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2009-200_____BWR Vessel & Internals Project (BWRVIP)

June 17, 2009

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

Attention: Joseph Williams

Subject: Project No. 704 – Comments and Corrections to NRC Draft Safety Evaluation of Appendix K of BWRVIP-76 (License Renewal Appendix of Core Shroud Inspection and Flaw Evaluation Guidelines)

Reference: Letter from Stacey L. Rosenberg (NRC) to Rick Libra (BWRVIP Chairman), "Draft Safety Evaluation for Electric Power Research Institute (EPRI) Boiling Water Rector Vessel and Internals Project Topical Report 'BWR Vessel and Internals Project, BWR Core Shroud Inspection and Flaw Evaluation Guidelines (BWRVIP-76)' for License Renewal, Appendix K (TAC NO. MD4433)," dated April 9, 2009.

The purpose of this letter is to provide BWRVIP clarifications and corrections in the NRC draft Safety Evaluation (SE) of Appendix K of BWRVIP-76 that was transmitted by the NRC letter referenced above. That NRC letter requested that the BWRVIP comment on any factual errors or clarity concerns in the draft SE

Enclosed are five (5) copies of the following items:

1. A comment table listing each numbered comment, its location in the NRC draft SE, the issue or topic and a discussion. The page and line numbers referred to in this table are from the "clean" copy of the draft SE (see item 3 below).
2. The draft SE in "Track Changes" mode showing the proposed BWRVIP revisions. Note that the blank lines on pages 4 and 5 are where EPRI proprietary information has been removed. This proprietary information was previously identified to you.
3. A "clean" copy of the draft SE for locating the comments identified in item 1 above. Note that the blank lines on pages 4 and 5 are where EPRI proprietary information has been removed.

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

Sincerely,

Rick Libra

Rick Libra
Exelon
Chairman, BWR Vessel and Internals Project
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3420 Hillview Avenue, Palo Alto, CA 94304-1395 USA • 650.855.2000 • Customer Service 800.313.3774 • www.epri.com

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Item 1

BWRVIP Technical Corrections and Proposed Revisions

NRC Safety Evaluation of BWRVIP-76, Appendix K, dated April 9, 2009
BWR Core Shroud Inspection and Flaw Evaluation Guidelines for License Renewal

BWRVIP Technical Corrections and Proposed Revisions

NRC Safety Evaluation of BWRVIP-76, Appendix K, dated April 9, 2009
BWR Core Shroud Inspection and Flaw Evaluation Guidelines for License Renewal

Comment No.	Location (in NRC SE) Page and Line Number	Issue	Discussion
1	Page 10, line 20	**Correction:** Fracture toughness values in BWRVIP-100-A	BWRVIP-100-A identifies several fracture toughness values lower than the value in Appendix C of BWRVIP-76.
2	Page 10, lines 30 and 39	**Clarification:** Reference to BWRVIP-99	Regarding crack growth rates, the draft SE references only BWRVIP-99 but not two other crack growth reports published by the BWRVIP and recently submitted to the NRC: BWRVIP-14-A and BWRVIP-99-A. BWRVIP-14-A (and its original predecessor BWRVIP-14 approved by the NRC) contains crack growth rates for the depth direction for stainless steel BWR internal components with fluence values $<5 \times 10^{20}$ n/cm^2. BWRVIP-99-A contains crack growth rates for the depth direction for stainless steel BWR internal components with fluence values from 5×10^{20} n/cm^2 to 3×10^{21} n/cm^2. BWRVIP-14-A should also be referenced since the lower fluence values will apply to the evaluation of some welds in the license renewal period. See suggested revisions to the last paragraph of Section 3.3 in the SE.
3	Page 10, lines 32 -36	**Editorial Error:** Inspection intervals for shrouds with neutron fluence equal to or greater than 1×10^{21} n/cm^2	These lines state "The BWRVIP stated… and will develop generic inspection intervals for core shroud welds that are exposed to a neutron fluence value equal to or greater than 1×10^{21} n/cm^2." The BWRVIP response to the Request for Additional Information (RAI) referred to here stated the following: "The BWRVIP intends to investigate the development of generic inspection intervals for high fluence conditions." The response to the RAI further stated: "However, since that time BWRVIP-99 and BWRVIP-100-A have been issued and approved by NRC. Consequently criteria have been

Comment No.	Location (in NRC SE) Page and Line Number	Issue	Discussion
			established to address the effects of fluence on crack growth and fracture toughness that exceed the limits specified in BWRVIP-76. An analysis performed to these criteria will, on a plant specific basis, establish an inspection frequency. BWR utilities are required to follow this guidance when performing flaw evaluations." These BWRVIP methodologies continue to be the BWRVIP position for determining inspection intervals for cracked core shroud high fluence conditions subject to the limitations identified in the BWRVIP reports. See suggested revisions to the last paragraph of Section 3.4 of the draft SE.
4	Page 11, line 34	**Clarification:** Bounded by BWRVIP-76	This line states: "The applicant is to verify that its plant is bounded by TR BWRVIP-76." All U. S. BWR plants have committed to follow the guidance in BWRVIP-76 unless they notify the NRC otherwise. Furthermore, it is not known what "bounded by" means. The BWRVIP suggests this sentence be deleted since the following sentence adequately describes the commitment requested of the renewal applicant
5	Page 12, lines 15-19	**Factual Error:** Crack growth rate and related fluence range	BWRVIP-14 and BWRVIP-99 (and –A versions BWRVIP-14-A and BWRVIP-99-A) address crack growth rates whereas BWRVIP-100-A addresses fracture toughness. Furthermore, crack growth rates in BWRVIP-99 (and BWRVIP-99-A) are for components with a fluence range of 5×10^{20} n/cm^2 to 3×10^{21} n/cm^2, not equal to or greater than 1×10^{21} n/cm^2 as stated in the SE The BWRVIP-100-A report has fracture toughness values for several ranges of fluence values. The BWRVIP suggests that the wording be revised to state that the crack growth rates and fracture toughness values for irradiated materials are for the fluence ranges as specified in the reports.
6	Page 13, lines 10-11	**Clarification:**	Suggest adding BWRVIP-14-A and wording to require reference to

Comment No.	Location (in NRC SE) Page and Line Number	Issue	Discussion
		Reference to BWRVIP-99 and BWRVIP-100-A	the latest NRC approved versions of BWRVIP-14-A, BWRVIP-99-A and BWRVIP-100-A.

Item 2

DRAFT SAFETY EVALUATION (SE) BY THE

OFFICE OF NUCLEAR REACTOR REGULATION

FOR ELECTRIC POWER RESEARCH INSTITUTE (EPRI)

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

TOPICAL REPORT (TR) "BWR VESSEL AND INTERNALS PROJECT, BWR CORE SHROUD INSPECTION AND FLAW EVALUATION GUIDELINES (BWRVIP-76)"

FOR LICENSE RENEWAL (LR) - APPENDIX K

PROJECT NO. 704

DRAFT SAFETY EVALUATION (SE) BY THE

OFFICE OF NUCLEAR REACTOR REGULATION

FOR ELECTRIC POWER RESEARCH INSTITUTE (EPRI)

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

TOPICAL REPORT (TR) "BWR VESSEL AND INTERNALS PROJECT, BWR CORE SHROUD

INSPECTION AND FLAW EVALUATION GUIDELINES (BWRVIP-76)"

FOR LICENSE RENEWAL (LR) - APPENDIX K

PROJECT NO. 704

1.0 INTRODUCTION

1.1 History: License Renewal Appendix

By letter dated December 9, 1999, (Agencywide Documents Access and Management System (ADAMS) Accession No. ML082620712), as supplemented by letters dated June 8, 2005, (ADAMS Accession No. ML051640498), and April 21, 2008 (ADAMS Accession No. ML081200068), the BWRVIP submitted for the U.S. Nuclear Regulatory Commission (NRC) staff review and approval the EPRI Proprietary Report TR-114232, "BWR Vessel and Internals Project, BWR Core Shroud Inspection and Flaw Evaluation Guidelines (BWRVIP-76)."

