. Each specific weld region is discussed in the Section 2.2 description of the potential failure locations.

b. Assessment of Aging Effects and Programs

The LPCI coupling inspection history is described in Section 3.0. There is very limited information available due to accessibility limitations. The generic vendor communications

that apply to the LPCI coupling and address the crack initiation and growth aging effects are also identified. The potential failure locations for each LPCI coupling component is individually discussed in Section 2.2.

Table 3-1 summarizes the inspection recommendations for each LPCI coupling location. These recommendations are based on the results of a conservative safety assessment of each location. The details of the safety assessment are described in Section 2.2. Redundancy considerations within the LPCI coupling are used in the basis for some of the components to determine the inspection priority and strategy; however, redundancy was not used to eliminate inspections. In this case, the term 'redundancy' describes the inherent design features of the coupling, which prevent some components from completely separating. In other words, failure of certain components will still permit the LPCI to retain its function with acceptable leakage. Redundancy with respect to an independent system (e.g., core spray) is not utilized in defining the inspection requirements. For license renewal, the assessment for these components was re-performed without redundancy considerations. It was determined that the Section 2.2 and Table 3-1 conclusions with respect to inspection priority and strategy would not be affected. Based on these assessments, the following LPCI coupling components/welds need to be addressed with a plant-specific inspection strategy for license renewal:

BWR 4/5

- Shroud attachment ring to shroud weld
- Clamp/bolt assembly
- Clamp eye bolt to clamp weld
- Eye bolt nut to clamp weld

BWR 6

- Elbow and elbow extension welds
- Thermal shield split halves to shield ring weld
- Thermal shield ring to elbow extension weld
- Strut to shroud weld
- Strut to elbow pad weld
- Elbow pad to elbow weld
- Shroud attachment ring to elbow extension weld
- Shroud attachment ring to shroud weld

The applicant will need to demonstrate that: 1) the safety assessment of individual LPCI coupling components, and 2) the evaluation of the safety consequences of individual LPCI coupling component failure, applies to their plant's CLB.

The inspection strategy for the LPCI coupling involves a baseline inspection of the recommended locations using modified visual (VT). The modified visual examination methods are briefly discussed in Section 3.2. A reference to the implementation requirements and definitions for these methods is also provided. Section 3.4 describes baseline inspection approaches and provides implementation guidance. Reinspection approaches are described in

Section 3.5. Should degradation be detected in a LPCI coupling component or weld, Section 3.4.1 presents the scope expansion methodology.

c. Demonstration that the Effects of Aging are Adequately Managed

Crack initiation and growth is the aging effect for the LPCI coupling that require aging management review for license renewal. These aging effects will be managed by an inspection program incorporating the recommendations described in Section 3.0. The inspection methods and implementation guidance addresses the:

- The LPCI coupling locations that require inspection.
- Extent of baseline inspection for each location.
- Extent of reinspection for each location.
- Methodology for scope expansion should degradation be detected.
- Analysis methods to determine the need for corrective action if degradation is detected.

Implementation of the inspection recommendations in an inspection program and the resulting plant-specific strategy will provide a verification of the LPCI coupling structural integrity requirements. Therefore, there is reasonable assurance that crack initiation and growth will be adequately managed so that the intended functions of the LPCI coupling will be maintained consistent with the CLB in the extended operating period.

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).

A.4 Time Limited Aging Analyses (54.21[c][1])

The six criteria contained in the NEI industry guideline (Reference A. [3]) were applied to identify the time limited aging analysis (TLAA) issues. That is, those calculations and analyses that:

1. Involve the LPCI coupling,
2. Consider the effects of aging,
3. Involve time-limited assumptions defined by the current operating term,
4. Were determined to be relevant in make a safety determination,
5. Involved conclusions or provide the basis for conclusions related to the capability of the LPCI coupling to perform its intended function, and
6. Are incorporated or contained by reference in the CLB.

If a plant-specific analysis identified by an applicant meets all six criteria above, then this analysis will be considered a TLAA for license renewal and evaluated by the applicant. The crack growth rate applied in flaw evaluation methodologies may result in a plant-specific TLAA issue. A bounding crack growth rate is established for the flaw evaluation methodologies in Section 5.0. Alternatively, a lower crack growth rate may be used if it can be technically

justified, is reviewed by the applicant to determine if the TLAA criteria apply, and is provided in the license renewal application for NRC review and approval.

A.5 Exemptions (54.211c1[21)

Exemptions associated with LPCI coupling that contain TLAA analysis issues will be identified and evaluated for license renewal by individual applicants.

A.6 Technical Specification Changes or Additions (54.22)

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.

A.7 Demonstration that Activities will Continue to be Conducted in Accordance with the CLB (54.29[a])

Sections A.1, A.2, and A.3 address the requirements 54.21(a) of the rule. The LPCI coupling components that are subject to aging management review are identified, and it is demonstrated that the effects of aging are adequately managed.

Sections A.4 and A.5 address the requirements of 54.21(c) of the rule. Plant-specific time limited aging analyses (TLAAs) and exemptions that require evaluation will be evaluated by the applicant.

Section A.6 addresses the requirements of 54.22 of the rule. There are no technical specification changes or additions necessary to manage the effects of aging for the LPCI coupling during the period of extended operation.

Therefore, actions have been identified and have been or will be taken by utilities with BWR plants, such that there is reasonable assurance that the activities authorized by license renewal for the LPCI coupling will conducted in accordance with the CLB.

A.8 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 BWRVIP-42 shall be summarily described in the Final Safety Analysis Report license renewal supplement in accordance with 10 CFR [54.21(d)].

A.9 References

8. A-1 Title 10 of the Code of Federal Regulations, Part 54, "Requirements for License Renewal of Operating Licenses for Nuclear Power Plants," (60 Federal Register 22461), May 8, 1995.

9. A-2 Nuclear Energy Institute Report NEI 95-10 (Rev. 0), Industry Guideline for Implementing the Requirements of 10 CFR Part 54 the License Renewal Rule.

10. A-3 NUMARC 90-03, BWR Reactor Pressure Vessel Internals License Renewal Industry Report, Revision 1, June 1992.

11. A-4 NUREG-1557, Summary of Technical Information and Agreements from Nuclear Management and Resources Council Industry Reports Addressing License Renewal, October 1996.

B
NRC FINAL SAFETY EVALUATION

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

May 26, 2000

Carl Terry, BWRVIP Chairman
Niagara Mohawk Power Company
Post Office Box 63
Lycoming, NY 13093

SUBJECT: FINAL SAFETY EVALUATION OF THE "BWRVIP VESSEL AND INTERNALS PROJECT, "BWR VESSEL AND INTERNALS PROJECT, LPCI COUPLING INSPECTION AND FLAW EVALUATION GUIDELINES (BWRVIP-42)," (TAC NO. MA1102)

Dear Mr. Terry:

The NRC staff has completed its review of the Electric Power Research Institute (EPRI) proprietary report TR-108726 "BWR Vessel and Internals Project, LPCI Coupling Inspection and Flaw Evaluation Guideline (BWRVIP-42)." This report was submitted to the U.S. Nuclear Regulatory Commission (NRC) for staff review by letter dated December 11, 1997, and was supplemented by letter dated September 8, 1998. It provides generic guidelines intended to present the appropriate inspection recommendations to ensure the integrity and safety function of the subject safety-related low pressure coolant injection (LPCI) couplings.

By letter dated October 21, 1999, the BWRVIP responded to the open items in the staff's initial safety evaluation (SE), dated June 14, 1999. The NRC staff has reviewed the proposed revisions to the BWRVIP-42 report and finds, in the enclosed SE, that the revised guidance of the BWRVIP-42 report, with the modifications as described in the attached SE, is acceptable for inspection of the subject safety-related RPV internal components. This finding is based on information submitted by the above cited letters. The staff has concluded that licensee implementation of the guidelines in the BWRVIP-42 report, as modified, will provide an acceptable level of quality for inspection and flaw evaluation of the safety-related components addressed.

The staff requests that you incorporate the staff's recommendation, as well as your responses to other issues raised in the staff's initial SE, into a revised, final BWRVIP-42 report. Please inform the staff within 90 days of the date of this letter as to your proposed actions and schedule for such a revision.

Carl Terry -2-

Please contact C. E. (Gene) Carpenter, Jr., of my staff at (301) 415-2169, if you have any further questions regarding this subject.

Sincerely,

Jack Strosnider

Jack R. Strosnider, Director
Division of Engineering
Office of Nuclear Reactor Regulation

Enclosure: As stated

cc: See next page

U.S. NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION SAFETY EVALUATION OF
"BWR VESSEL AND INTERNALS PROJECT, LPCI COUPLING INSPECTION
AND FLAW EVALUATION GUIDELINES (BWRVIP-42),"
EPRI TOPICAL REPORT TR-108726, DECEMBER 1997

1.0 INTRODUCTION

1.1 Background

By letter dated December 11, 1997, as supplemented by letter dated September 8, 1998, the Boiling Water Reactor Vessel and Internals Project (BWRVIP) submitted both the proprietary and non-proprietary versions of the report, "BWR Vessel and Internals Project, BWR LPCI Inspection and Flaw Evaluation Guidelines (BWRVIP-42)," for NRC staff review and approval. The NRC staff requested additional information (RAI) in a letter dated April 14, 1998, and BWRVIP responded to the RAI by letter dated September 8, 1998.

The BWRVIP-42 report contains generic guidelines to BWRVIP members on inspection and flaw evaluation of low pressure coolant injection (LPCI) couplings. These guidelines considered degradation susceptibility, degradation mechanisms, loads, and inspection strategies for LPCI couplings. The intent of the report, when approved by NRC, is to provide an acceptable level of quality and inspection and flaw evaluation guidance to BWRVIP members that can be used to assure adequate BWR LPCI coupling integrity when meeting the specified acceptance criteria.

By letter dated June 14, 1999, the staff forwarded its initial safety evaluation (SE) of the BWRVIP-42 report to BWRVIP. This SE had several open items, repeated below, and requested that BWRVIP address these issues in a timely manner. By letter dated October 21, 1999, BWRVIP responded to the open items in the staff's initial SE.

1.2 Purpose

The staff reviewed the BWRVIP-42 report, as supplemented, to determine whether its revised guidance addressed the open items in the staff's initial SE, and if it would provide acceptable levels of quality for inspection and flaw evaluation (I&E) of the subject safety-related RPV internal components. The review considered the consequences of component failures, potential degradation mechanisms and past service experience, and the ability of the proposed inspections to detect degradation in a timely manner.

1.3 Organization of the Report

Because the BWRVIP-42 report, as revised, is proprietary, this SE was written so as not to repeat proprietary information contained in the report or its revision. The staff does not discuss in any detail the provisions of the guidelines nor the parts of the guidelines it finds acceptable. A brief summary of the contents of the BWRVIP-42 report is given in Section 2.0 of this SE, with a detailed evaluation in Section 3.0. The conclusion is summarized in Section 4.0. The

ENCLOSURE

presentation of this evaluation is structured according to the organization of the BWRVIP-42 report.

2.0 SUMMARY OF BWRVIP-42 REPORT

The BWRVIP-42 report addresses the following topics in the following order:

- LPCI Coupling Design and Susceptibility Information - The LPCI coupling assemblies are described in detail by a series of illustrations and differences among the various models of BWRs (BWR/4, BWR/5, and BWR/6) are identified. The various types of LPCI coupling susceptibility factors and material degradation mechanisms (e.g., intergranular stress corrosion cracking, IGSCC, which has factors that include environment, materials and stress state; fatigue by flow induced vibration and/or thermal cycling; and, aging embrittlement) that could impact the LPCI couplings are described in general terms. Potential failure locations are addressed from the standpoint of inspection priority, susceptibility to degradation, and consequences of failures in terms of component functions and plant safety.

- Inspection Strategy - The BWRVIP-42 report recommends the specific locations, NDE methods, and inspection frequencies for examinations of the LPCI coupling assemblies. The report also describes the inspection basis and methods, the recommended baseline inspection scope, the reinspection frequency, scope expansion, and reporting of inspection results.

- Loads and Load Combinations - The various types of loads (e.g., pressures, seismic, etc.) of concern are listed and load combinations are described.

- Flaw Evaluation Methodologies - This section presents methods which can be used to determine if observed flaws are acceptable from the structural integrity and leakage points of view. It describes flaw evaluations for the elbow/elbow extension welds and other weld locations and a leakage evaluation.

The BWRVIP-42 report also contains an Appendix A, "BWR LPCI Coupling Demonstration of Compliance with the Technical Information Requirements of the License Renewal Rule (10 CFR 54.21)." Appendix A is not evaluated in this SE report, but will be evaluated under a separate review.

3.0 STAFF EVALUATION

The staff's June 14, 1999, initial SE provided three open items. BWRVIP, in its letter of October 21, 1999, addressed these items, which are discussed below.

Issue 2.2 Potential Failure Locations (Inaccessible Welds)

The staff's June 14, 1999, initial SE stated:

> The BWRVIP Inspection Committee is conducting a study to improve access to welds that were described as inaccessible in the BWRVIP-42 report. The staff will review and evaluate the BWRVIP study before making a determination on the subject of inaccessible LPCI coupling welds.

BWRVIP's October 21, 1999 Response to Issue 2.2:

Of the seven (7) locations identified as inaccessible, only two are of a priority that are recommended for inspection. One of the two locations is only applicable to the BWR 4/5 design and the other is only applicable to the BWR 6 design. The two locations are full penetration welds and are in uncreviced locations. So at worst, each facility can only have one inaccessible location and the locations represent the best conditions for resisting IGSCC. As stated in BWRVIP-42, the other inspectable locations, which include creviced areas, can provide indirect or bounding evidence of the condition of the inaccessible locations.

However, the NRC's comment is appropriate and the BWRVIP proposes the following resolution that should allow this issue to be removed from the BWRVIP-42 SE:

The I&E guidelines contain numerous recommendations that require extensive technological development for their implementation such as inspection of the subject LPCI locations. It is possible that, after adequate attempts, the industry may determine that a recommendation (such as the inspection of the hidden LPCI welds), as written, cannot be implemented as set forth in the I&E guideline. Rather than track this inaccessible location issue separately through the staff's SE, we propose that BWRVIP provide a report to the NRC which describes our progress on the development of inspection tooling for inaccessible locations. In addition, to address future situations where a BWRVIP recommendation cannot be implemented, the BWRVIP proposes a programmatic control that includes NRC notification. BWRVIP-42 will be revised to include the below paragraph.

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

It is also proposed that, when the other I&E guidelines are revised for final issuance, the paragraph above be included. These actions allow BWRVIP members to identify recommendations that cannot be implemented and provides for appropriate notification and coordination with the NRC.

Staff's Evaluation:

The staff finds that the paragraph to be included in the revised BWRVIP-42 report should be rewritten as the following:

> "If, during the course of implementing these recommendations, it is determined that implementation cannot be achieved as described in the I&E guideline, 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 actions planned by the licensee, will be summarized and reported to the NRC by letter within 90 days."

With this revision to the proposed paragraph, the staff finds that these actions adequately addresses this open item.

4

Issue 3.3 Visual Inspection

The staff's June 14, 1999, initial SE stated:

> The specific inspection methods recommended in the BWRVIP-42 report rely on the methodologies described in the BWRVIP-03 Report, dated October, 1995, with the conclusions and exceptions as stated in the staff's SE dated June 8, 1998. The staff has received Revision 1 to the BWRVIP-03 report, dated March 31, 1999, which is intended to address the issues raised in the staff's SE. The staff will review the BWRVIP-03, Revision 1, before making a determination on the acceptability of this report for the subject components.

BWRVIP's October 21, 1999 Response to Issue 3.3:

> This issue has been resolved as stated in the NRC's Final Safety Evaluation of the "BWR Vessel and Internals Project, Reactor Pressure Vessel and Internals Examination Guidelines (BWRVIP-03), Revision 1," dated July 15, 1999. When BWRVIP-42 is issued incorporating the NRC's SE, the reference to Modified VT-1 (MVT-1) will be replaced with Enhanced VT-1 (EVT-1).

Staff's Evaluation:

> The BWRVIP-03, Revision 1, report (dated March 1999) states " . . . that when Modified VT-1 is specified for a visual inspection, the EVT-1 technique should be applied." Therefore, the staff finds that BWRVIP's response adequately addressed this item provided that their revised visual inspection methodology for LPCI couplings remains consistent with those cited in the BWRVIP–03, Rev. 1, report.

Issue 3.0 Scope Expansion

(Note: This item was not specifically listed as an Issue in the SE but was discussed in the fourth paragraph of Section 3.)

The staff's June 14, 1999, initial SE stated:

> The BWRVIP needs to address inspection scope expansion to include these "low and/or no inspection required" locations based on the inspection results of examined sites.

BWRVIP's October 21, 1999 Response to Issue 3.0:

> The BWRVIP has addressed the need for scope expansion to "low and/or no inspection required" locations. Section 3.6 of the Guideline states:
>
> > "If one or more flaws are found during the inspection or reinspection of a specific location, all of the remaining locations of the same type in all LPCI couplings in the plant should be inspected during the same refueling outage. In addition, if flaws are found, the effect of degradation of the location on other locations should be considered in determining if scope expansion to other locations is also warranted.
>
> For scope expansion to the other locations, a plant-specific determination should be made on a case-by-case basis on the extent of additional inspections, evaluations, or alternate actions."

The paragraphs recognize the need to expand scope to other locations.

Staff's Evaluation:

The staff finds that BWRVIP's response adequately addressed this item. However, it should be noted that any expansion or modification to the inspection guidance in the BWRVIP-42 report should be reported to the NRC staff, as described above in the staff's evaluation of Issue 2.2.

4.0 CONCLUSION

The staff has reviewed the BWRVIP-42 report, as revised, and finds that the guidance of the BWRVIP-42 report is acceptable for inspection of the subject safety-related internal components except where the staff's conclusions differ from the proposed guidance, as discussed above. The staff has concluded that licensee implementation of the guidelines in BWRVIP-42, with the staff's final comments addressed above, will provide an acceptable level of quality for examination of the safety-related components addressed in the BWRVIP-42 document. The staff requests that the BWRVIP review and resolve the issues raised in the enclosed SE, and incorporate the staff's conclusions into a revised BWRVIP-42 report. Please inform the staff in writing as to this resolution.

5.0 REFERENCES

1. Terry, C., BWRVIP, to USNRC, "BWR Vessel and Internals Project: BWR LPCI Coupling Inspection and Flaw Evaluation Guidelines (BWRVIP-42)," EPRI Report TR-108726, December 11, 1997.

2. Carpenter, C.E., USNRC, to C. Terry, BWRVIP, "Proprietary Request for Additional Information - Review of "BWR Vessel and Internals Project, BWR LPCI Coupling Inspection and Flaw Evaluation Guidelines (BWRVIP-42)" (TAC No. MA1104)," April 18, 1998.

3. Wagoner, V., BWRVIP, to USNRC, "BWRVIP Response to NRC Request for Additional Information on BWRVIP-42 (Reference Project 704)," September 8, 1998.

4. Strosnider, J.R., USNRC, to C. Terry, BWRVIP, "Safety Evaluation of the 'BWR Vessel and Internals Project, BWR LPCI Coupling Inspection and Flaw Evaluation Guidelines (BWRVIP-42)' (TAC No. MA1104)," June 14, 1999.

5. Terry, C., BWRVIP, to Carpenter, C.E., USNRC, "BWRVIP Response to NRC Safety Evaluation of BWRVIP-42," October 21, 1999.

C
NRC ACCEPTANCE FOR COMPLIANCE WITH THE NRC LICENSE RENEWAL RULE

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

2001-009A

January 9, 2001

Mr. Carl Terry, BWRVIP Chairman
Niagara Mohawk Power Company
Post Office Box 63
Lycoming, NY 13093

SUBJECT: ACCEPTANCE FOR REFERENCING OF "BWR VESSEL AND INTERNALS PROJECT, LPCI COUPLING INSPECTION AND FLAW EVALUATION GUIDELINES (BWRVIP-42)," EPRI TOPICAL REPORT TR-108726, AND "APPENDIX A, BWR LPCI COUPLING, DEMONSTRATION OF COMPLIANCE WITH THE TECHNICAL INFORMATION REQUIREMENTS OF THE LICENSE RENEWAL RULE (10 CFR 54.21)"

Dear Mr. Terry:

By letter dated December 11, 1997, as supplemented by letters dated September 8, 1998, and October 21, 1999, the Boiling Water Reactor Vessel and Internals Project (BWRVIP) submitted the Electric Power Research Institute (EPRI) proprietary Report TR-108726, "BWR Vessel and Internals Project, LPCI Coupling Inspection and Flaw Evaluation Guidelines (BWRVIP-42)," for NRC staff review and approval. The BWRVIP-42 report included an initial non-proprietary version, which was supplemented by an expanded non-proprietary version by letter dated March 23, 1999. Also included in the initial submittal was "Appendix A, BWR LPCI Coupling, Demonstration of Compliance with the Technical Information Requirements of the License Renewal Rule (10 CFR 54.21)," for staff review in accordance with the License Renewal Rule (10 CFR Part 54).

The BWRVIP-42 report contains generic guidelines to BWRVIP members on inspection and flaw evaluation of low pressure coolant injection (LPCI) couplings. These guidelines considered degradation susceptibility, degradation mechanisms, loads, and inspection strategies for LPCI couplings. The intent of the report is to provide an acceptable level of quality and inspection and flaw evaluation guidance to BWRVIP members that can be used to assure adequate BWR LPCI coupling integrity when meeting the specified acceptance criteria.

In response to the staff's request for additional information (RAI), dated April 14, 1998, the BWRVIP provided supplemental information by letter dated September 8, 1998. The NRC staff issued its initial safety evaluation report (SER) by letter dated June 14, 1999, which found the BWRVIP-42 report to be acceptable for inspection and assessment of the subject safety-related internal components, except where the staff's conclusions differed from the BWRVIP's, as discussed in the initial SE's open items. By letter dated October 21, 1999, the BWRVIP provided a response which proposed guidance to resolve the issues identified in the

staff's initial SE, modifying the BWRVIP-42 report. The staff issued a final SER (FSER) by letter dated May 26, 2000, which found the revised guidance of the BWRVIP-42 to be acceptable for the inspection and flaw evaluation of the subject internal components for the current operating period of BWRs.

As documented in the enclosed license renewal (LR) SE, the NRC staff has completed its review of the BWRVIP-42 report. As indicated in the LR SE, the staff found the BWRVIP-42 report acceptable for licensees participating in the BWRVIP to reference in a license renewal application to the extent specified and under the limitations delineated in the LR SE. In order for licensees participating in the BWRVIP to rely on the report, they must commit to the accepted aging management programs (AMPs) defined therein, and complete the action items described in the LR SE. By referencing the BWRVIP-42 report and the AMPs in it, and completing the action items, an applicant will provide sufficient information for the staff to make a finding that there is reasonable assurance that the applicant will adequately manage the effects of aging so that the intended functions of the reactor vessel internal components covered by the scope of the report will be maintained consistent with the current licensing basis during the period of extended operation.

The staff does not intend to repeat its review of the matters described in the report and found acceptable in the LR SE when the report is incorporated by reference in a LR application, except to ensure that the report's conclusions apply to the specified plant.

In accordance with the procedures established in NUREG-0390, "Topical Report Review Status," the staff requests that the BWRVIP publish the accepted version of BWRVIP-42 within 90 days after receiving this letter. In addition, the published version will incorporate this letter and the enclosed LR SE between the title page and the abstract.

To identify the version of the report that was accepted by the staff, the staff requests that the BWRVIP include "A" following the topical report number (e.g., BWRVIP-42-A).

Sincerely,

CIGrimes

Christopher I. Grimes, Branch Chief
License Renewal and Standardization Branch
Division of Regulatory Improvement Programs
Office of Nuclear Reactor Regulation

Project No. 704

Enclosure: Final Safety Evaluation Report

cc w/encl: See next page

FINAL LICENSE RENEWAL SAFETY EVALUATION REPORT
BY THE OFFICE OF NUCLEAR REACTOR REGULATION
FOR
"BWR VESSEL AND INTERNALS PROJECT, LPCI COUPLING
INSPECTION AND FLAW EVALUATION GUIDELINES (BWRVIP-42),"
EPRI TOPICAL REPORT TR-108726, DECEMBER 1997
FOR COMPLIANCE WITH THE LICENSE RENEWAL RULE (10 CFR PART 54)

1.0 INTRODUCTION

1.1 Background

By letter dated December 11, 1997, as supplemented by letters dated September 8, 1998, and October 21, 1999, the Boiling Water Reactor Vessel and Internals Project (BWRVIP) submitted the Electric Power Research Institute (EPRI) proprietary Report TR-108726, "BWR Vessel and Internals Project, BWR LPCI Inspection and Flaw Evaluation Guidelines (BWRVIP-42)," for NRC staff review and approval. The BWRVIP-42 report included an initial non-proprietary version, which was supplemented by an expanded non-proprietary version by letter dated March 23, 1999. Also included was in the initial submittal was "Appendix A, BWR LPCI Coupling, Demonstration of Compliance with the Technical Information Requirements of the License Renewal Rule (10 CFR 54.21)," for staff review in accordance with the License Renewal Rule (10 CFR Part 54).

The BWRVIP-42 report contains generic guidelines to BWRVIP members on inspection and flaw evaluation of low pressure coolant injection (LPCI) couplings. These guidelines considered degradation susceptibility, degradation mechanisms, loads, and inspection strategies for LPCI couplings. The intent of the report is to provide an acceptable level of quality and inspection and flaw evaluation guidance to BWRVIP members that can be used to assure adequate BWR LPCI coupling integrity when meeting the specified acceptance criteria.