TR BWRVIP-76 combines the guidance from several BWRVIP TRs and incorporates information from several NRC staff reviews and SEs. By letter dated July 28, 2006, (ADAMS Accession No. ML062140594), the NRC staff issued the SE for BWRVIP-76. That SE did not cover the LR related Appendix K, which was originally submitted with the TR.

The review of Appendix K, "Guidelines for Inspection of BWR Core Shrouds: Demonstration of Compliance with the Technical Information Requirements of the License Renewal Rule under 10 CFR [Title 10 of the *Code of Federal Regulations*] Part 54.21," has now been completed by the NRC staff.

In accordance with 10 CFR 54.21, each LR application (LRA) includes an integrated plant assessment (IPA) and an evaluation of time-limited aging analyses (TLAA). The IPA must identify and list those structures and components subject to an aging management review (AMR) 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

ENCLOSURE

application include any technical specification (TS) 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-76 TR applies to its facility and that the results of the Appendix K 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 below by the NRC staff. With this exception, such an applicant may rely on the BWRVIP-76 TR for the demonstration required by 10 CFR 54.21(a)(3) with respect to the components and structures within the scope of the TR. 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.

By referencing the BWRVIP-76 TR, as supplemented and modified, and meeting these limitations, an applicant will provide sufficient information that will enable the NRC 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 TR will be maintained consistent with the current licensing basis during the period of extended operation.

1.2 Purpose and Applicability

The NRC staff reviewed the BWRVIP-76 TR and its Appendix K to determine whether its guidance will provide acceptable levels of quality for inspection and flaw evaluation of the subject safety-related reactor vessel internal (RVI) components during the period of extended operation. The review also considered compliance with the LR Rule in order to allow applicants the option of incorporating the BWRVIP-76 guidelines by reference in a plant-specific IPA and associated TLAAs.

Any BWRVIP member utility may reference this TR in a LRA to satisfy the requirements of: 1) 10 CFR 54.21(a)(3) for demonstrating that the effects of aging on the core shroud components within the scope of this TR will be adequately managed, and 2) 10 CFR 54.21(c)(1) for demonstrating the appropriate findings regarding the identification and evaluation of TLAAs for the core shroud for the period of extended operation. The NRC staff also concludes that, upon completion of the renewal applicant action items set forth in Section 4.1 below, referencing this TR in an LRA and summarizing in a final safety analysis report (FSAR) supplement, the aging management programs (AMPs) and the TLAA evaluations contained in this TR will provide the NRC staff with sufficient information to make the findings required by 10 CFR 54.29(a)(1) and (a)(2) for components within the scope of this TR.

2.0 SUMMARY

The BWRVIP-76 TR and its Appendix K contain a generic evaluation of the management of the effects on aging on the subject safety-related RVI components so 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-76 TR and want to incorporate the TR and Appendix K by reference into a plant-specific IPA and associated TLAAs.

The BWRVIP-76 TR addresses the following topics:

1) Introduction: It provides the objective for an acceptable regulated and unified industry approach for inspecting horizontal, vertical, and radial ring welds in repaired and unrepaired BWR core shrouds, and for inspecting repair components and anchorages in repaired shrouds. The TR also provides a brief background review of prior industry inspections of these welds.

2) Inspection Strategy for Welds in Unrepaired Shrouds: It provides inspection strategies and methods for horizontal welds in unrepaired core shrouds based on the category classification of the welds. It provides limitations addressing a required plant-specific evaluation. The TR also provides the inspection requirements and acceptance standards for vertical welds.

3) Inspection Strategy for Welds in Repaired Shrouds: It provides guidelines for recommended inspections of horizontal, vertical, and radial ring welds in repaired shrouds. This includes sampling of vertical welds and/or screening of horizontal welds. In addition, the TR provides the guidelines and suggested schedules for the inspection of the repaired components and the associated repair anchorages.

4) Reporting Requirements: It provides guidance for reporting results of inspections that do, or do not, meet the inspection and evaluation (I&E) guidelines.

Appendix K of the BWRVIP-76 TR provides LR technical requirements for core shroud components which are discussed below:

Function of Core Shroud Assembly

According to the regulations at 10 CFR 54.4(a)(1)(ii) and (iii), the core shroud is required to ensure the capability to shutdown the reactor and maintain it in a safe shutdown condition and prevent or mitigate the consequences of accidents that could result in potential offsite exposure comparable to 10 CFR Part 100 guidelines. Therefore, the intended functions for the core shroud are to:

1) Provide a partition to separate the upward flow of the coolant through the core from the downward recirculation flow;

2) Maintain fuel alignment such that control rods can be inserted; and

3) Form part of the boundary to maintain water level in the core after a loss-of-coolant accident (LOCA). The intended functions are preserved under normal, upset, emergency, and faulted conditions. Appendix D.6 of the BWRVIP-76 TR identifies the safety factors that need to be considered to determine that stress levels for the various operating conditions are consistent with the CLB. The applied loads and load combinations are described in the BWRVIP-02 TR, "BWR Vessel Internals Project, BWR Core Shroud Repair Design Criteria."

Core Shroud Components Subject to Aging Management Review

Paragraph 54.21(a)(1) of the rRule provides the requirements for identifying the core shroud components that are subject to AMR. To satisfy the requirements of paragraph 54.21(a)(1), the Nuclear Energy Institute (NEI) provided guidelines (Reference 1) to identify the passive and long-lived components. All components, including the core shroud head flange bolted connection, in the core shroud assembly are passive and long-lived, and therefore, the core shroud assembly is subject to AMR. The AMR of the core shroud head flange bolted connection, however, is included in the review of the top guide assembly.

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

a) Description of Aging Effects

The BWRVIP industry report (Reference 2) is used to identify the aging mechanisms for the core shroud materials. The NUREG-1557 (Reference 3) is used to establish the correlation between the aging effects and their associated aging mechanisms. Based on the previous industry experience, it was determined that crack initiation and growth due to stress corrosion cracking (SCC) is the only aging effect that requires aging management review for the core shroud. This conclusion is consistent with the scope and intent of the re-inspection guidelines. The causes of the SCC and a susceptibility assessment for the core shroud (including fabrication history, water chemistry, material carbon content, neutron fluence, and hot operating time) are provided in Appendix B.1 of the BWRVIP-76 TR. Based on the susceptibility considerations, the various BWR shrouds are placed in three categories. The categories consider the material specification (Type 304 or 304L), method of fabrication (welded plate rings or forged rings), and operating history relative to coolant conductivity. The categories are defined as follows:

Category A:

Category B:

Category C:

Inspection of vertical welds in this category are discussed in Section 3.2 of this SER.

b) Assessment of Aging Effects and Programs

Inspection of Un-repaired Core Shrouds

The BWRVIP determined that the extent of inspection required for a given plant is determined based on three susceptibility factors which can be readily evaluated: hot operating time, conductivity and shroud material type, and fabrication features. The three categories (A, B, and C) were used in the shroud inspections and flaw evaluations. The inspection criteria for categories B or C will be used by the applicants to ensure structural integrity of the core shroud assembly during the LR period.