In response to the staff's request for additional information (RAI), dated April 14, 1998, the BWRVIP provided supplemental information by letter dated September 8, 1998. The NRC staff issued its initial safety evaluation report (SER) by letter dated June 14, 1999, which found the BWRVIP-42 report to be acceptable for inspection and assessment of the subject safety-related internal components, except where the staff's conclusions differed from the BWRVIP's, as discussed in the initial SE's open items. By letter dated October 21, 1999, the BWRVIP provided a response which proposed guidance to resolve the issues identified in the staff's initial SE, modifying the BWRVIP-42 report. The staff issued a final SER (FSER) by letter dated May 26, 2000, which found the revised guidance of the BWRVIP-42 to be acceptable for the inspection and flaw evaluation of the subject internal components for the current operating period of BWRs.

Enclosure

1.2 Purpose

The staff reviewed the BWRVIP-42 report and its Appendix A to determine whether its guidance will provide acceptable levels of quality for inspection and flaw evaluation of the subject safety-related RPV internal components within the scope of the report during the period of extended operation. The staff also considered compliance with the LR Rule in order to allow applicants for renewal the option of incorporating the BWRVIP-42 guidelines by reference in a plant-specific integrated plant assessment (IPA) and associated time-limited aging analyses (TLAA).

Section 54.21 of the LR Rule requires, in part, that each application for license renewal contain an IPA and an evaluation of TLAA. The IPA must identify and list those structures and components subject to an aging management review and demonstrate that the effects of aging will be adequately managed so that their intended functions will be maintained consistent with the current licensing basis (CLB) for the period of extended operation. In addition, 10 CFR 54.22 requires that each application include any technical specification changes or additions necessary to manage the effects of aging during the period of extended operation as part of the renewal application.

If a LR applicant participating in the BWRVIP confirms that the BWRVIP-42 report applies to its facility and that the results of the Appendix A, IPA and TLAA evaluation are in effect at its plant, then no further review by the NRC staff of the issues described in the documents is necessary, except as specifically identified by the staff, below. With this exception, such an applicant may rely on the BWRVIP-42 report for the demonstration required by 10 CFR 54.21(a)(3) with respect to the components and structures within the scope of the report. Under such circumstances, the NRC staff intends to rely on the evaluation in this LR SE to make the findings required by 10 CFR 54.29 with respect to a particular application, except as necessary to ensure that the BWRVIP-42 report's conclusions apply to the specified plant.

1.3 Organization of Safety Evaluation Report

Because the BWRVIP-42 report, as supplemented and modified, is proprietary, this SE was written so as not to repeat information contained in the proprietary portions of the report. The staff does not discuss in any detail the proprietary provisions of the guidelines nor the parts of those guidelines it finds acceptable. A brief summary of the contents of the BWRVIP-42 report is given in Section 2.0 of this SE, with the NRC staff's evaluation presented in Section 3.0. The conclusions are summarized in Section 4.0. The presentation of the evaluation is structured according to the organization of the BWRVIP-42 report.

2.0 SUMMARY OF BWRVIP-42 REPORT

The BWRVIP-42 report and its Appendix A contain a generic evaluation of the management of the effects of aging on the subject RPV internal components such that their intended functions will be maintained consistent with the CLB for the period of extended operation. This evaluation applies to BWR applicants who have committed to implementing the BWRVIP-42 report and want to incorporate the report and Appendix A by reference into a plant-specific IPA and associated TLAA.

2.1 BWRVIP-42 Topics

The BWRVIP-42 report addresses the following topics in the following order:

- LPCI Coupling Design and Susceptibility Information - The LPCI coupling assemblies are described in detail by a series of illustrations and differences among the various models of BWRs (BWR/4, BWR/5, and BWR/6). The various types of LPCI coupling susceptibility factors and material degradation mechanisms (e.g., intergranular stress corrosion cracking - IGSCC, which has factors that include environment, materials and stress state; fatigue by flow induced vibration and/or thermal cycling; and, aging embrittlement) that could impact the LPCI couplings are described in general terms. Potential failure locations are addressed from the standpoint of inspection priority, susceptibility to degradation, and consequences of failures in terms of component functions and plant safety.

- Inspection Strategy - The BWRVIP-42 report recommends the specific locations, non-destructive examination (NDE) methods, and inspection frequencies for examinations of the LPCI coupling assemblies. The report also describes the inspection basis and methods, the recommended baseline inspection scope, the reinspection frequency, scope expansion, and reporting of inspection results.

- Loads and Load Combinations - The various types of loads (e.g., pressures, seismic, etc.) of concern are listed and load combinations are described.

- Flaw Evaluation Methodologies - This section presents methods which can be used to determine if observed flaws are acceptable from the structural integrity and leakage points of view. It describes flaw evaluations for the elbow/elbow extension welds and other weld locations and a leakage evaluation.

2.2 Identification of Structures and Components Subject to an Aging Management Review

10 CFR 54.21(a)(1) requires that an IPA identify and list those structures and components within the scope of license renewal that are subject to an aging management review. Structures and components subject to an aging management review are those structures and components that (1) perform an intended function, as described in 10 CFR 54.4, without moving parts or without a change in configuration or properties and (2) are not subject to replacement based on a qualified life or specified time period. These structures and components are also referred to as "passive" and "long-lived" structures and components.

Section 2.0 of the BWRVIP-42 report describes the intended function of the LPCI coupling, to provide a flow path between the reactor vessel thermal sleeve and the core shroud.

The BWRVIP-42 report's Appendix A identifies the passive and long-lived components as required by 10 CFR 54.21(a)(1). The BWRVIP-42 report states that all of the components in the LPCI coupling are passive and long lived and are subject to aging management review.

2.3 Effects of Aging

The BWRVIP identified the aging mechanisms and aging effects for the internals using the guidance from NUMARC 90-02, "BWR Reactor Pressure Vessel License Renewal Industry Report," Revision 1, dated August 1992. The BWRVIP also used NUREG-1557, "Summary of Technical Information and Agreements from Nuclear Management and Resources Council Industry Reports Addressing License Renewal," dated October 1996, to correlate the aging effects and their associated aging mechanisms. Using these reports, the BWRVIP determined that crack initiation and growth is the only aging effect that requires aging management review for the LPCI coupling.

In Section 2.0 of the BWRVIP-42 report, the BWRVIP discussed the causes of crack initiation and growth and provided a susceptibility assessment, and also discussed the susceptibility factors of environment, materials, and stress state. The BWRVIP discussed each of the LPCI coupling's potential cracking locations, determining that:

1. many locations in the LPCI coupling are subject to an aggressive environment and are within a region of high electrochemical corrosion potential (ECP);

2. LPCI coupling materials at locations where a heat affected zone or excessive cold work exists may be susceptible to crack initiation and growth due to stress corrosion cracking;

3. based on the configuration, most LPCI coupling components, regardless of the grade of material, are potentially susceptible to crack initiation and growth; and,

4. regions with the highest expected crack initiation and growth susceptibility are the creviced locations, especially those regions subject to high weld residual stresses.

Historically, visual inspections have been performed of the LPCI coupling in several plants and no indications or cracking have been found.

2.4 Aging Management Programs

10 CFR 54.21(a)(3) requires that the applicant demonstrate, for each component identified, that the effects of aging will be adequately managed so that the intended function will be maintained consistent with the CLB for the period of extended operation.

Section 3.0 of the BWRVIP-42 report discusses the inspection strategy to be used for ensuring that cracks that might occur in the LPCI coupling are detected in a timely manner. The inspection methods and implementing guidance addresses the:

- LPCI coupling locations that require inspection;
- Extent of baseline inspection for each location;
- Extent of reinspection for each location;
- Methodology for scope expansion should degradation be detected; and,
- Analysis methods to determine the need for corrective action if degradation is detected.

The BWRVIP committed to address development of the technology to inspect inaccessible welds and to have the individual LR applicant notify the NRC of actions planned. The staff accepted this commitment. The BWRVIP concluded that both its inspection program and plant-specific considerations will result in verification of the structural integrity, consistent with the CLB, for the subject RPV internal components.

2.5 Time-Limited Aging Analyses (TLAA)

10 CFR 54.21(1)(c) requires that each application for license renewal contain an evaluation of TLAA as defined in 10 CFR 54.3, and that the applicant shall demonstrate that:

(i) The analyses remain valid for the period of extended operation;

(ii) The analyses have been projected to the end of the period of extended operation; or

(iii) The effects of aging on the intended function(s) will be adequately managed for the period of extended operation.

The TLAA considered in the BWRVIP-42 report are those licensee calculations and analyses that:

(1) involve the LPCI coupling;

(2) consider the effects of aging;

(3) involve time-limited assumptions defined by the current operating term;

(4) were determined to be relevant by the licensee in making a safety determination;

(5) involve conclusions or provide the basis for conclusions related to the capability of the LPCI coupling to perform its intended function; and,

(6) are contained or incorporated by reference in the CLB.

With respect to the BWRVIP-42 report, if a plant-specific analysis, as identified by an applicant, meets all six of the above criteria, the analysis will be considered a TLAA for license renewal and evaluated by the applicant.

The crack growth rate applied in flaw evaluation methodologies may result in a plant specific TLAA issue. The BWRVIP-42 report established a bounding crack growth rate that has been previously accepted by the NRC; however, it states that a lower crack growth rate may be used, if justified and approved by the NRC. Accelerated crack growth rates due to fatigue either from low cycle thermal cycling or high cycle flow induced vibrations are not applicable, since the BWRVIP has shown that fatigue is not a significant degradation mechanism as supported by field experience and testing.

3.0 STAFF EVALUATION

The staff's FSER of the BWRVIP-42 report for the current operating term was transmitted by letter dated May 26, 2000, to Carl Terry, BWRVIP Chairman. The NRC staff determined that the contents and recommendations in the BWRVIP-42 report, when coupled with the BWRVIP's

responses to the specific information requests in the staff's April 14, 1999, RAI, and the open items in the staff's initial SE dated June 14, 1999, provides a sufficient and acceptable basis for performing examinations and evaluating postulated flaw indications for the subject safety-related BWR internal components. The NRC staff concluded that licensee implementation of the guidelines in the BWRVIP-42 report will provide an acceptable level of quality for inspection and flaw evaluation of the components addressed for the current operating term.

The staff has further reviewed the BWRVIP-42 report and its Appendix A to determine if it demonstrates that the effects of aging on the reactor vessel components within the scope of the report will be adequately managed so that the components' intended functions will be maintained consistent with the CLB for the period of extended operation, in accordance with 10 CFR 54.21(a)(3). This is the last step in the IPA described in 10 CFR 54.21(a).

Besides the IPA, 10 CFR Part 54 requires an evaluation of TLAA in accordance with 10 CFR 54.21(c). The staff reviewed the BWRVIP-42 report to determine if the TLAA covered by the report were evaluated for license renewal in accordance with 10 CFR 54.21(c)(1).

3.1 Structures and Components Subject to Aging Management Review (AMR)

The staff agrees that the LPCI coupling components are subject to an AMR because they perform intended functions without moving parts or without a change in configuration or properties, and are not subject to replacement based on a qualified life or specified time period. The staff concludes that BWR applicants for license renewal must identify the appropriate subject RPV internal components as subject to aging management to meet the applicable requirements of 10 CFR 54.21(a)(1).

3.2 Intended Functions

The staff agrees that the intended function of the LPCI coupling is as stated, to provide a flow path between the reactor vessel thermal sleeve and the core shroud.

3.3 Effects of Aging

The information necessary to demonstrate compliance with the requirements of the license renewal rule 10 CFR 54.21 is provided in Appendix A of the BWRVIP-42 report. The BWR Reactor Pressure Vessel Industry Report NUMARC 90-02, Revision 1, August 1992, and the resolution to the NRC's questions on that industry report were used to identify the aging mechanisms for the LPCI coupling. If the industry report concluded that the aging mechanism was significant then the aging mechanism was included in the aging management review. Using this methodology, it was determined that crack initiation and growth was the only aging effect that required aging management review.

Accordingly, NUREG-1557 states that crack initiation and growth are the aging effects that need to be considered. Although the LPCI coupling is not specifically addressed in the industry report, the mechanisms affecting the coupling are described and evaluated. NUREG-1557 establishes the correlation between the aging effects and their associated aging mechanisms. For the reasons stated in NUREG-1557, the staff agrees that crack initiation and growth is the only aging effect applicable to the LPCI coupling components.

3.4 Aging Management Programs (AMP)

The staff evaluated the BWRVIP's AMP to determine if it contains the following 10 elements constituting an adequate AMP for license renewal:

(1) Scope of Program: The program contains preventative measures to mitigate SCC; inservice inspection (ISI) to monitor the effects of SCC on the intended function of the components, and repair and/or replacement as needed to maintain the ability to perform the intended function

(2) Preventive Actions: Coolant water chemistry is monitored and maintained in accordance with EPRI guidelines. Maintaining high water purity reduces susceptibility to SCC. Hydrogen additions are effective in reducing electrochemical (corrosion) potentials in the recirculation piping system, but are less effective in the core region. Noble metal additions, through a catalytic action, appear to increase the effectiveness of hydrogen additions in the core region.

(3) Parameters Monitored or Inspected: Inspection and flaw evaluation are performed in accordance with BWRVIP guidelines, as approved by the NRC.

(4) Detection of Aging Effects: Inspection in accordance with BWRVIP guidelines provides adequate assurance that degradation due to SCC is detected before any loss of the intended function of the LPCI coupling components.

(5) Monitoring and Trending: The inspection schedule is in accordance with applicable approved BWRVIP guidelines and is adequate for timely detection of cracks. Scope of examination expansion and re-inspection beyond the baseline inspection are required if flaws are detected.

(6) Acceptance Criteria: Any degradation is evaluated in accordance with the applicable approved BWRVIP guidelines.

(7) Corrective Actions: The corrective actions proposed by the BWRVIP in the BWRVIP-56 report are under staff review.

(8) & (9) Confirmation Process and Administrative Controls: Site QA procedures, review and approval processes and administrative controls are implemented in accordance with the requirements of Appendix B to 10 CFR 50 and will continue to be adequate for the license renewal period.

(10) Operating Experience: The BWRVIP-42 report did not identify any crack indications found in LPCI couplings, but cracking has occurred in a number of vessel internal components. Weld regions are the most susceptible, although it is not clear whether this is due to sensitization and/or impurities associated with the welds or the high residual stresses in the weld regions.

The staff's FSER of the BWRVIP-42 report for the current operating term was transmitted by letter dated May 26, 2000, to Carl Terry, BWRVIP Chairman. For the reasons set forth in the FSER, the staff concluded that the inspection strategy and evaluation methodologies discussed in the BWRVIP-42 report are acceptable. Based on the implementation of the BWRVIP-42

initiation and growth will be adequately managed such that the intended functions of the subject safety-related RPV internal components will be maintained consistent with the CLB for the period of extended operation.

3.5 Time Limited Aging Analyses (TLAA)

The BWRVIP-42 report did not find any of the six TLAA criteria listed in Section 2.5 to be applicable for license renewal for the LPCI coupling components. Therefore, the staff concludes that the BWRVIP-42 document does not contain any generic TLAA issues pertinent for the subject safety-related BWR internal components.

The staff concludes that the crack growth rate applied in flaw evaluation methodologies may result in a plant specific TLAA issue. The BWRVIP-42 report established a bounding crack growth rate that has been previously accepted by NRC; however, it states that a lower crack growth rate may be used, if justified and approved by the NRC. The staff agrees that accelerated crack growth rates due to fatigue either from low cycle thermal cycling or high cycle flow induced vibrations are not applicable, since the BWRVIP-42 report has shown that fatigue is not a significant degradation mechanism based on field experience and testing.

4.0 CONCLUSIONS

The staff has reviewed the BWRVIP-42 report. On the basis of its review, as set forth above, the staff concludes that the BWRVIP-42 report provides an acceptable demonstration that the BWRVIP member utilities referencing this report will adequately manage the aging effects of reactor vessel components within the scope of the report, with the exception of the noted renewal applicant action items set forth in Section 4.1, below, so that there is reasonable assurance that the LPCI coupling will perform its intended functions in accordance with the CLB during the period of extended operation. The staff also concludes that, upon completion of the renewal applicant action items, the BWRVIP-42 report provides an acceptable evaluation of time-limited aging analyses for the LPCI coupling for the BWRVIP member utilities for the period of extended operation.

Any BWR utility may reference this report in a license renewal application to satisfy the requirements of (1) 10 CFR 54.21(a)(3) for demonstrating that the effects of aging on the LPCI couplings will be adequately managed and (2) 10 CFR 54.21(c)(1) for demonstrating the appropriate findings regarding evaluation of time-limited aging analyses for the LPCI coupling for the period of extended operation. The staff also concludes that, upon completion of the renewal applicant action items set forth in Section 4.1, below, referencing the BWRVIP-42 report and its Appendix A in a license renewal application and summarizing in an FSAR supplement the aging management programs and the TLAA evaluations contained in this report will provide the staff with sufficient information to make the findings required by Sections 54.29(a)(1) and (a)(2) for components within the scope of this report.

4.1 Renewal Applicant Action Items

The following are license renewal applicant action items to be addressed in the plant-specific license renewal application when incorporating the BWRVIP-42 report in a renewal application:

(1) The license renewal applicant is to verify that its plant is bounded by the BWRVIP-42 report. Further, the renewal applicant is to 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, including actions planned to inspect welds that are presently inaccessible. If corrective actions are necessary, the applicant shall either commit to follow the guidance in the staff- approved BWRVIP-56 report, "LPCI Coupling Repair Design Criteria," or describe the process that will be utilized to repair the LPCI couplings, if needed. Applicants for license renewal will be responsible for describing any such commitments and identifying how such commitments will be controlled. Any deviations from the aging management programs within the BWRVIP-42 report described as necessary to manage the effects of aging during the period of extended operation and to maintain the functionality of the reactor vessel components or other information presented in the report, such as materials of construction, 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).

(2) 10 CFR 54.21(d) requires that an FSAR supplement for the facility contain a summary description of the programs and activities for managing the effects of aging and the evaluation of TLAAs for the period of extended operation. Those applicants for license renewal referencing the BWRVIP-42 report for the LPCI coupling internals shall ensure that the programs and activities specified as necessary in the BWRVIP-42 report are summarily described in the FSAR supplement.

(3) 10 CFR 54.22 requires that each application for license renewal include any technical specification changes (and the justification for the changes) or additions necessary to manage the effects of aging during the period of extended operation as part of the renewal application. In its Appendix A to the BWRVIP-42 report, the BWRVIP stated that there are no generic changes or additions to technical specifications associated with the LPCI coupling as a result of its aging management review and that the applicant will provide the justification for plant-specific changes or additions. Those applicants for license renewal referencing the BWRVIP-42 report for the LPCI coupling internals shall ensure that the inspection strategy described in the BWRVIP-42 report does not conflict with or result in any changes to their technical specifications. If technical specification changes do result, then the applicant must ensure that those changes are included in its application for license renewal.

(4) Applicants referencing the BWRVIP-42 report for license renewal should identify and evaluate any potential TLAA issues which may impact the structural integrity of the subject RPV internal components. This is discussed in more detail in Section 2.5 of this SE.

(5) The BWRVIP committed to address development of the technology to inspect inaccessible welds and to have the individual LR applicant notify the NRC of actions planned. Applicants referencing the BWRVIP-42 report for license renewal should identify this action as open and to be addressed once the BWRVIP's response to this issue has been reviewed and accepted by the staff.

5.0 REFERENCES

1. NUREG-1557, Summary of Technical Information and Agreements from Nuclear Management and Resources Council Industry Reports Addressing License Renewal, October 1996.

2. Carl Terry, BWRVIP, to USNRC, "BWR Vessel and Internals Project, LPCI Coupling Inspection and Flaw Evaluation Guidelines (BWRVIP-42)," EPRI Report TR-108726, dated December 1997.

3. C. E. Carpenter, USNRC, to Carl Terry, BWRVIP, "Propriety Request for Additional Information - Review of BWR Vessel and Internals Project Report, "BWR Vessel and Internals Project, LPCI Coupling Inspection and Flaw Evaluation Guidelines (BWRVIP-42)," (TAC No. MA1104), dated April 18,1998.

4. Carl Terry, BWRVIP, to Carpenter, C.E., USNRC, "BWRVIP Response to NRC Safety Evaluation of BWRVIP-42" dated October 21, 1999.

5. J. R. Strosnider, USNRC, to Carl Terry, BWRVIP, "Safety Evaluation of BWR Vessel and Internals Project Report, LPCI Coupling Inspection and Flaw Evaluation Guidelines (BWRVIP-42), EPRI Report TR-108726," dated June 14,1999.

6. J. R. Strosnider, USNRC, to Carl Terry, BWRVIP, "Final Safety Evaluation of BWR Vessel and Internals Project Report, LPCI Coupling Inspection and Flaw Evaluation Guidelines (BWRVIP-42), EPRI Report TR-108726," dated May 26, 2000.

D
RECORD OF REVISIONS (BWRVIP-42-A)

NOTE: The revisions described in this appendix were incorporated into BWRVIP-42-A (EPRI Report 1011470). Changes due to the revisions are NOT marked with margins bars in the current version of the report (BWRVIP-42, Revision 1).

BWRVIP-42-A	Information from the following documents was used in preparing the changes included in this revision of the report: 1. *BWR Vessel and Internals Project, LPCI Coupling Inspection and Flaw Evaluation Guidelines (BWRVIP-42),* December, 1997. EPRI Report TR-108726. 2. Proprietary Request for Additional Information-Review of BWR Vessel and Internals Project, BWR LPCI Coupling Inspection and Flaw Evaluation Guidelines (BWRVIP-42) (TAC NO. MA1104) (98-104B). 3. BWRVIP Response to NRC Request for Additional Information on BWRVIP-42 (Reference Project 704) (98-378). 4. Safety Evaluation of the "BWR Vessel and Internals Project, BWR Vessel and Internal Project, LPCI Coupling Inspection and Flaw Evaluation Guidelines (BWRVIP-42)", (TAC NO. MA1102) (99-217A). 5. Project 704-BWRVIP Response to NRC Safety Evaluation of BWRVIP-42 (99-428). 6. NRC Final Safety Evaluation on BWRVIP-42 (2000-156). 7. Acceptance for Referencing of "BWR Vessel and internals Project, LPCI Coupling Inspection and Flaw Evaluation Guidelines (BWRVIP-42)," EPRI Topical Report TR-108726, and "Appendix A, BWR LPCI Coupling, Demonstration of Compliance with the Technical Information Requirements of the License Renewal Rule (10 CFR 54.21) (2001-009A). 8. *BWRVIP-94: BWR Vessel and Internals Project, Program Implementation Guide,* August 2001. EPRI Report 1006288. Details of the revisions can be found in Table D-1.

Table D-1
Details of revisions

Required Revision	Source of Requirement for Revision	Description of Revision Implementation
	General Comment	Discussion of IASCC in Section 2.1.1 revised.
BWRVIP will propose response to "Use of NDE Uncertainty" at a later date.	Response to SE on BWRVIP-63 (2001-188)	Last sentence of Section 5.1.3 modified; section 5.1.4 (Flaw Characterization) added
All I&E Guidelines to be revised to replace CSVT and MVT by EVT-1, VT-1 or VT-3. "EVT-1 will be specified as the primary technique when fine, tight IGSCC is a primary concern. In other locations, VT-1 or VT-3 will be used as appropriate."	Response to SE on BWRVIP-03, Item 3.3-4 (99-115)	Section 3.3, Definition of MVT-1 replaced with: "Enhanced VT-1 as used in this document is a visual inspection capable of achieving 1/2 mil resolution." Section 3.3, subsection "Basis for Recommendation…": "Modified VT-1" replaced with "Enhanced VT-1" 4 places. Table 3-1, "Modified VT-1" replaced with "Enhanced VT-1" for inspection locations 45-3b, 45-12, 6-1a, 6-4 and 6-6b.
The following paragraph will be included in all revised I&E Guidelines: *"If, during the course of implementing these recommendations, it is determined that implementation cannot be achieved as described in the I&E guideline, 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."*	Final SE on BWRVIP-42 (2000-156)	Section 3.7 (Reporting of Inspection Requirements) deleted from BWRVIP-42. All reporting requirements for this and other Inspection and Flaw Evaluation Guidelines are contained in BWRVIP-94: BWRVIP Program Implementation Guide
	General Comment	Section 5.1.2 revised: Use of crack growth rates in flaw evaluations clarified.
	Editorial	Section 5.1.5 revised: Use of "2x" in un-inspected areas clarified.
End of Revisions		

E
RECORD OF REVISIONS (BWRVIP-42, REV. 1)

BWRVIP-42, Rev.1	Information from the following documents was used in preparing the changes included in this revision of the report: 1. *BWRVIP-42-A: BWR Vessel and Internals Project, LPCI Coupling Inspection and Flaw Evaluation Guidelines*. EPRI, Palo Alto, CA: 2005. 1011470. Details of the revisions can be found in Table E-1.

Table E-1
Details of revisions

Required Revision	Source of Requirement for Revision	Description of Revision Implementation
Add NEI 03-08 Implementation Requirements	BWRVIP-94, Rev. 1, Requirement	Added Section 1.3 to state that Sections 3, 4 and 5 are "needed" and the remainder of the report is provided for information only.
Incorporate inspection strategy for inaccessible welds		Revised Section 2.2 to indicate that until an inspection technique becomes available the inaccessible welds shall be evaluated according to the guidelines in Section 3.9 Revised Section 3 to incorporate inspection strategy for inaccessible welds Revised Section 3.6 on Scope Expansion to include additional guidance for inaccessible welds
Incorporate leakage evaluation for inaccessible welds		Revised Section 5 to incorporate methodology for determining leakage from inaccessible welds
Update Section 5 for clarity and to update Z-factor equations.	Internal comment	Restructured Section 5 to improve clarity and updated Z-factor equations per the current ASME Section XI Code rules
End of Revisions		

F

NRC REQUEST FOR ADDITIONAL INFORMATION ON BWRVIP-42, REV. 1

BWRVIP 2013-143A

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

August 5, 2013

Dennis Madison
Southern Nuclear
Chairman, BWR Vessel and Internals Project
3420 Hillview Avenue
Palo Alto, CA 94304-1395

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION FOR THE BWRVIP [BOILING WATER REACTOR VESSEL INTERNALS PROJECT]-42, REVISION 1, "LOW PRESSURE COOLANT INJECTION (LPCI) COUPLING INSPECTION AND FLAW EVALUATION GUIDELINES" (TAC NO. MF0363)

Dear Mr. Madison:

By letter dated December 10, 2012, the BWRVIP submitted, Licensing Topical Report (LTR) BWRVIP-42, Revision 1, "Low Pressure Coolant Injection (LPCI) Coupling Inspection and Flaw Evaluation Guidelines," dated October 2012 (Agencywide Documents Access and Management System Accession No. ML12349A308), to the U.S. Nuclear Regulatory Commission (NRC) for review.