Section 3.0 of the BWRVIP-76 inspection guidelines addresses the inspection requirements for repaired core shroud welds. The BWRVIP recommends that inspections of repaired core shroud welds are necessary to provide periodic confirmation of the integrity of the repaired shroud during the LR period. The applicant is required to develop an inspection program incorporating the requirements of the inspection guidelines. In addition, the repair program shall consider vendor recommendations, industry experience, aging effects, and the critical components and features of the repair design.

c) Demonstration that the Effects of Aging are Adequately Managed

Based on the industry's experience it has been established that SCC is the only aging effect for the core shroud that requires AMR for LR. This aging effect will be managed by incorporating the inspection strategies described in Section 2.0 (un-repaired shrouds) and Section 3.0 (repaired shrouds) of the BWRVIP-76 TR, when appropriate, in the plant-specific inspection plans. To further demonstrate that SCC is adequately managed, the BWRVIP provides strategies that are

based on current knowledge of the core shroud cracking issue and inspection experience at various plants. It provides a staged approach with respect to the inspection effort and associated analyses that are logically expanded, as necessary, to confirm core shroud structural integrity. As more inspections are performed, specific aspects of implementing the inspection strategy may be further refined and incorporated in plant-specific inspection plans.

Implementation of the inspection strategy provided in the inspection guidelines of the BWRVIP-76 TR and the resulting plant-specific inspection plans during the LR period will provide a verification of core shroud structural integrity requirements. Therefore, there is reasonable assurance that SCC crack initiation and growth will be adequately managed so that the intended functions of the core shroud will be maintained consistent with the CLB in the LR period.

Time-Limited Aging Analyses

The regulation at 10 CFR 54.21(1)(c) requires that each application for LR contain an evaluation of TLAAs 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.

BWRVIP-76, Appendix K provides guidance to licensees regarding the identification of potential TLAAs, in their unit's CLB. The six criteria contained in the NEI industry guideline (Reference 1) were applied to define criteria that may be used to identify potential TLAAs. Specifically, calculations and analyses which involve:

1. the core shroud assembly,
2. a consideration of the effects of aging,
3. time-limited assumptions defined by the current operating term,
4. a determination relevant to a safety determination,
5. conclusions (or provide the basis for conclusions) related to the capability of the core shroud to perform its intended function, and
6. incorporation or reference of the calculation or analyses in the plants' CLB may be a TLAA.

If a plant-specific analysis identified by an applicant meets all six criteria above, then this analysis will be considered a TLAA for LR and evaluated by the applicant. The plant-specific analyses of the core shroud for fatigue will be reviewed by the applicant to determine if the TLAA criteria apply.

Determination of the inspection intervals for core shroud welds is based on the generic fracture mechanics analyses described in Appendix D of the BWRVIP-76 TR. The methodology and assumptions used in these analyses result in the following potential TLAA issues. The applicant may be required to evaluate these issues in a plant-specific analysis.

1) The length of time evaluated in the analyses.

2) Linear elastic fracture mechanics (LEFM) is required if specified fluence level threshold values are exceeded during the extended operating period.

3) The effects of BWR industry operating experience on the number of postulated flaws assumed in the analyses.

4) The applicable crack growth rates are shown to be greater than $5x10^{-5}$ in/hr.

Exemptions (54.21[c][2])

Exemptions associated with the core shroud that contain TLAA analysis issues will be identified and evaluated for LR by individual applicants.

TS Changes or Additions (54.22)

The BWRVIP stated that there are no generic changes or additions to TSs associated with the core shroud as a result of this aging management review to ensure that the effects of aging are adequately managed. Individual applicants will identify plant-specific changes.

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 LR for the core shroud will continue to be conducted in accordance with the CLB.

3.0 STAFF EVALUATION

The NRC staff reviewed TR BWRVIP-76, Appendix K, to determine if it demonstrates that the effects of aging on the core shroud components within the scope of the TR 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). Besides the IPA, Part 54 requires an evaluation of TLAAs in accordance with 10 CFR 54.21(c). The NRC staff reviewed the TR BWRVIP-76, Appendix K, to determine if the TLAAs covered by the TR were evaluated for LR in accordance with 10 CFR 54.21(c)(1).

3.1 Structures and Components Subject to AMR

The NRC staff agrees that core shroud components are subject to AMR because they perform intended functions without moving parts or without a change in the configuration or properties. The NRC staff concludes that, to meet the applicable requirements of 10 CFR 54.21(a)(1), the BWR LR applicants must identify the appropriate safety-related core shroud components that

are subject to AMR. The NRC staff also agrees with the BWRVIP's assessment regarding the intended function of the core shroud component which is addressed in Section 2.0 of this SE.

3.2 Effects of Aging

The information necessary to demonstrate compliance with the requirements of the LR Rule 10 CFR 54.21 is provided in Appendix K of the BWRVIP-76 TR. The industry report (Reference 2) and the resolution to the NRC questions on this TR were used to identify the aging mechanisms for the core shroud. If the industry report concluded that an aging mechanism is significant, then that aging mechanism was included in the AMR.

Using this methodology, it was determined that crack initiation and growth are the only aging effects that require AMR.

The staff's position on identification of applicable aging effects requiring management for BWR core shroud and core shroud assembly components is given in Section 4.1 of this SE under License Renewal Action Items (6) and (7).

3.3 AMPs

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

1) Scope of Program: The program is focused on managing the effects of crack initiation and growth due to SCC. The program contains preventive 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. For those plants using hydrogen water chemistry (HWC) or noble metal chemical addition (NMCA), hydrogen additions are effective in reducing electrochemical (corrosion) potentials in the recirculation piping system, but are less effective in the core region. NMCA, through a catalytic action, increases the effectiveness of hydrogen additions in the core region.

3) Parameters Monitored or Inspected: The AMP monitors the effects of SCC on the intended function by detection and sizing of cracks by inservice inspection. Table IWB-2500 Category B-N-2 specifies visual VT-3 examination of all accessible surfaces of the core support structure. Inspection and flaw evaluation are performed in accordance with the BWRVIP-76 guidelines, which specifies ultrasonic or visual examinations (EVT-1), as approved by the NRC.

4) Detection of Aging Effects: Inspection in accordance with BWRVIP guidelines assures that degradation due to SCC is detected before any loss of the intended function of the core shroud 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 ASME Code Section XI or other acceptable flaw evaluation criteria, such as the applicable NRC staff-approved BWRVIP-76 guidelines.

7) Corrective Actions: Repair and replacement procedures are equivalent to those requirements in the ASME Code, Section XI.

8) Confirmation Process and Administrative Controls: Site QA confirmatory procedures, and review and approval processes are implemented in accordance with the requirements of Appendix B to 10 CFR Part 50.

9) Administrative Controls: Site QA administrative control processes are implemented in accordance with the requirements of Appendix B to 10 CFR Part 50.

10) Operating Experience: Cracking of the core shroud welds has been detected at several domestic and overseas BWRs. In July 1994, the NRC staff issued Generic Letter 94-03 (Reference 4) which required the applicant to inspect the core shroud welds. NUREG-1557 (Reference 3) is used to establish the correlation between the aging effects and their associated aging mechanisms.

In its SE for TR BWRVIP-76, the NRC staff concluded that the discussed inspection strategy and evaluation methodologies, as supplemented and modified, will provide an acceptable level of quality for examination of the core shroud components for the current operating period of BWRs. Further, based on the applicant's implementation of the BWRVIP-76 inspection program, as supplemented and modified, the NRC staff finds that there is reasonable assurance that crack initiation and growth will be adequately managed so that the intended functions of the core shroud components will be maintained consistent with the CLB for the period of extended operation.

Emerging Issues:

Discovery of intergranular stress corrosion cracking (IGSCC) on the upper support location of the tie rod repair at Hatch Unit 1 during the unit's spring 2006 refueling outage suggests that the inspection criteria for the tie rod repair hardware for the extended period of operation should be re-evaluated. The BWRVIP re-evaluation should take into consideration the presence of any high stress region that exceeds the threshold limits for IGSCC in the tie rod repair hardware. In this context, in RAI 76(LR)-1 by letter dated July 2, 2007(ADAMS Accession Number ML071830529), the NRC staff requested that the BWRVIP address the presence of high stress region that exceeds the threshold limits for IGSCC in the tie rod repair hardware. In its response, by letter dated April 21, 2008, the BWRVIP stated that all applicants were directed to inspect their tie rod repairs during their next scheduled outage. Thus far, no additional cracking was found in the tie rod repairs. However, the BWRVIP stated that it will evaluate the implications of the Hatch Unit 1 tie rod repair cracking, which may result in the incorporation of

revised inspection recommendations for the tie rod repair hardware in the BWRVIP-76 TR. The NRC staff accepts this response and reiterates that the applicants should address the issue related to their tie rod repairs in their LRAs. Therefore, the NRC staff considers that its concern related to RAI 76(LR)-1 is resolved when the BWRVIP includes its response to this RAI in the approved version of Appendix K of TR BWRVIP-76.

Reduction in ductility and fracture toughness can occur in stainless steel RVI components when they are exposed to high energy neutrons (E > 1 MeV). Appendix C of TR BWRVIP-76 provides guidance to evaluate the structural integrity of core shroud horizontal welds affected by exposure to neutron radiation. In this appendix, the BWRVIP discusses the use of generic fracture mechanics analyses for establishing inspection intervals for the core shroud welds with cracks. Previous data suggested that the fracture toughness values tend to decrease when stainless steel materials are exposed to high energy neutron fluence.

In August 2006, the BWRVIP issued a NRC staff-approved BWRVIP-100-A TR, "Updated Assessment of the Fracture Toughness of Irradiated Stainless Steel for BWR Core Shrouds," which discusses fracture toughness results for the irradiated stainless steel materials. In RAI 76(LR)-2, the NRC staff stated that for stainless steel materials with exposure to a neutron fluence value equal to or greater than 1 X 10^{21} n/cm^2 (E > 1 MeV), the BWRVIP-100-A TR identified lower fracture toughness values than that of the value reported in Appendix C of TR BWRVIP-76. During a LR period, core shroud welds, and base materials may be exposed to neutron fluence values of 1 X 10^{21} n/cm^2 (E > 1 MeV) or greater. Since the inspection frequency in the BWRVIP-76 TR is based on fracture toughness values which are not consistent with TR BWRVIP-100-A, the NRC staff requested that the BWRVIP reevaluate the inspection frequency and strategy that are specified in TR BWRVIP-76, Appendix C, Section 3.
The BWRVIP in its response to RAI 76(LR)-2 stated that at the time of issuance of TR BWRVIP-76, the methodology for determining crack growth rates in high fluence stainless steel materials with an exposure to a neutron fluence value equal to or greater than 1 X 10^{21} n/cm^2 (E > 1 MeV) was not established. However, since that time this methodology was reviewed and approved by the NRC staff in TR "BWRVIP-99:, "BWR Vessel and Internals Project, Crack Growth Rates in Irradiated BWR Stainless Steel Internal Components" (ADAMS Accession No. ML052070126)" and in the BWRVIP-100-A TR (ADAMS Accession No. ML040650779). The BWRVIP stated that it will incorporate the crack growth rate evaluations and fracture toughness values, specified in the BWRVIP-99 and BWRVIP-100-A TRs, in TR BWRVIP-76, andsuch that will these NRC approved methodologies will address the evaluation of flaws in high fluence core shroud weldsdevelop generic inspection intervals for core shroud welds that are exposed to a neutron fluence value equal to or greater than 1 X 10^{21} n/cm^2 (E > 1 MeV). Since the evaluations of crack growth rates and fracture toughness in core shroud assembly were previously accepted by the NRC staff, the NRC accepts this response and considers that its concern related to RAI 76(LR)-2 is resolved. Note that NRC-approved TR "BWR Vessel and Internals Project, Evaluation of Crack Growth in BWR Stainless Steel RPV Internals (BWRVIP-14)" addresses crack growth in unirradiated material, i.e., fluences <5 X10^{20} n/cm^2. The applicants shall reference the latest version of NRC staff-approved BWRVIP-14-A, BWRVIP-99-A and BWRVIP-100-A TRs in their RVI components' AMP.

3.4 Time Limited Aging Analyses

Criteria developed in BWRVIP-76, Appendix K for identifying TLAAs associated with core shroud integrity calculations or analyses were discussed in Section 2.0 of this SE. The NRC staff has reviewed the guidance provided for identifying such TLAAs and has concluded that, if a plant-specific analysis meets all six criteria specified in Section 2.0 of this SE, the analysis will be considered a TLAA for LR and will need to be evaluated by the applicant on a plant-specific basis. Hence, the NRC staff approves of the framework given in BWRVIP-76, Appendix K for the identification of core shroud related TLAAs.

4.0 CONCLUSION

The NRC staff has reviewed Appendix K of TR BWRVIP-76 submitted by the BWRVIP. On the basis of its review, as set forth above, the NRC staff concludes that the Appendix K of BWRVIP-76 TR provides an acceptable demonstration that BWRVIP member utilities referencing this TR will adequately manage the aging effects of core shroud components within the scope of the TR, 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 core shroud components will perform their intended functions in accordance with the CLB during the period of extended operation.

Any BWRVIP member utility may reference this TR in a LRA to satisfy the requirements of:

1) Regulation 10 CFR 54.21(a)(3) for demonstrating that the effects of aging on the core shroud components within the scope of this TR will be adequately managed, and

2) Regulation 10 CFR 54.21(c)(1) for demonstrating the appropriate findings regarding the identification and evaluation of TLAAs for the core shroud for the period of extended operation.

The NRC staff also concludes that, upon completion of the renewal applicant action items set forth in Section 4.1 below, referencing this TR in an LRA and summarizing in a final safety analysis report (FSAR) supplement, the AMPs and the TLAA evaluations contained in this TR will provide the NRC 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 TR.

4.1 LR Action Items

The following are applicant action items to be addressed in the plant-specific LRA when incorporating TR BWRVIP-76 in a renewal application:

1) The applicant is to verify that its plant is bounded by TR BWRVIP-76. Further, tThe renewal applicant is to commit to programs described as necessary in TR BWRVIP-76 to manage the effects of aging on the functionality of the core shroud assembly during the period of extended operation. LR applicants will be responsible for describing any such commitments and identifying how such commitments will be controlled. Any deviations from the AMPs within TR BWRVIP-76 described as necessary to manage the effects of aging during the period of extended operation and to maintain the functionality of the core shroud components or other information presented in the TR, such as materials of construction, must 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) Regulation 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 LR referencing the BWRVIP-76 TR for the core shroud must ensure that the programs and activities specified as necessary in the BWRVIP-76 TR are summarily described in the FSAR supplement.