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

On June 19, 2013, Mr. Larry Steinert, representing BWRVIP, and I agreed that the NRC staff will receive your response to the enclosed RAI questions by September 30, 2013. If you have any questions regarding the enclosed RAI questions, please contact me at 301-415-7297.

Sincerely,

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

Project No. 704

Enclosure:
RAI questions

REQUEST FOR ADDITIONAL INFORMATION (RAI) ON

LICENSING TOPICAL REPORT BWRVIP-42, REVISION 1

"LOW PRESSURE COOLANT INJECTION (LPCI) COUPLING

INSPECTION AND FLAW EVALUATION GUIDELINES"

BOILING WATER REACTOR (BWR) VESSEL & INTERNALS PROJECT (BWRVIP)

A general RAI question

RAI-1

This RAI question regards the bounding nature of the Licensing Topical Report (LTR) BWRVIP-42, Revision 1, "Low Pressure Coolant Injection (LPCI) Coupling Inspection and Flaw Evaluation Guidelines." Section 2 and Section 3 of BWRVIP-42, Revision 1, provide information and a strategy for two categories of BWR plants: (1) BWR/4 and BWR/5 and (2) BWR/6. Confirm that this general categorization is good for all BWR/4, BWR/5, and BWR/6 plants having LPCI couplings and no plant-specific features of any plant would make any part of Sections 2 and 3 invalid.

Issue-specific RAI questions

RAI-2

For aging embrittlement, Section 2.1.3 of the LTR states, "conditions that favor IGSCC [intergranular stress corrosion cracking] (low ferrite) are opposite to the conditions that promote aging embrittlement (high ferrite). Thus....aging embrittlement is not expected to be a significant issue for the LPCI coupling." Provide quantitative data to substantiate the claim: 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. Explain why this reduced level of fracture toughness will not become a safety concern.

RAI-3

Section 3.9.1 of the LTR 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. The NRC staff has questions for both.

- For Step 1, the LTR indicated that the start of the inspection interval for the inaccessible weld is the time at which 75 percent of the similar priority High/Low/No Inspection (H/L/N) plant-specific accessible welds are found to be cracked. It further states that this corresponds to an approximate 75 percent likelihood that the inaccessible weld is cracked. This is acceptable if the crack growth rate is slow and the components are

ENCLOSURE

- inspected frequently. However, if a flaw is detected in the accessible welds in the future and is evaluated to be critical and requires repairs, then the assumption of a slow crack growth rate will be no longer true, and a repair-needed flaw in the inaccessible welds could become critical during a long inspection cycle (e.g., 4 years) to endanger LPCI's function of providing coolant when the emergency core cooling system (ECCS) is activated. Please address this concern and modify the proposed criterion for the start of the inspection interval for the inaccessible welds at the time when 75 percent of the similar priority H/L/N plant-specific accessible welds are found to be cracked. Possible remedies are using 50 percent instead of 75 percent, or maintain 75 percent but add additional measures when evaluation of the detected flaws in the accessible welds concludes that the flaw evaluation criteria are exceeded and a repair is needed.

- 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. Due to the same reasons as stated above, using essentially the average calculated times for the 75 percent population of accessible cracked welds may allow a repair-needed flaw in the inaccessible welds to become critical during a long inspection cycle (e.g., 4 years) to endanger LPCI's function of providing coolant when the ECCS is activated. Please address this concern and modify the proposed criterion as necessary. A possible remedy is to maintain the proposed length of the inspection interval but use the shortest calculated operating time for all similar accessible cracked welds when evaluation of the detected flaws in the accessible welds concludes that the flaw evaluation criteria are exceeded and a repair is needed.

RAI-4

Section 3.9.2 of the LTR discussed how similar accessible welds were determined without considering applied stresses. 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. Please justify the LTR's approach of obtaining information on inaccessible welds from cracking of similar accessible welds, considering that large difference between their stresses (applied + residual) could make the inaccessible welds and the corresponding similar accessible welds completely unrelated even they were made of the same material.

RAI-5

The title of Section 3.10.1 of the LTR, includes partially accessible welds, but partially accessible welds are not mentioned in the subsequent text. Please clarify.

RAI-6

Section 5.1.2.1 of the LTR recommended that the limit load methodology described in Appendix C of Section XI of the 2004 Edition of the American Society of Mechanical Engineers (ASME) Code be used to determine the critical and allowable flaw lengths. However, the limit load equations presented in the LTR are not consistent with those in the 2004 Edition of the ASME Code, Section XI. Please note that the 2004 and later Edition of the ASME Code made two major changes to the Appendix C methodology:

(1) The definition of flow stress σ_f was revised from $3S_m$, where S_m is the allowable stress per ASME Code, Appendix I to $\sigma_f = (S_y + S_u)/2$, using ASME Code specified yield and ultimate strength of the material, or $\sigma_f = (\sigma_y + \sigma_u)/2$ if the measured yield and ultimate strength of the material are available.

(2) The equations connecting the applied stresses and the failure bending stress for the non-flux welds and flux welds (i.e., Equations 5-5 and 5-6 of the LTR) were revised to adopt 4 safety factors for membrane stresses and 4 safety factors for bending stresses.

These changes were not implemented in the LTR's limit load methodology of Section 5.1.2.1. Please revise the LTR's methodology to be consistent with the 2004 and later editions of the ASME Code, Section XI, Appendix C because, for instance, the LTR's methodology is non-conservative for Level C loading when compared to the Appendix C approach of the 2004 and later editions of the ASME Code, Section XI.

RAI-7

Regarding the limit load methodology for multiple circumferential indications, the LTR proposed to stack the lengths of all the indications together after accounting for crack growth and flaw proximity and consider them as one indication. In addition, the LTR proposed the limit load methodology described in BWRVIP-76-A as an alternative. Since the July 27, 2006, safety evaluation (SE) (Accession No. ML 062140413) for BWRVIP-76 did not evaluate any limit load methodology, please confirm that "the limit load methodology described in BWRVIP-76-A" referred to the specific limit load methodology of the Distributed Ligament Length (DLL) computer code presented in Appendix D of BWRVIP-76-A.

RAI-8

Section 5.1.4 of the LTR presents leak rate calculation methods, including a method documented in Electric Power Research Institute NP-3596-SR, "PICEP: Pipe Crack Evaluation Program (Revision 1)." This LTR section also proposes 10 steps to predict leak rates from inaccessible welds. The NRC staff requests the following:

(1) Step 1 identifies the total number of inaccessible welds. Please confirm that the total number of inaccessible welds identified in Step 1 is for one LPCI coupling and all LPCI couplings in a plant are identical, so the 10 steps apply to each of the LPCI couplings in a plant.

(2) Step 3 is related to computing the leak rate from each similar accessible weld that is judged to have a through-wall flaw. Section 5.1.1.3 of the TR states, "in cases where only visual inspection is conducted, it is necessary to assume the indications are through-wall for the purpose of structural margin evaluation." Please confirm that the above statement of Section 5.1.1.3 also applies to leak rate evaluation in Step 3. Further, Section 5.1.1.3 states, "UT [ultrasonic testing] examination could be performed to better characterize the crack." Please clarify that if UT is used, then a flaw may not be judged through-wall, depending on a flaw evaluation based on the size (length and depth) of the detected flaw.

RAI-9

The NRC SE dated January 9, 2001 (Accession No. ML010100157), on BWRVIP-42 with emphasis on license renewal (LR) applications (Appendix C of the LTR) specified 5 renewal applicant action items. The following requests are intended to remove some of the action items:

- Action Item 1 requires the applicants for LR referencing the BWRVIP-42 report for the LPCI coupling internals verify that its plant is bounded by the BWRVIP-42 report. This may be removed, pending your satisfactory response to RAI-1. Action Item 1 further requires the applicants:

  > 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, including actions planned to inspect welds that are presently inaccessible. If corrective actions are necessary, the applicants shall either commit to follow the guidance in the staff-approved BWRVIP-56 report, "LPCI Coupling Repair Design Criteria," or describe the process that will be utilized to repair the LPCI couplings, if needed. Applicants for license renewal will be responsible for describing any such commitments and identifying how such commitments will be controlled. Any deviations from the aging management programs within the BWRVIP-42 report described as necessary to manage the effects of aging during the period of extended operation and to maintain the functionality of the reactor vessel components or other information presented in the report, such as materials of construction, will have to be identified by the renewal applicant and evaluated on a plant-specific basis in accordance with 10 CFR [Title 10 of the *Code of Federal Regulations*] 54.21(a)(3) and (c)(1).

  Revise Appendix A by addressing the above appropriately so that this action item can be eliminated.

- Action Item 2 requires the applicants ensure that the programs and activities specified as necessary in the BWRVIP-42 report are summarily described in the Final Safety Analysis Report supplement. Please revise Appendix A of the LTR to include this requirement in accordance with 10 CFR 54.21(d) so that this action item can be eliminated.

- Action Item 3 requires the applicants ensure that the inspection strategy described in the BWRVIP-42 report does not conflict with or result in any changes to their technical specifications (TS). Please revise Paragraph A.6 of the LTR to state clearly that there are no TS regarding LPCI coupling inspection. If this is not the case, please revise Paragraph A.6 to elaborate on your effort of examining all TS regarding LPCI coupling inspection in accordance with 10 CFR 54.22 to determine "there are no changes or additions to the technical specifications associated with LPCI coupling as a result of this aging management review to ensure that the effects of aging are adequately managed" so that this action item can be eliminated.

- Action Item 4 requires the applicants identify and evaluate any potential time-limited aging analyses issues which may impact the structural integrity of the subject reactor pressure vessel RPV internal components. Paragraph A.4 of the LTR is consistent with this requirement, except that this paragraph states, "Alternatively, Section 5.0 also allows use of measured crack growth rates or plant-specific information in predicting the crack growth rate." Please revise the statement to add "Any alternative crack growth rates shall be provided in the license renewal application for NRC review and approval." With this statement, this action item can be eliminated.

RAI-10

On June 8, 2009, General Electric-Hitachi (GEH) issued Safety Communication (SC) 09-01, "Annulus Pressurization Loads Evaluation," related to Annulus Pressurization (AP) loads, also referenced as "New Loads," and the corresponding stresses on the RPV, internals, and containment structures. SC 09-01 identifies that "...the AP loads used as input for design adequacy evaluations of NSSS [nuclear steam supply system] safety related components for "New Loads" plants might have resulted in non-conservative evaluations." The NRC staff also recently became aware of three other related GEH SCs, namely SC 09-03, Revision 1 related to core shroud recirculation line break loads, SC 11-07 related to a new load combination, and SC 12-20 related to acoustic load errors, all of which were issued on June 10, 2013. In addition, the NRC is aware of some plant-specific re-evaluations of New Loads performed that increased the AP loads acting on the core spray piping and sparger components, and the similar effects may apply to LPCI couplings. Please provide additional guidance in Section 4 of BWRVIP-42, Revision 1, so that the AP loads can be properly addressed by licensees to reflect the correct hydrodynamic loads in response to SC 09-01.

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BWRVIP RESPONSES TO NRC REQUEST FOR ADDITIONAL INFORMATION ON BWRVIP-42, REV. 1

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

2015-059 BWR Vessel & Internals Project (BWRVIP)

May 20, 2015

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

Attention: Joseph Holonich

Subject: Project No. 704 – BWRVIP Response to NRC Request for Additional Information on BWRVIP-42, Revision 1

Reference: Letter from Joseph J. Holonich (NRC) to Dennis Madison (BWRVIP Chairman), Request for Additional Information for the BWRVIP [Boiling Water Reactor Vessel Internals Project]-42, Revision 1, "Low Pressure Coolant Injection (LPCI) Coupling Inspection and Flaw Evaluation Guidelines" (TAC NO. MF0363), dated August 5, 2013

Enclosed are five (5) copies of the BWRVIP response to the NRC Request for Additional Information (RAI) on the BWRVIP report entitled "BWRVIP-42, Revision 1: BWR Vessel and Internals Project, Low Pressure Coolant Injection (LPCI) Coupling Inspection and Flaw Evaluation Guidelines". The RAI was transmitted to the BWRVIP by the NRC letter referenced above.