3) Regulation 10 CFR 54.22 requires that each application for LR include any TS 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 Appendix K of TR BWRVIP-76, the BWRVIP stated that there are no generic changes or additions to TSs associated with the core shroud as a result of its AMR and that the applicant will provide the justification for plant-specific changes or additions. Those LR applicants referencing TR BWRVIP-76 for the core shroud must ensure that the inspection strategy described in TR BWRVIP-76 does not conflict with or result in any changes to their TSs. If TS changes do result, then the applicant must ensure that those changes are included in its application for LR.

4) The applicants shall reference the latest NRC staff approved versions of TRs BWRVIP-14-A, BWRVIP-99-A and BWRVIP-100-A in their RVI components' AMP. The applicants shall make a statement in their LRAs that the crack growth rate evaluations and fracture toughness values specified in these TRs shall be used for cracked core shroud welds that are exposed to athe neutron fluence values as specified in those reports equal to or greater than 1×10^{21} n/cm^2 (E > 1 MeV). The applicants shall also confirm that they will incorporate any emerging inspection guidelines developed by the BWRVIP for these welds.

5) The applicants that have core shrouds with tie rod repairs shall make a statement in their AMPs associated with the RVI components that they have evaluated the implications of the Hatch Unit 1 tie rod repair cracking on their units and incorporated revised inspection guidelines, if any, developed by the BWRVIP.

6) The NRC staff's guidance in Table IV.B1 of the GALL Report lists two potentially applicable aging effects (i.e., in addition to cracking) for generic BWR reactor vessel internal components (including BWR core shroud and core shroud repair assembly components) that are made from either stainless steel (including CASS) or nickel alloy: (1) loss of material due to pitting and crevice corrosion (Refer to GALL AMR IV.B1-15), and (2) cumulative fatigue damage (Refer to GALL AMR Item IV.B1-14). BWR applicant's for renewal will need to assess their designs to see if the generic guidelines for managing cumulative fatigue damage in GALL AMR item IV.B1-14 and for management loss of material due to pitting and crevice corrosion in GALL AMR IV.B1-15 are applicable to the design of their core shroud components (including welds) and any core shroud repair assembly components that have been installed through a design modification of the plant. If these aging affects are applicable to the design of these components as a result of exposing them to a reactor coolant with integrated neutron flux environment, applicants for license renewal will need to: (1) identify the aging effects as aging effects requiring management for the core shrouds and for their core shroud

repair assembly components if a repair design modification has been implemented, and (2) identify the specific aging management programs or time-limited aging analyses that will be used to manage these aging effects during the period of extended operation. Refer to License Renewal Applicant Action Item 7) for additional guidance on identifying the aging effects requiring management (AERMs) for core shroud components or core shroud repair assembly components that made from materials other than stainless steel (including CASS) or nickel alloy.

7) For BWR LRAs, identification of AERMs for core shroud components or core shroud repair assembly components that are made from materials other than stainless steel (including CASS) or nickel alloy will need to be addressed on a plant specific basis that is consistent with the Note format criteria for plant-specific AMR items in latest NRC-approved version TR NEI-95-10.

8) License renewal applicants shall reference the latest version of NRC staff-approved topical reports BWRVIP-14-A, BWRVIP-99-A and BWRVIP-100-A in their RVI components' AMP, as discussed in section 3.3 of this safety evaluation.

5.0 REFERENCES

1. Nuclear Energy Institute Report, NEI 95-10, Revision 0, Industry Guideline for Implementing the Requirements of 10 CFR Part 54 the license renewal rule.

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

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

4. NRC Generic Letter 94-03, "Intergranular Stress Corrosion Cracking of Core Shrouds in Boiling Water Reactors," July 25, 1994.

Principal Contributors: J. Medoff, G. Cheruvenki

Date: April 9, 2009

Item 3

DRAFT SAFETY EVALUATION (SE) BY THE

OFFICE OF NUCLEAR REACTOR REGULATION

FOR ELECTRIC POWER RESEARCH INSTITUTE (EPRI)

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

TOPICAL REPORT (TR) "BWR VESSEL AND INTERNALS PROJECT, BWR CORE SHROUD INSPECTION AND FLAW EVALUATION GUIDELINES (BWRVIP-76)"

FOR LICENSE RENEWAL (LR) - APPENDIX K

PROJECT NO. 704

DRAFT SAFETY EVALUATION (SE) BY THE

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

TOPICAL REPORT (TR) "BWR VESSEL AND INTERNALS PROJECT, BWR CORE SHROUD

INSPECTION AND FLAW EVALUATION GUIDELINES (BWRVIP-76)"

FOR LICENSE RENEWAL (LR) - APPENDIX K

PROJECT NO. 704

1.0 INTRODUCTION

1.1 History: License Renewal Appendix

By letter dated December 9, 1999, (Agencywide Documents Access and Management System (ADAMS) Accession No. ML082620712), as supplemented by letters dated June 8, 2005, (ADAMS Accession No. ML051640498), and April 21, 2008 (ADAMS Accession No. ML081200068), the BWRVIP submitted for the U.S. Nuclear Regulatory Commission (NRC) staff review and approval the EPRI Proprietary Report TR-114232, "BWR Vessel and Internals Project, BWR Core Shroud Inspection and Flaw Evaluation Guidelines (BWRVIP-76)."

TR BWRVIP-76 combines the guidance from several BWRVIP TRs and incorporates information from several NRC staff reviews and SEs. By letter dated July 28, 2006, (ADAMS Accession No. ML062140594), the NRC staff issued the SE for BWRVIP-76. That SE did not cover the LR related Appendix K, which was originally submitted with the TR.

The review of Appendix K, "Guidelines for Inspection of BWR Core Shrouds: Demonstration of Compliance with the Technical Information Requirements of the License Renewal Rule under 10 CFR [Title 10 of the *Code of Federal Regulations*] Part 54.21," has now been completed by the NRC staff.

In accordance with 10 CFR 54.21, each LR application (LRA) includes an integrated plant assessment (IPA) and an evaluation of time-limited aging analyses (TLAA). The IPA must identify and list those structures and components subject to an aging management review (AMR) 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

ENCLOSURE

application include any technical specification (TS) 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-76 TR applies to its facility and that the results of the Appendix K 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 below by the NRC staff. With this exception, such an applicant may rely on the BWRVIP-76 TR for the demonstration required by 10 CFR 54.21(a)(3) with respect to the components and structures within the scope of the TR. 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.

By referencing the BWRVIP-76 TR, as supplemented and modified, and meeting these limitations, an applicant will provide sufficient information that will enable the NRC 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 TR will be maintained consistent with the current licensing basis during the period of extended operation.

1.2 Purpose and Applicability

The NRC staff reviewed the BWRVIP-76 TR and its Appendix K to determine whether its guidance will provide acceptable levels of quality for inspection and flaw evaluation of the subject safety-related reactor vessel internal (RVI) components during the period of extended operation. The review also considered compliance with the LR Rule in order to allow applicants the option of incorporating the BWRVIP-76 guidelines by reference in a plant-specific IPA and associated TLAAs.

Any BWRVIP member utility may reference this TR in a LRA to satisfy the requirements of: 1) 10 CFR 54.21(a)(3) for demonstrating that the effects of aging on the core shroud components within the scope of this TR will be adequately managed, and 2) 10 CFR 54.21(c)(1) for demonstrating the appropriate findings regarding the identification and evaluation of TLAAs for the core shroud for the period of extended operation. The NRC staff also concludes that, upon completion of the renewal applicant action items set forth in Section 4.1 below, referencing this TR in an LRA and summarizing in a final safety analysis report (FSAR) supplement, the aging management programs (AMPs) and the TLAA evaluations contained in this TR will provide the NRC staff with sufficient information to make the findings required by 10 CFR 54.29(a)(1) and (a)(2) for components within the scope of this TR.