Please note that the enclosed response contains proprietary information. A letter requesting that the response be withheld from public disclosure and an affidavit describing the basis for withholding this information are provided as Attachment 1. The response includes yellow shading and brackets to indicate the proprietary information. The proprietary information is also marked with the letters "TS" in the margin indicating the information is considered trade secrets in accordance with 10CFR2.390.

Two (2) copies of a non-proprietary version of the BWRVIP response to the RAI are also enclosed. This non-proprietary response is identical to the enclosed proprietary response except that the proprietary information has been deleted.

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BWRVIP 2015-059

If you have any questions on this subject please call Ron DiSabatino (Exelon, BWRVIP Assessment Committee Technical Chairman) at 717.456.3685.

Sincerely,

Andrew McGehee, EPRI, BWRVIP Program Manager
Tim Hanley, Exelon Corp., BWRVIP Chairman

Non-Proprietary BWRVIP Response to NRC Request for Additional Information on BWRVIP-42, Rev 1

Response to Request for Additional Information (RAI)
"BWRVIP-42, Revision 1, "BWR Vessel and Internals Project:
Low Pressure Coolant Injection (LPCI) Coupling Inspection and Flaw Evaluation Guidelines" (TAC NO. MF0363)

Each item from the NRC Request for Information (RAI) is repeated below verbatim followed by the BWRVIP response to that item.

A general RAI Question

RAI-1

This RAI question regards the bounding nature of the Licensing Topical Report (LTR). BWRVIP-42, Revision 1, "Low Pressure Coolant Injection (LPCI) Coupling Inspection and Flaw Evaluation Guidelines." Section 2 and Section 3 of BWRVIP-42, Revision 1, provide information and a strategy for two categories of BWR plants: (1) BWR/4 and BWR/5 and (2) BWR/6.

Confirm that this general categorization is good for all BWR/4, BWR/5, and BWR/6 plants having LPCI couplings and no plant-specific features of any plant would make any part of Sections 2 and 3 invalid.

BWRVIP Response to RAI-1

The two categorizations of LPCI couplings were developed by the report author (General Electric) after careful examination of generic and plant specific drawings. General Electric has extensive knowledge in this area and it is believed that the categorizations are comprehensive and applicable to all BWR/4, /5 and /6 plants. However, note also that Section 1.2 of the report states that the report provides "*plant-specific information on LPCI coupling configurations and materials of fabrication based on the best available information. Plants are advised to confirm the accuracy of this information to evaluate the applicability of the inspection recommendations.*" Any differences existing between the drawings presented in the report and the configurations existing in plants would be identified by individual utilities and reported to the BWRVIP. No such instances have been reported.

Issue-specific RAI questions

RAI-2

For aging embrittlement, Section 2.1.3 of the LTR states, "conditions that favor IGSCC [intergranular stress corrosion cracking] (low ferrite) are opposite to the conditions that promote aging embrittlement (high ferrite). Thus....aging embrittlement is not expected to be a significant issue for the LPCI coupling." Provide quantitative data to substantiate the claim: 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. Explain why this reduced level of fracture toughness will not become a safety concern.

BWRVIP Response to RAI-2

The current position of the BWRVIP is 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. The BWRVIP proposes that no change be made to BWRVIP-42, Revision 1 at this time. 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.

RAI-3

Section 3.9.1 of the LTR 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. The NRC staff has questions for both.

- For Step 1, the LTR indicated that the start of the inspection interval for the inaccessible weld is the time at which 75 percent of the similar priority High/Low/No Inspection (H/L/N) plant-specific accessible welds are found to be cracked. It further states that this corresponds to an approximate 75 percent likelihood that the inaccessible weld is cracked. This is acceptable if the crack growth rate is slow and the components are inspected frequently. However, if a flaw is detected in the accessible welds in the future and is evaluated to be critical and requires repairs, then the assumption of a slow crack growth rate will be no longer true, and a repair-needed flaw in the inaccessible welds could become critical during a long inspection cycle (e.g., 4 years) to endanger LPCI's function of providing coolant when the emergency core cooling system (ECCS) is activated. Please address this concern and modify the proposed criterion for the start of the inspection interval for the inaccessible welds at the time when 75 percent of the similar priority H/L/N plant-specific accessible welds are found to be cracked. Possible remedies are using 50 percent instead of 75 percent, or maintain 75 percent but add additional measures when evaluation of the detected flaws in the accessible welds concludes that the flaw evaluation criteria are exceeded and a repair is needed.

- 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. Due to the same reasons as stated above, using essentially the average calculated times for the 75 percent population of accessible cracked welds may allow a repair-needed flaw in the inaccessible welds to become critical during a long inspection cycle (e.g., 4 years) to endanger LPCI's function of providing coolant when the ECCS is activated. Please address this concern and modify the proposed criterion as necessary. A possible remedy is to maintain the proposed length of the inspection interval but use the shortest calculated operating time for all similar accessible cracked welds when evaluation of the detected flaws in the accessible welds concludes that the flaw evaluation criteria are exceeded and a repair is needed.

BWRVIP Response to RAI-3

As stated in BWRVIP Letter 2011-048 (Reference 2) several considerations were used to define the 75% cracking of similar accessible welds criterion. These include:

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The 75% value was selected to provide a high likelihood that a crack would exist in a hidden weld when it was predicted to exist, that adequate structural and leakage margins would be maintained and to ensure that unnecessary repair procedures would not be implemented. This provides a more optimum use of resources and helps preclude accumulating personnel exposure that does not provide additional safety benefit.

Because all the similar accessible welds are inspected when a crack is detected, piping integrity is closely monitored and the inspection results provide an accurate representation of the whole population of welds of this type, including the hidden welds. This means that the results for the similar accessible welds can be used to predict the condition of the inaccessible welds with an acceptable level of confidence.

BWRVIP-42, Revision 1 requires all flaws be evaluated in accordance with Section 5 of the report and that structural and leakage margins be maintained for the period until the next inspection. Thus, even though a significant portion of the population of welds may be cracked, all existing flaws must meet the required structural and leakage margins specified in BWRVIP-42, Revision 1.

Extensive service experience and experimental studies have shown that the flaw growth from IGSCC is relatively slow and the flaw sizes and loads needed to result in pipe failure are very large. This ensures that flaws can be present in piping for long periods of time without creating significant potential for unacceptable margins against pipe failure. This provides added assurance that flaws in the inaccessible welds will maintain significant margins against failure similar to those of the accessible welds.

Moreover, the guideline requires leakage from inaccessible welds to be estimated and continually evaluated against station LOCA analyses based on assumed through-wall flaws in accessible welds where cracking of any size has been detected. This provides an additional means to monitor the condition of the inaccessible welds and added assurance that inaccessible welds maintain adequate structural and leakage integrity.

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Because there is no viable inspection procedure to examine the inaccessible welds the current guidance in BWRVIP-42-A does not provide any inspection requirements for the hidden welds. In light of the inability to provide a viable inspection option for the hidden welds, the BWRVIP developed specific guidance to ensure that the hidden welds will maintain adequate structural and leakage margins and will be addressed when significant cracking is found in similar accessible locations. The BWRVIP believes this is a significant improvement over the current NRC-approved guideline (BWRVIP-42-A).

Finally, the NRC has accepted an identical approach (Reference 3) for management of inaccessible welds in the core spray system which has been shown to be more prone to cracking than has the LPCI system. (In fact all of the LPCI couplings in the U.S. fleet of BWRs have been inspected at least once and no cracking has been observed to date.) Given the NRC acceptance of the methodology to address core spray cracking and the lack of cracking in LPCI systems, the BWRVIP proposes that no change be made to the methodology in BWRVIP-42, Revision 1.

RAI-4

Section 3.9.2 of the LTR discussed how similar accessible welds were determined without considering applied stresses. 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. Please justify the LTR's approach of obtaining information on inaccessible welds from cracking of similar accessible welds, considering that large difference between their stresses (applied + residual) could make the inaccessible welds and the corresponding similar accessible welds completely unrelated even they were made of the same material.

BWRVIP Response to RAI-4

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.

Note that, for the purposes of performing flaw evaluations, consideration of applied stresses *is* important and this is appropriately addressed by the methodology in Section 5 of the BWRVIP-42, Revision 1 report.

RAI-5

The title of Section 3.10.1 of the LTR, includes partially accessible welds, but partially accessible welds are not mentioned in the subsequent text. Please clarify.

BWRVIP Response to RAI-5

In the context of Section 3.10.1, "partially accessible welds" refers to any weld which is partially accessible for inspection but cannot be inspected over 100% of its length. As a practical matter, access limitations on certain welds in the LPCI system (as well as welds on many other components), may limit the amount of inspection coverage that can be obtained. The universal BWRVIP policy is that inspections should comprise examination of all accessible regions of a weld given limitations due to the state of the art of inspection tooling. Since the title of the Section is confusing and does not conform to conventional BWRVIP terminology, the BWRVIP proposes deletion of the words" partially accessible" from the Section title.

RAI-6

Section 5.1.2.1 of the LTR recommended that the limit load methodology described in Appendix C of Section XI of the 2004 Edition of the American Society of Mechanical Engineers (ASME) Code be used to determine the critical and allowable flaw lengths. However, the limit load equations presented in the LTR are not consistent with those in the 2004 Edition of the ASME Code, Section XI. Please note that the 2004 and later Edition of the ASME Code made two major changes to the Appendix C methodology:

(1) The definition of flow stress σt was revised from 3Sm, where Sm is the allowable stress per ASME Code, Appendix I to $\sigma t = (Sy + Su)/2$, using ASME Code specified yield and ultimate strength of the material, or $\sigma t = (cry + au)/2$ if the measured yield and ultimate strength of the material are available.

(2) The equations connecting the applied stresses and the failure bending stress for the non-flux welds and flux welds (i.e., Equations 5-5 and 5-6 of the LTR) were revised to adopt 4 safety factors for membrane stresses and 4 safety factors for bending stresses.

These changes were not implemented in the LTR's limit load methodology of Section 5.1.2.1. Please revise the LTR's methodology to be consistent with the 2004 and later editions of the ASME Code, Section XI, Appendix C because, for instance, the LTR's methodology is non-conservative for Level C loading when compared to the Appendix C approach of the 2004 and later editions of the ASME Code, Section XI.

BWRVIP Response to RAI-6

The BWRVIP has previously reviewed the effect of changes in Appendix C, Section XI, ASME Code on the structural integrity assessment of BWR internal components and has concluded that a change to the BWRVIP guidance is not warranted. There are two primary reasons for this conclusion.

First, the ASME makes periodic revisions to the Code. The revisions are either included as Code Cases or outright revisions to the Code. The changes are included in the Addenda (currently issued every 12 months) or new editions (issued every three years). The general practice is to allow the user to specify the Code edition used for a specific plant. The user is allowed the option of using a later Code or the original Code of record. This approach has been accepted by the NRC staff unless the revisions in the later Code versions are specifically not approved by the NRC. Thus, the use of the earlier Code editions (1989 to 2001 editions) in BWRVIP-42, Revision 1 is consistent with accepted practice.

Secondly, the impact of the revised Code rules is very small for flaw evaluation of reactor internal piping. The flaw evaluation methodology in BWRVIP-42 (and the subsequent revisions) was based on Appendix C in the 1989 edition of the ASME Code. The newer Code rules referred to in this RAI are based on the revised Appendix C of Section XI first published in the 2002 Addenda and later formally issued in the 2004 Edition of the ASME Code (referred herein as 'new Code rules'). The major changes in the new Code rules were the new definition of the flow strength and different safety factors for membrane and bending stresses for different operating conditions (Level A, B, C and D). The BWRVIP conducted a generic evaluation of the difference between the new Code rules and the 1989-2001 Code rules (referred herein as 'old Code rules'). The objective of the study was to determine if there was a compelling reason to revise the current guidelines to incorporate the 2004 Appendix C rules for evaluation of flaws in BWR internal piping. The evaluation concluded that there were no significant differences in allowable flaw size for piping and shroud components determined using the new and old Code rules. The primary reason is that, while the new Code rules would indicate that allowable flaw size is somewhat smaller for Level C conditions (and only Level C conditions), the piping and shroud evaluations are bounded by Level B or Level D conditions for which the Code changes make little difference. The key points in the evaluation are summarized here.

Table 1 shows a comparison of the key aspects of the old and new Code rules. Table 2 shows the specific structural factors in the new Code rules for circumferential flaws. The effects of the flow stress differences and the different structural factors are summarized below.

The flow stress is defined as (Sy + Su) / 2 rather than 3 Sm where Sy and Su are the Code values of the yield and ultimate strength respectively. For Type 304 or 316 stainless steel at 550°F, the new flow stress is (18.8 + 63.5) / 2 = 41.15 ksi rather than 3 Sm= 3 x 16.9 = 50.7 ksi used in the previous rules. This would imply that the 2004 Code rules are more conservative for austenitic piping by a factor of 1.23 (50.7/41.15).

However, the structural factors were defined for Level A-D conditions (Table 1) and separate factors were defined for both membrane and bending stresses. Taking the Level B factors as an

example, the new rules require a factor of 2.4 for membrane and 2.0 for bending instead of the 2.77 used in the old rules. This introduces a somewhat less conservative element in the calculation with respect to the structural factors under the new rules. If one averages the new structural factors for bending and membrane stress (2.4 + 2) / 2 = 2.2 and compares it to the old factor of 2.77, it is seen that the new rules would be less conservative by the factor of 1.26. Thus, when the conservatism due to the flow stress (1.23) is included with the reduced safety factors (1.26), one can conclude (at least for Level B conditions) that the 2004 Code rules and the 2001 Code rules essentially lead to the same overall structural factors.

This conclusion holds true for all conditions except Level C. For level C conditions, the combination of the new safety factors and the revised flow stress do, in fact, lead to a situation where the old Code rules are non-conservative by 15 or 20 percent. However, Level C is not limiting for the reactor internal components for the following reasons:

- Table 3 shows the typical load combinations (from BWRVIP-42) used for the evaluation of BWR LPCI components. The load combinations of interest are for Level B and Level D conditions since it includes the SSE loading. (Note that some of the hydrodynamic loads are not significant for reactor internals in plants with Mark I containments.)

- The membrane stress (for which the difference between the new and old Code rules are most significant) in the LPCI components is smaller since the differential pressure between the OD and ID is less than that in pressure boundary piping.

Based on the fact that the old rules and the new Code rules lead to the same overall structural factors for Level B or Level D conditions which are governing, it was concluded that no changes in the structural evaluation methodology are technically warranted.

The BWRVIP considered making the changes to the evaluation methodology solely to be in strict compliance with the latest version of the Code. However, since it was not necessary from a technical perspective and since it would require a significant effort by industry to revise flaw evaluations and flaw handbooks, the proposal was rejected.

Table 1. Comparison of the Features of the Old and New Code Rules

Old Code Rules (1989 to 2001 Codes)	New Code Rules (Post 2004 Codes)
The flow stress is assumed to be equal to 3Sm where Sm is the ASME Code Design Stress Intensity. For Type 304 or 316 stainless steel at 550°F, the flow stress is 3 Sm= 3 x 16.9 = 50.7 ksi.	The flow stress is defined as (Sy + Su) / 2 rather than 3 Sm where Sy and Su are the Code values of the yield and ultimate strength respectively. For Type 304 or 316 stainless steel at 550°F, the new flow stress is (18.8 + 63.5) / 2 = 41.15 ksi.
The structural factors are based on two classifications – 2.77 for Service Levels A and B (normal and upset conditions, respectively) including design conditions and 1.39 for Service Levels C and D (emergency and faulted conditions, respectively). This is consistent with the IWB-3600 of Section XI.	The structural factors were defined for Level A-D conditions (Table 2) and separate factors were defined for both membrane and bending stresses.
Different Z factors for SMAW and SAW welds.	Z factor is the same for all flux welds and is set equal to the value for SAW welds
The structural factors are specified for (Pm+Pb).	Separate factors for both membrane and bending stresses as shown in Table 2.

Table 2. Structural Factors for Circumferential Flaws

Service Level	Old Code Rules (1989 to 2001)	New Code Rules (Post 2004)	
	Structural Factor on Pm+Pb	Membrane Stress Pm SF_m	Bending Stress Pb SF_b
A	2.77	2.7	2.3
B	2.77	2.4	2.0
C	1.39	1.8	1.6
D	1.39	1.3	1.4

Table 3. Load Combinations for LPCI Components

No.	Load Combination	Level
1	NL + U-ΔP + DRGn + OBE + SRV	A/B
2	NL + U-ΔP + DRGa + CHUG + SRVads	C
3	NL + A-ΔP + DRGa + (JR+AP) + SSE	D
4	NL + A-ΔP + DRGa + CHUG + SRVads + SSE	D

RAI-7

Regarding the limit load methodology for multiple circumferential indications, the LTR proposed to stack the lengths of all the indications together after accounting for crack growth and flaw proximity and consider them as one indication. In addition, the LTR proposed the limit load methodology described in BWRVIP-76-A as an alternative. Since the July 27, 2006, safety evaluation (SE) (Accession No. ML 062140413) for BWRVIP-76 did not evaluate any limit load methodology, please confirm that "the limit load methodology described in BWRVIP-76-A" referred to the specific limit load methodology of the Distributed Ligament Length (DLL) computer code presented in Appendix D of BWRVIP-76-A.

BWRVIP Response to RAI-7

Combining multiple circumferential indications (after accounting for crack growth and flaw proximity) and considering them as one indication produces the most conservative results. BWRVIP-42, Revision 1 also offers the option of considering the individual segments as described in BWRVIP-76, Rev. 1-A. The methodology used in BWRVIP-76, Rev. 1-A is in fact the Limit Load method used in the Distributed Ligament Length (DLL) Code and described in Appendix D of BWRVIP-76-A.

RAI-8

Section 5.1.4 of the LTR presents leak rate calculation methods, including a method documented in Electric Power Research Institute NP-3596-SR, "PICEP: Pipe Crack Evaluation Program (Revision 1)." This LTR section also proposes 10 steps to predict leak rates from inaccessible welds. The NRC staff requests the following:

(1) Step 1 identifies the total number of inaccessible welds. Please confirm that the total number of inaccessible welds identified in Step 1 is for one LPCI coupling and all LPCI couplings in a plant are identical, so the 10 steps apply to each of the LPCI couplings in a plant.

(2) Step 3 is related to computing the leak rate from each similar accessible weld that is judged to have a through-wall flaw. Section 5.1.1.3 of the TR states, "in cases where only visual inspection is conducted, it is necessary to assume the indications are through-wall for the purpose of structural margin evaluation." Please confirm that the above statement of Section 5.1.1.3 also applies to leak rate evaluation in Step 3.

Further, Section 5.1.1.3 states, "UT [ultrasonic testing] examination could be performed to better characterize the crack." Please clarify that if UT is used, then a flaw may not be judged through-wall, depending on a flaw evaluation based on the size (length and depth) of the detected flaw.

BWRVIP Response to RAI-8

The total number of inaccessible welds described in Step 1 of Section 5.1.4 is for one LPCI coupling and the ten steps for leak rate calculation apply to each LPCI coupling.
When only visual inspection is performed, the indication is assumed to be a through-wall. This is applicable (i.e. visual indication is assumed to be through-wall) for leak rate evaluation described in Section 5.1.4 also. If UT is used and a part through crack indication is found, the flaw may not be judged to be through-wall depending upon the flaw characterization. In such a case, crack growth evaluation may be performed to determine if the crack becomes through-wall during the evaluation period. If a through-wall crack is predicted, the leak rate will be evaluated based on the predicted length.

RAI-9

The NRC SE dated January 9, 2001 (Accession No. ML010100157), on BWRVIP-42 with emphasis on license renewal (LR) applications (Appendix C of the LTR) specified 5 renewal applicant action items. The following requests are intended to remove some of the action items:

A. Action Item 1 requires the applicants for LR referencing the BWRVIP-42 report for the LPCI coupling internals verify that its plant is bounded by the BWRVIP-42 report. This may be removed, pending your satisfactory response to RAI-1. Action Item 1 further requires the applicants:

   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, including actions planned to inspect welds that are presently inaccessible. If corrective actions are necessary, the applicants shall either commit to follow the guidance in the staff-approved BWRVIP-56 report, "LPCI Coupling Repair Design Criteria," or describe the process that will be utilized to repair the LPCI couplings, if needed.

   Applicants for license renewal will be responsible for describing any such commitments and identifying how such commitments will be controlled. Any deviations from the aging management programs within the BWRVIP-42 report described as necessary to manage the effects of aging during the period of extended operation and to maintain the functionality of the reactor vessel components or other information presented in the report, such as materials of construction, will have to be identified by the renewal applicant and evaluated on a plant-specific basis in accordance with 10 CFR [Title 10 of the *Code of Federal Regulations]* 54.21(a)(3) and (c)(1).

   Revise Appendix A by addressing the above appropriately so that this action item can be eliminated.

B. Action Item 2 requires the applicants ensure that the programs and activities specified as necessary in the BWRVIP-42 report are summarily described in the Final Safety Analysis Report supplement. Please revise Appendix A of the LTR to include this requirement in

accordance with 10 CFR 54.21(d) so that this action item can be eliminated.

C. Action Item 3 requires the applicants ensure that the inspection strategy described in the BWRVIP-42 report does not conflict with or result in any changes to their technical specifications (TS). Please revise Paragraph A.6 of the LTR to state clearly that there are no TS regarding LPCI coupling inspection. If this is not the case, please revise Paragraph A.6 to elaborate on your effort of examining all TS regarding LPCI coupling inspection in accordance with 10 CFR 54.22 to determine "there are no changes or additions to the technical specifications associated with LPCI coupling as a result of this aging management review to ensure that the effects of aging are adequately managed" so that this action item can be eliminated.

D. Action Item 4 requires the applicants identify and evaluate any potential time-limited aging analyses issues which may impact the structural integrity of the subject reactor pressure vessel RPV internal components. Paragraph A.4 of the LTR is consistent with this requirement, except that this paragraph states, "Alternatively, Section 5.0 also allows use of measured crack growth rates or plant-specific information in predicting the crack growth rate." Please revise the statement to add "Any alternative crack growth rates shall be provided in the license renewal application for NRC review and approval." With this statement, this action item can be eliminated.

BWRVIP Response to RAI-9

A. With regard to the Action Item 1 requirement that LR applicants referencing BWRVIP-42 for the LPCI coupling internals verify that their plants are bounded by the BWRVIP-42 report, see the response to RAI-1.

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.

To address instances where a plant needs to deviate from the guidance in BWRVIP-42, an additional paragraph will be added at the end of paragraph A.3.c that states the following:

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).

B. A new paragraph will be added to Appendix A as follows:

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 BWRVIP-42 shall be summarily described in

the Final Safety Analysis Report license renewal supplement in accordance with 10 CFR 55.21(d).

Note: Current paragraphs A.6 and A.7 will be re-numbered A.7 and A.8.

C. The BWRVIP is not aware of any plants that specifically address LPCI couplings in their technical specifications (TS), but cannot confirm this. The BWRVIP does not monitor the content of TS, nor does the BWRVIP believe it is appropriate for the BWRVIP to do so. The existing text in paragraph A.6 was intended to state that there is nothing in BWRVIP-42 that would be cause for changes or additions to the TS. To address Action Item 3, the BWRVIP will 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.

Note: As noted in the response to B above, paragraph A.6 will be re-numbered to A.7.

D. The last two sentences of paragraph A.4 that read, "Alternatively, Section 5.0 also allows use of measured crack growth rates or plant-specific information in predicting the crack growth rate. The use of alternate approaches will be reviewed by the applicant to determine if the TLAA criteria apply." will be replaced with the following:

Alternatively, a lower crack growth rate may be used if it can be technically justified, is reviewed by the applicant to determine if the TLAA criteria apply, and it is provided in the license renewal application for NRC review and approval.

Additionally, the last sentence of Section 5.1.1.3, Crack Growth, which reads, "However, a lower crack growth rate can be used, if technically justified.", will be revised to read as follows:

However, a lower crack growth rate can be used if technically justified and documented in a deviation disposition in accordance with BWRVIP-94 [14].

Note: BWRVIP-94 (Reference 4 below) will also be added to the references in Section 6 of BWRVIP-42 (as reference 14).

RAI-10

On June 8, 2009, General Electric-Hitachi (GEH) issued Safety Communication (SC) 09-01, "Annulus Pressurization Loads Evaluation," related to Annulus Pressurization (AP) loads, also referenced as "New Loads," and the corresponding stresses on the RPV, internals, and containment structures. SC 09-01 identifies that "...the AP loads used as input for design

adequacy evaluations of NSSS [nuclear steam supply system] safety related components for "New Loads" plants might have resulted in non-conservative evaluations." The NRC staff also recently became aware of three other related GEH SCs, namely SC 09-03, Revision 1 related to core shroud recirculation line break loads, SC 11-07 related to a new load combination, and SC 12-20 related to acoustic load errors, all of which were issued on June 10, 2013. In addition, the NRC is aware of some plant-specific re-evaluations of New Loads performed that increased the AP loads acting on the core spray piping and sparger components, and the similar effects may apply to LPCI couplings. Please provide additional guidance in Section 4 of BWRVIP-42, Revision 1, so that the AP loads can be properly addressed by licensees to reflect the correct hydrodynamic loads in response to SC 09-01.

BWRVIP Response to RAI-10

The BWRVIP is aware of the numerous GEH Safety Communications and understands that they may have an effect on one or more of the BWRVIP Guidelines. 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. As such, the BWRVIP proposes that no changes be made to BWRVIP-42 Revision 1 at this time. Note that the BWRVIP is currently evaluating the impact of the SCs on all of the BWRVIP Inspection Guidelines and will issue revised guidance where deemed necessary.