2.0 SUMMARY

The BWRVIP-76 TR and its Appendix K contain a generic evaluation of the management of the effects on aging on the subject safety-related RVI components so 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-76 TR and want to incorporate the TR and Appendix K by reference into a plant-specific IPA and associated TLAAs.

The BWRVIP-76 TR addresses the following topics:

1) Introduction: It provides the objective for an acceptable regulated and unified industry approach for inspecting horizontal, vertical, and radial ring welds in repaired and unrepaired BWR core shrouds, and for inspecting repair components and anchorages in repaired shrouds. The TR also provides a brief background review of prior industry inspections of these welds.

2) Inspection Strategy for Welds in Unrepaired Shrouds: It provides inspection strategies and methods for horizontal welds in unrepaired core shrouds based on the category classification of the welds. It provides limitations addressing a required plant-specific evaluation. The TR also provides the inspection requirements and acceptance standards for vertical welds.

3) Inspection Strategy for Welds in Repaired Shrouds: It provides guidelines for recommended inspections of horizontal, vertical, and radial ring welds in repaired shrouds. This includes sampling of vertical welds and/or screening of horizontal welds. In addition, the TR provides the guidelines and suggested schedules for the inspection of the repaired components and the associated repair anchorages.

4) Reporting Requirements: It provides guidance for reporting results of inspections that do, or do not, meet the inspection and evaluation (I&E) guidelines.

Appendix K of the BWRVIP-76 TR provides LR technical requirements for core shroud components which are discussed below:

Function of Core Shroud Assembly

According to the regulations at 10 CFR 54.4(a)(1)(ii) and (iii), the core shroud is required to ensure the capability to shutdown the reactor and maintain it in a safe shutdown condition and prevent or mitigate the consequences of accidents that could result in potential offsite exposure comparable to 10 CFR Part 100 guidelines. Therefore, the intended functions for the core shroud are to:

1) Provide a partition to separate the upward flow of the coolant through the core from the downward recirculation flow;

2) Maintain fuel alignment such that control rods can be inserted; and

3) Form part of the boundary to maintain water level in the core after a loss-of-coolant accident (LOCA). The intended functions are preserved under normal, upset, emergency, and faulted conditions. Appendix D.6 of the BWRVIP-76 TR identifies the safety factors that need to be considered to determine that stress levels for the various operating conditions are consistent with the CLB. The applied loads and load combinations are described in the BWRVIP-02 TR, "BWR Vessel Internals Project, BWR Core Shroud Repair Design Criteria."

Core Shroud Components Subject to Aging Management Review

Paragraph 54.21(a)(1) of the rule provides the requirements for identifying the core shroud components that are subject to AMR. To satisfy the requirements of paragraph 54.21(a)(1), the Nuclear Energy Institute (NEI) provided guidelines (Reference 1) to identify the passive and long-lived components. All components, including the core shroud head flange bolted connection, in the core shroud assembly are passive and long-lived, and therefore, the core shroud assembly is subject to AMR. The AMR of the core shroud head flange bolted connection, however, is included in the review of the top guide assembly.

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

a) Description of Aging Effects

The BWRVIP industry report (Reference 2) is used to identify the aging mechanisms for the core shroud materials. The NUREG-1557 (Reference 3) is used to establish the correlation between the aging effects and their associated aging mechanisms. Based on the previous industry experience, it was determined that crack initiation and growth due to stress corrosion cracking (SCC) is the only aging effect that requires aging management review for the core shroud. This conclusion is consistent with the scope and intent of the re-inspection guidelines. The causes of the SCC and a susceptibility assessment for the core shroud (including fabrication history, water chemistry, material carbon content, neutron fluence, and hot operating time) are provided in Appendix B.1 of the BWRVIP-76 TR. Based on the susceptibility considerations, the various BWR shrouds are placed in three categories. The categories consider the material specification (Type 304 or 304L), method of fabrication (welded plate rings or forged rings), and operating history relative to coolant conductivity. The categories are defined as follows:

Category A:

Category B:

Category C:

Inspection of vertical welds in this category are discussed in Section 3.2 of this SER.

b) Assessment of Aging Effects and Programs

Inspection of Un-repaired Core Shrouds

The BWRVIP determined that the extent of inspection required for a given plant is determined based on three susceptibility factors which can be readily evaluated: hot operating time, conductivity and shroud material type, and fabrication features. The three categories (A, B, and C) were used in the shroud inspections and flaw evaluations. The inspection criteria for categories B or C will be used by the applicants to ensure structural integrity of the core shroud assembly during the LR period.

Section 3.0 of the BWRVIP-76 inspection guidelines addresses the inspection requirements for repaired core shroud welds. The BWRVIP recommends that inspections of repaired core shroud welds are necessary to provide periodic confirmation of the integrity of the repaired shroud during the LR period. The applicant is required to develop an inspection program incorporating the requirements of the inspection guidelines. In addition, the repair program shall consider vendor recommendations, industry experience, aging effects, and the critical components and features of the repair design.

c) Demonstration that the Effects of Aging are Adequately Managed

Based on the industry's experience it has been established that SCC is the only aging effect for the core shroud that requires AMR for LR. This aging effect will be managed by incorporating the inspection strategies described in Section 2.0 (un-repaired shrouds) and Section 3.0 (repaired shrouds) of the BWRVIP-76 TR, when appropriate, in the plant-specific inspection plans. To further demonstrate that SCC is adequately managed, the BWRVIP provides strategies that are

based on current knowledge of the core shroud cracking issue and inspection experience at various plants. It provides a staged approach with respect to the inspection effort and associated analyses that are logically expanded, as necessary, to confirm core shroud structural integrity. As more inspections are performed, specific aspects of implementing the inspection strategy may be further refined and incorporated in plant-specific inspection plans.

Implementation of the inspection strategy provided in the inspection guidelines of the BWRVIP-76 TR and the resulting plant-specific inspection plans during the LR period will provide a verification of core shroud structural integrity requirements. Therefore, there is reasonable assurance that SCC crack initiation and growth will be adequately managed so that the intended functions of the core shroud will be maintained consistent with the CLB in the LR period.

Time-Limited Aging Analyses

The regulation at 10 CFR 54.21(1)(c) requires that each application for LR contain an evaluation of TLAAs 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.

BWRVIP-76, Appendix K provides guidance to licensees regarding the identification of potential TLAAs, in their unit's CLB. The six criteria contained in the NEI industry guideline (Reference 1) were applied to define criteria that may be used to identify potential TLAAs. Specifically, calculations and analyses which involve:

1. the core shroud assembly,
2. a consideration of the effects of aging,
3. time-limited assumptions defined by the current operating term,
4. a determination relevant to a safety determination,
5. conclusions (or provide the basis for conclusions) related to the capability of the core shroud to perform its intended function, and
6. incorporation or reference of the calculation or analyses in the plants' CLB may be a TLAA.

If a plant-specific analysis identified by an applicant meets all six criteria above, then this analysis will be considered a TLAA for LR and evaluated by the applicant. The plant-specific analyses of the core shroud for fatigue will be reviewed by the applicant to determine if the TLAA criteria apply.

Determination of the inspection intervals for core shroud welds is based on the generic fracture mechanics analyses described in Appendix D of the BWRVIP-76 TR. The methodology and assumptions used in these analyses result in the following potential TLAA issues. The applicant may be required to evaluate these issues in a plant-specific analysis.

1) The length of time evaluated in the analyses.