References:

1. *BWRVIP-234: BWR Vessel and Internals Project, Thermal Aging and Neutron Embrittlement Evaluation of Cast Austenitic Stainless Steels for BWR Internals.* EPRI, Palo Alto, CA: 2009. 1019060.
2. BWRVIP Letter 2011-048, D. Czufin (Chairman, BWRVIP) to J. Rowley (NRC), "Project No. 704 – BWRVIP Response to NRC Request for Additional Information on BWRVIP-18, Revision 1," March 4, 2011.
3. R.A. Nelson (NRC) to D. Czufin (Chairman, BWRVIP), "Final Safety Evaluation for Electric Power Research Institute Boiling Water Reactor Vessel and Internals Technical Report 1016568, BWRVIP-18 Revision 1: BWR Core Spray Internals Inspection and Flaw Evaluation Guidelines (TAC No. ME2189)," January 30, 2012.
4. *BWRVIP-94NP, Revision 2: BWR Vessel and Internals Project, Program Implementation Guide.* EPRI, Palo Alto, CA: 2011. 1024452.

H

MAIL ON BWRVIP-42, REVISION 1 SE, DATED MARCH 3, 2016 (ADAMS ACCESSION NO. ML16063A477)

From: Contractor - Wirtz, Charles <cwirtz@contractor.epri.com>
Sent: Thursday, March 03, 2016 3:52 PM
To: Holonich, Joseph
Cc: McGehee, Andrew; Odell, Andrew D:(GenCo-Nuc); Carter, Bob; Dyle, Robin; Sheng, Simon; Mendiola, Anthony; McHale, John; Richter, Steven K.
Subject: [External_Sender] RE: BWRVIP-42, Rev 1 Review Actions

Joe,

As we discussed on today's call, please see the following proposed clarifications to be added to the "-A" version of BWRVIP-42, Revision 1 to resolve possible conditions 3a, 3b, and 3c.

3a). 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.*)

3b). 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."

3c). 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."

We believe the above inserts are consistent with sample sentences provided by the Staff below. Please let us know if these proposed inserts resolve the Staff's concerns.

Note that this email does not contain any EPRI proprietary information.

Chuck

Charles Wirtz
ELECTRIC POWER RESEARCH INSTITUTE
Ph # 704-595-2618
Together... Shaping the Future of Electricity

From: Holonich, Joseph [mailto:Joseph.Holonich@nrc.gov]
Sent: Thursday, September 17, 2015 9:55 AM
To: Contractor - Wirtz, Charles <cwirtz@contractor.epri.com>
Cc: McGehee, Andrew <AMcGehee@epri.com>; Odell, Andrew D:(GenCo-Nuc) <Andrew.Odell@exeloncorp.com>; Carter, Bob <bcarter@epri.com>; Dyle, Robin <rdyle@epri.com>; Ronald J. DiSabatino (ronald.disabatino@exeloncorp.com) <ronald.disabatino@exeloncorp.com>; Sheng, Simon <Simon.Sheng@nrc.gov>; Mendiola, Anthony <Anthony.Mendiola@nrc.gov>; McHale, John <John.McHale@nrc.gov>
Subject: RE: BWRVIP-42, Rev 1 Review Actions

Chuck,

To avoid possible miscommunication on words that can eliminate Conditions 3(a), 3(b), and 3(c), please see below for some possible sentences. As we discussed earlier today, the BWRVIP can develop some wording that it can finalize in a letter to the staff.

Sample added sentence in the TLR for deletion of Condition 3(a):

The plants are required to reexamine their AP load calculation and make necessary revision, if necessary, considering the potentially increased AP loads as revealed in GE SC09-01.

Sample added sentence in the TLR for deletion of Condition 3(b):

If the calculated time is less than the time to the next proposed scheduled inspection, the plants are required to shorten the proposed scheduled inspection interval accordingly.

Sample added sentence in the TLR for deletion of Condition 3(c):

In any plant-specific leakage assessment, the plants are required to present a summary on its allowable leakage determination with the reference(s) clearly stated. The calculated leakage through detected and postulated flaws shall be bounded by this allowable leakage.

Joe

From: Contractor - Wirtz, Charles [mailto:cwirtz@contractor.epri.com]
Sent: Wednesday, September 16, 2015 4:07 PM
To: Holonich, Joseph
Cc: McGehee, Andrew; Odell, Andrew D:(GenCo-Nuc); Carter, Bob; Dyle, Robin; Ronald J. DiSabatino (ronald.disabatino@exeloncorp.com)
Subject: [External_Sender] BWRVIP-42, Rev 1 Review Actions

Joe,

This email is a follow-up to the message I just left for you.

As an action item out of yesterday's call, the BWRVIP said they would caucus and then let the NRC know whether it was the BWRVIP's preference for the BWRVIP-42, Rev.1 CASS issue to wait for at least the draft SE for BWRVIP-234 to be issued so any actions taken to resolve the CASS issue for BWRVIP-42, Rev. 1 would be consistent with, or at least with the knowledge of, the BWRVIP-234 SE. It was decided that is our preference.

Additionally, on the call yesterday the BWRVIP indicated that outside of the CASS issue, it did not object with the NRC proceeding with development of the BWRVIP-42, Rev. 1 SE. After additional consideration, we now request that the NRC not proceed with development of the SE in order to provide time for additional consideration of the issues that Simon raised with the entire BWRVIP team. Additionally, for those items where the BWRVIP members on the call agreed that some clarification could be made and it was discussed that perhaps that could just be handled by documenting the proposed changes in an email that could be posted in ADAMS, it was later realized that would be out of process for us in that any new paragraphs to be inserted into BWRVIP-42, Rev. 1 would need to be approved by our committee review process.

Please give me a call so we can further discuss the intricacies on how to proceed from here.

Chuck

Charles Wirtz
ELECTRIC POWER RESEARCH INSTITUTE
Ph # 704-595-2618
Together... Shaping the Future of Electricity

I

RECORD OF REVISIONS FOR BWRVIP-42, REVISION 1-A

BWRVIP-42, Revision1-A	Information from the following documents was used in preparing the changes made from BWRVIP-42, Revision 1 _to BWRVIP-42, Revision 1-A 1. BWRVIP-42, Revision 1: BWR Vessel and Internal Project, Low Pressure Coolant Injection (LPCI) Coupling Inspection and Flaw Evaluation Guidelines, EPRI, Palo Alto, CA:2010. 2. Letter from Joseph Holonich (NRC) to Dennis Madison (BWRVIP Chairman), "REQUEST FOR ADDITIONAL INFORMATION FOR THE BWRVIP [BOILING WATER REACTOR VESSEL INTERNALS PROJECT]-42, REVISION 1, "LOW PRESSURE COOLANT INJECTION (LPCI) COUPLING INSPECTION AND FLAW EVALUATION GUIDELINES" (TAC MF0363)", dated August 5, 2013. (BWRVIP Correspondence File No. 2013-143A). 3. Letter form Tim Hanley (BWRVIP Chairman) to Document Control Desk (NRC), Attention Joseph Holonich, "Project No. 704 – BWRVIP Response to NRC Request for Additional Information on BWRVIP-42, Revision 1," dated May 20, 2015. (BWRVIP Correspondence File No, 2015-059). 4. E-mail on BWRVIP-42, Revision 1, dated March 3, 2016 (ADAMs Accession No. ML 16063A477) 5. "Letter from Kevin Hsueh (NRC) to Tim Hanley (BWRVIP Chairman) "FINAL PROPRIETARY SAFETY EVALUATION OF ThE BWRVIP-42, REVISION 1, LOW PRESSURE COOLANT INJECTION (LPCI) COUPLING INSPECTION AND FLAW EVALUATION GUIDELINES (TAC NO. MF0363)." DATED August 8, 2016. (BWRVIP Correspondence File No. 2016-088A). Details of this revision are provided in Table I-1.

Table I-1
Details of Revisions

Required Revision	Source of Requirement for Revision	Description of Revision Implementation
Add NRC Safety Evaluation (SE) behind report title page	NRC request	Added NRC SE on BWRVIP-42, Revision 1 after the Disclaimer page
Revise report to incorporate language on need to use measured CGRs in flaw evaluations if they exceed assumed CGRs.	NRC SE Condition 2(b)	Added new section 3.5.2 as follows: In proposed future inspections, the utilities must confirm that the measured CGRs (i.e., the calculated CGR based on the current and 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.
Revise report to indicate that when 50% and then again when 75% of accessible similar welds are found to be cracked in the future, the utility must inform the NRC Office of Nuclear Reactor Regulation by letter about reaching these two thresholds within 90 days.	NRC SE Condition 2(a)	Section 3.9.1 revised to include NRC requested language to indicate that when 50% and then again when 75% of accessible similar welds are found to be cracked in the future, the utility must inform the NRC Office of Nuclear Reactor Regulation by letter about reaching these two thresholds within 90 days.
Add requirement to assess implications of GEH SC 09-01 on AP loads for LPCI coupling flaw evaluations	BWRVIP commitment made in e-mail to NRC on March 3, 2016 (ADAMS Accession No. ML 16063A477)	Added the following language to Section 4.1.6: Plants should reexamine their AP load calculations and update those calculations, where necessary, considering the potential for increased AP loads documented in Reference 14.

Table I-1 (continued)
Details of Revisions

Required Revision	Source of Requirement for Revision	Description of Revision Implementation
Add requirement to consider loss of fracture toughness of CASS components when conducting flaw evaluations of flaws in or near CASS components	NRC SE Condition 1 for CASS locations	Added the following to Section 5.0 : Note: For welds at CASS locations, i.e., weld 45-12 and weld 45-3b, if Baseline inspections or Re-inspections of identify flaws away from the weld centerline such that the detected flaws may be in the CASS material (LPCI sleeve flange or Shroud attachment ring), the resulting flaw evaluation per Section 5.0 shall be modified considering the reduced fracture toughness of CASS materials discussed in Appendix A of the SE for BWRVIP-234 (See BWRVIP-234-A).
Add requirement to submit a deviation disposition when using CGRs lower than those specified in BWVIP guidance.	BWRVIP commitment in response to NRC RAI No. 9.	Add the following to Section 5.1.1.3: However, a lower crack growth rate can be used, if technically justified and documented in a deviation disposition in accordance with BWRVIP-94[15].
Add new Reference: BWRVIP-94NP, Revision 2: BWR Vessel and Internals Project, Program Implementation Guide. EPRI, Palo Alto, CA: 2011. 1024452	BWRVIP commitment in response to NRC RAI No. 9.	Added new Reference 15: BWRVIP-94NP, Revision 2: BWR Vessel and Internals Project, Program Implementation Guide. EPRI, Palo Alto, CA: 2011. 1024452

Table I-1 (continued)
Details of Revisions

Required Revision	Source of Requirement for Revision	Description of Revision Implementation
Revise Section 5.1.2.1.5 to state: "The time to reach the minimum acceptable structural margin must be greater than the time to the next scheduled inspection. Otherwise, the inspection interval must be reduced."	BWRVIP commitment made in e-mail to NRC on March 3, 2016 (ADAMS Accession No. ML 16063A477)	Revised Section 5.1.2.1.5 as follows: Allowable flaw size (determined from Section 5.1.2.1.4) = (Detected flaw size + Additional allowance due to NDE uncertainty (if appropriate) + Crack growth (crack growth rate * time) at both tips). The time to reach the minimum acceptable structural margin so derived must be greater than the time to the next scheduled inspection. Otherwise, the inspection interval must be reduced.
Add the following to 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 that the plant remains within their design basis. The leakage assessment should include all applicable references regarding the determination of calculated and allowable leakage.	BWRVIP commitment made in e-mail to NRC on March 3, 2016 (ADAMS Accession No. ML 16063A477)	Added to following to the end of 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 that the plant remains within their design basis. The leakage assessment should include all applicable references regarding the determination of calculated and allowable leakage.
Requirement to identify deviations from BWRVIP-42 requirements in license renewal applications	BWRVIP commitment in response to NRC RAI No. 9 Part A.	Added the following at the end of Section A-3: "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)."

Table I-1 (continued)
Details of Revisions

Required Revision	Source of Requirement for Revision	Description of Revision Implementation
Add the following to Section A.4: Alternatively, a lower crack growth rate may be used if it can be technically justified, is reviewed by the applicant to determine if the TLAA criteria apply, and is provided in the license renewal application for NRC review and approval	BWRVIP commitment in response to NRC RAI No. 9.	Added the following sentence to Section A-4: Alternatively, a lower crack growth rate may be used if it can be technically justified, is reviewed by the applicant to determine if the TLAA criteria apply, and is provided in the license renewal application for NRC review and approval.
Revise Section 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.	BWRVIP commitment in response to NRC RAI No. 9 Part C.	Section A.6 revised 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.
Requirement to include a summary description of BWRVIP-42 I&E Guidelines in the plant FSAR License Renewal Supplement.	BWRVIP commitment in response to NRC RAI No. 9 Part B. Although the RAI response stated that a new paragraph A6 would be inserted, instead a new paragraph A8 was inserted with no renumbering of sections.	Added a new Section A.8: A.8 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 BWRVIP-42 shall be summarily described in the Final Safety Analysis Report license renewal supplement in accordance with 10 CFR 54.21[d].
End		