2) Linear elastic fracture mechanics (LEFM) is required if specified fluence level threshold values are exceeded during the extended operating period.

3) The effects of BWR industry operating experience on the number of postulated flaws assumed in the analyses.

4) The applicable crack growth rates are shown to be greater than $5x10^{-5}$ in/hr.

Exemptions (54.21[c][2])

Exemptions associated with the core shroud that contain TLAA analysis issues will be identified and evaluated for LR by individual applicants.

TS Changes or Additions (54.22)

The BWRVIP stated that there are no generic changes or additions to TSs associated with the core shroud as a result of this aging management review to ensure that the effects of aging are adequately managed. Individual applicants will identify plant-specific changes.

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 LR for the core shroud will continue to be conducted in accordance with the CLB.

3.0 STAFF EVALUATION

The NRC staff reviewed TR BWRVIP-76, Appendix K, to determine if it demonstrates that the effects of aging on the core shroud components within the scope of the TR 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). Besides the IPA, Part 54 requires an evaluation of TLAAs in accordance with 10 CFR 54.21(c). The NRC staff reviewed the TR BWRVIP-76, Appendix K, to determine if the TLAAs covered by the TR were evaluated for LR in accordance with 10 CFR 54.21(c)(1).

3.1 Structures and Components Subject to AMR

The NRC staff agrees that core shroud components are subject to AMR because they perform intended functions without moving parts or without a change in the configuration or properties. The NRC staff concludes that, to meet the applicable requirements of 10 CFR 54.21(a)(1), the BWR LR applicants must identify the appropriate safety-related core shroud components that

are subject to AMR. The NRC staff also agrees with the BWRVIP's assessment regarding the intended function of the core shroud component which is addressed in Section 2.0 of this SE.

3.2 Effects of Aging

The information necessary to demonstrate compliance with the requirements of the LR Rule 10 CFR 54.21 is provided in Appendix K of the BWRVIP-76 TR. The industry report (Reference 2) and the resolution to the NRC questions on this TR were used to identify the aging mechanisms for the core shroud. If the industry report concluded that an aging mechanism is significant, then that aging mechanism was included in the AMR.

Using this methodology, it was determined that crack initiation and growth are the only aging effects that require AMR.

The staff's position on identification of applicable aging effects requiring management for BWR core shroud and core shroud assembly components is given in Section 4.1 of this SE under License Renewal Action Items (6) and (7).

3.3 AMPs

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

1) Scope of Program: The program is focused on managing the effects of crack initiation and growth due to SCC. The program contains preventive 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. For those plants using hydrogen water chemistry (HWC) or noble metal chemical addition (NMCA), hydrogen additions are effective in reducing electrochemical (corrosion) potentials in the recirculation piping system, but are less effective in the core region. NMCA, through a catalytic action, increases the effectiveness of hydrogen additions in the core region.

3) Parameters Monitored or Inspected: The AMP monitors the effects of SCC on the intended function by detection and sizing of cracks by inservice inspection. Table IWB-2500 Category B-N-2 specifies visual VT-3 examination of all accessible surfaces of the core support structure. Inspection and flaw evaluation are performed in accordance with the BWRVIP-76 guidelines, which specifies ultrasonic or visual examinations (EVT-1), as approved by the NRC.

4) Detection of Aging Effects: Inspection in accordance with BWRVIP guidelines assures that degradation due to SCC is detected before any loss of the intended function of the core shroud 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 ASME Code Section XI or other acceptable flaw evaluation criteria, such as the applicable NRC staff-approved BWRVIP-76 guidelines.

7) Corrective Actions: Repair and replacement procedures are equivalent to those requirements in the ASME Code, Section XI.

8) Confirmation Process and Administrative Controls: Site QA confirmatory procedures, and review and approval processes are implemented in accordance with the requirements of Appendix B to 10 CFR Part 50.

9) Administrative Controls: Site QA administrative control processes are implemented in accordance with the requirements of Appendix B to 10 CFR Part 50.

10) Operating Experience: Cracking of the core shroud welds has been detected at several domestic and overseas BWRs. In July 1994, the NRC staff issued Generic Letter 94-03 (Reference 4) which required the applicant to inspect the core shroud welds. NUREG-1557 (Reference 3) is used to establish the correlation between the aging effects and their associated aging mechanisms.

In its SE for TR BWRVIP-76, the NRC staff concluded that the discussed inspection strategy and evaluation methodologies, as supplemented and modified, will provide an acceptable level of quality for examination of the core shroud components for the current operating period of BWRs. Further, based on the applicant's implementation of the BWRVIP-76 inspection program, as supplemented and modified, the NRC staff finds that there is reasonable assurance that crack initiation and growth will be adequately managed so that the intended functions of the core shroud components will be maintained consistent with the CLB for the period of extended operation.

Emerging Issues:

Discovery of intergranular stress corrosion cracking (IGSCC) on the upper support location of the tie rod repair at Hatch Unit 1 during the unit's spring 2006 refueling outage suggests that the inspection criteria for the tie rod repair hardware for the extended period of operation should be re-evaluated. The BWRVIP re-evaluation should take into consideration the presence of any high stress region that exceeds the threshold limits for IGSCC in the tie rod repair hardware. In this context, in RAI 76(LR)-1 by letter dated July 2, 2007(ADAMS Accession Number ML071830529), the NRC staff requested that the BWRVIP address the presence of high stress region that exceeds the threshold limits for IGSCC in the tie rod repair hardware. In its response, by letter dated April 21, 2008, the BWRVIP stated that all applicants were directed to inspect their tie rod repairs during their next scheduled outage. Thus far, no additional cracking was found in the tie rod repairs. However, the BWRVIP stated that it will evaluate the implications of the Hatch Unit 1 tie rod repair cracking, which may result in the incorporation of

revised inspection recommendations for the tie rod repair hardware in the BWRVIP-76 TR. The NRC staff accepts this response and reiterates that the applicants should address the issue related to their tie rod repairs in their LRAs. Therefore, the NRC staff considers that its concern related to RAI 76(LR)-1 is resolved when the BWRVIP includes its response to this RAI in the approved version of Appendix K of TR BWRVIP-76.

Reduction in ductility and fracture toughness can occur in stainless steel RVI components when they are exposed to high energy neutrons (E > 1 MeV). Appendix C of TR BWRVIP-76 provides guidance to evaluate the structural integrity of core shroud horizontal welds affected by exposure to neutron radiation. In this appendix, the BWRVIP discusses the use of generic fracture mechanics analyses for establishing inspection intervals for the core shroud welds with cracks. Previous data suggested that the fracture toughness values tend to decrease when stainless steel materials are exposed to high energy neutron fluence.

In August 2006, the BWRVIP issued a NRC staff-approved BWRVIP-100-A TR, "Updated Assessment of the Fracture Toughness of Irradiated Stainless Steel for BWR Core Shrouds," which discusses fracture toughness results for the irradiated stainless steel materials. In RAI 76(LR)-2, the NRC staff stated that for stainless steel materials with exposure to a neutron fluence value equal to or greater than 1×10^{21} n/cm^2 (E > 1 MeV), the BWRVIP-100-A TR identified lower fracture toughness value than that of the value reported in Appendix C of TR BWRVIP-76. During a LR period, core shroud welds, and base materials may be exposed to neutron fluence values of 1×10^{21} n/cm^2 (E > 1 MeV) or greater. Since the inspection frequency in the BWRVIP-76 TR is based on fracture toughness values which are not consistent with TR BWRVIP-100-A, the NRC staff requested that the BWRVIP reevaluate the inspection frequency and strategy that are specified in TR BWRVIP-76, Appendix C, Section 3. The BWRVIP in its response to RAI 76(LR)-2 stated that at the time of issuance of TR BWRVIP-76, the methodology for determining crack growth rates in stainless steel materials with an exposure to a neutron fluence value equal to or greater than 1×10^{21} n/cm^2 (E > 1 MeV) was not established. However, since that time this methodology was reviewed and approved by the NRC staff in TR BWRVIP-99, "BWR Vessel and Internals Project, Crack Growth Rates in Irradiated BWR Stainless Steel Internal Components (ADAMS Accession No. ML052070126)" and in the BWRVIP-100-A TR (ADAMS Accession No. ML040650779). The BWRVIP stated that it will incorporate the crack growth rate evaluations, specified in the BWRVIP-99 and BWRVIP-100-A TRs, in TR BWRVIP-76, and will develop generic inspection intervals for core shroud welds that are exposed to a neutron fluence value equal to or greater than 1×10^{21} n/cm^2 (E > 1 MeV). Since the evaluations of crack growth rates in core shroud assembly were previously accepted by the NRC staff, the NRC accepts this response and considers that its concern related to RAI 76(LR)-2 is resolved. The applicants shall reference the NRC staff-approved BWRVIP-99 and BWRVIP-100-A TRs in their RVI components' AMP.

3.4 Time Limited Aging Analyses

Criteria developed in BWRVIP-76, Appendix K for identifying TLAAs associated with core shroud integrity calculations or analyses were discussed in Section 2.0 of this SE. The NRC staff has reviewed the guidance provided for identifying such TLAAs and has concluded that, if a plant-specific analysis meets all six criteria specified in Section 2.0 of this SE, the analysis will be considered a TLAA for LR and will need to be evaluated by the applicant on a plant-specific

basis. Hence, the NRC staff approves of the framework given in BWRVIP-76, Appendix K for the identification of core shroud related TLAAs.

4.0 CONCLUSION

The NRC staff has reviewed Appendix K of TR BWRVIP-76 submitted by the BWRVIP. On the basis of its review, as set forth above, the NRC staff concludes that the Appendix K of BWRVIP-76 TR provides an acceptable demonstration that BWRVIP member utilities referencing this TR will adequately manage the aging effects of core shroud components within the scope of the TR, 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 core shroud components will perform their intended functions in accordance with the CLB during the period of extended operation.

Any BWRVIP member utility may reference this TR in a LRA to satisfy the requirements of:

1) Regulation 10 CFR 54.21(a)(3) for demonstrating that the effects of aging on the core shroud components within the scope of this TR will be adequately managed, and

2) Regulation 10 CFR 54.21(c)(1) for demonstrating the appropriate findings regarding the identification and evaluation of TLAAs for the core shroud for the period of extended operation.

The NRC staff also concludes that, upon completion of the renewal applicant action items set forth in Section 4.1 below, referencing this TR in an LRA and summarizing in a final safety analysis report (FSAR) supplement, the AMPs and the TLAA evaluations contained in this TR will provide the NRC 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 TR.

4.1 LR Action Items

The following are applicant action items to be addressed in the plant-specific LRA when incorporating TR BWRVIP-76 in a renewal application:

1) The applicant is to verify that its plant is bounded by TR BWRVIP-76. Further, the renewal applicant is to commit to programs described as necessary in TR BWRVIP-76 to manage the effects of aging on the functionality of the core shroud assembly during the period of extended operation. LR applicants will be responsible for describing any such commitments and identifying how such commitments will be controlled. Any deviations from the AMPs within TR BWRVIP-76 described as necessary to manage the effects of aging during the period of extended operation and to maintain the functionality of the core shroud components or other information presented in the TR, such as materials of construction, must 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) Regulation 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 LR referencing the BWRVIP-76 TR for the core shroud must ensure that the programs

and activities specified as necessary in the BWRVIP-76 TR are summarily described in the FSAR supplement.

3) Regulation 10 CFR 54.22 requires that each application for LR include any TS 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 Appendix K of TR BWRVIP-76, the BWRVIP stated that there are no generic changes or additions to TSs associated with the core shroud as a result of its AMR and that the applicant will provide the justification for plant-specific changes or additions. Those LR applicants referencing TR BWRVIP-76 for the core shroud must ensure that the inspection strategy described in TR BWRVIP-76 does not conflict with or result in any changes to their TSs. If TS changes do result, then the applicant must ensure that those changes are included in its application for LR.

4) The applicants shall reference the NRC staff approved TRs BWRVIP-99 and BWRVIP-100-A in their RVI components' AMP. The applicants shall make a statement in their LRAs that the crack growth rate evaluations specified in these TRs shall be used for cracked core shroud welds that are exposed to a neutron fluence value equal to or greater than 1×10^{21} n/cm^2 (E > 1 MeV). The applicants shall also confirm that they will incorporate any emerging inspection guidelines developed by the BWRVIP for these welds.

5) The applicants that have core shrouds with tie rod repairs shall make a statement in their AMPs associated with the RVI components that they have evaluated the implications of the Hatch Unit 1 tie rod repair cracking on their units and incorporated revised inspection guidelines, if any, developed by the BWRVIP.

6) The NRC staff's guidance in Table IV.B1 of the GALL Report lists two potentially applicable aging effects (i.e., in addition to cracking) for generic BWR reactor vessel internal components (including BWR core shroud and core shroud repair assembly components) that are made from either stainless steel (including CASS) or nickel alloy: (1) loss of material due to pitting and crevice corrosion (Refer to GALL AMR IV.B1-15), and (2) cumulative fatigue damage (Refer to GALL AMR Item IV.B1-14). BWR applicant's for renewal will need to assess their designs to see if the generic guidelines for managing cumulative fatigue damage in GALL AMR item IV.B1-14 and for management loss of material due to pitting and crevice corrosion in GALL AMR IV.B1-15 are applicable to the design of their core shroud components (including welds) and any core shroud repair assembly components that have been installed through a design modification of the plant. If these aging affects are applicable to the design of these components as a result of exposing them to a reactor coolant with integrated neutron flux environment, applicants for license renewal will need to: (1) identify the aging effects as aging effects requiring management for the core shrouds and for their core shroud repair assembly components if a repair design modification has been implemented, and (2) identify the specific aging management programs or time-limited aging analyses that will be used to manage these aging effects during the period of extended operation. Refer to License Renewal Applicant Action Item 7) for additional guidance on identifying the aging effects requiring management (AERMs) for core shroud components or core

shroud repair assembly components that made from materials other than stainless steel (including CASS) or nickel alloy.

7) For BWR LRAs, identification of AERMs for core shroud components or core shroud repair assembly components that are made from materials other than stainless steel (including CASS) or nickel alloy will need to be addressed on a plant specific basis that is consistent with the Note format criteria for plant-specific AMR items in latest NRC-approved version TR NEI-95-10.

8) License renewal applicants shall reference the NRC staff-approved topical reports BWRVIP-99 and BWRVIP-100-A in their RVI components' AMP, as discussed in section 3.3 of this safety evaluation.

5.0 REFERENCES

1. Nuclear Energy Institute Report, NEI 95-10, Revision 0, Industry Guideline for Implementing the Requirements of 10 CFR Part 54 the license renewal rule.

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

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

4. NRC Generic Letter 94-03, "Intergranular Stress Corrosion Cracking of Core Shrouds in Boiling Water Reactors," July 25, 1994.

Principal Contributors: J. Medoff, G. Cheruvenki

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