

FINAL SAFETY EVALUATION REPORT
FOR
"BWR VESSEL AND INTERNALS PROJECT,
BWR STANDBY LIQUID CONTROL SYSTEM/CORE PLATE
 Δ P INSPECTION AND FLAW EVALUATION GUIDELINES (BWRVIP-27)"
FOR COMPLIANCE WITH THE LICENSE RENEWAL RULE (10 CFR PART 54)

1.0 INTRODUCTION

1.1 Background

By letter dated April 25, 1997, the Boiling Water Reactor Vessel and Internals Project (BWRVIP) submitted to the U.S. Nuclear Regulatory Commission (NRC) the Electric Power Research Institute (EPRI) proprietary report TR-107286, "BWR Vessel and Internals Project, BWR Standby Liquid Control System/Core Plate Δ P Inspection and Flaw Evaluation Guidelines (BWRVIP-27)," April 1997. This report was supplemented by a letter dated July 13, 1998, which was in response to the NRC staff's request for additional information (RAI), dated December 14, 1997. The BWRVIP-27 report provides generic guidelines intended to present the appropriate inspection recommendations to manage the effects of aging on the reactor pressure vessel (RPV) internal components so that their intended functions will be maintained. It also provides design information on the core plate Δ P/Standby Liquid Control (Δ P/SLC) system, geometries, weld locations, and potential failure locations for the different categories of boiling water reactors (BWR/2 through BWR/6). By letter dated April 27, 1999, the NRC staff issued its safety evaluation (SE) on the BWRVIP-27 report's acceptability for the current operating period.

By letter dated May 15, 1998, the BWRVIP submitted a separate document, "Appendix B, BWR Standby Liquid Control System / Core Plate Δ P Inspection and Flaw Evaluation Guidelines, Demonstration of Compliance with the Technical Information Requirements of the License Renewal Rule (10 CFR 54.21)," for NRC staff review in accordance with the License Renewal Rule (10 CFR Part 54).

Section 54.21 of the License Renewal Rule requires, in part, that each application for license renewal contain 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 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 license renewal applicant participating in the BWRVIP confirms that the BWRVIP-27 document applies to its facility and that the results of the Appendix B 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 in its safety evaluation below. With this exception, such an applicant may rely on BWRVIP-27 for the demonstration required by Section 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 safety evaluation (SE) report to make the findings required by 10 CFR 54.29 with respect to a particular application.

1.2 Purpose

The staff reviewed the BWRVIP-27 report to determine whether its guidance will provide acceptable levels of quality for inspection and flaw evaluation of the RPV internal components within the scope of the report. The staff also considered compliance with the License Renewal Rule in order to allow applicants for renewal the option of incorporating the BWRVIP-27 guidelines by reference in a plant-specific integrated plant assessment (IPA) and associated time-limited aging analyses (TLAAs).

1.3 Organization of this Report

Because the BWRVIP report 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-27 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-27 report.

2.0 SUMMARY OF BWRVIP-27 REPORT

The BWRVIP-27 report and its Appendix B contain a generic evaluation of the management of the effects of aging on the subject RPV internal 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-27 report and want to incorporate the report and Appendix B by reference into a plant-specific IPA and associated TLAAs.

The BWRVIP-27 report addresses the following topics:

- Component Description and Function – The various core plate ΔP /SLC system configurations are described in detail by a series of illustrations along with brief descriptions of each configuration's function and characteristics. Differences among the various models of BWRs (BWR/2, BWR/3-5 and BWR/6) are identified.
- Susceptibility Factors – The various types of material degradation mechanisms (fatigue, stress corrosion cracking, age embrittlement) that could impact the ΔP /SLC internals are characterized. Materials, stress, and environmental factors are described in general terms, and followed by specific references to actual occurrences for each degradation mechanism relative to plant operating experience for particular mechanisms and components.
- Potential Failure Locations and Safety Consequences – Each of the vessel penetration configurations are addressed from the standpoint of inspection history, future susceptibility to degradation, and consequences of failures in terms of component functions and plant safety. Based on these qualitative considerations, the BWRVIP-27 report makes recommendations as to the need for inspections for each of the ΔP /SLC system configurations.

- Boron Mixing and Leakage Considerations – The mixing and leakage issues related to the degradation of $\Delta P/SLC$ internals are qualitatively and quantitatively addressed in this section.
- Background and Inspection History – Data on service related failures of components are summarized. The major sources of such data are the various GE service information letters (SILs) and rapid information communication service information letters (RICSILs).
- BWRVIP Inspection Guidelines – The guidelines recommend the specific locations, NDE methods, and inspection frequencies for examinations of core plate $\Delta P/SLC$ internals. The BWRVIP-27 report recommends that for most configurations, the current ASME inspection requirements be followed. For some configurations, however, an additional ultrasonic (UT) examination is recommended.

Appendix B discusses the following topics:

2.1 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.

In Section 2.0 of the BWRVIP-27 report, the BWRVIP describes the intended function of the core plate $\Delta P/Standby$ Liquid Control ($\Delta P/SLC$) system. The function is to provide direct redundancy to the control rod system to achieve safe shutdown of the reactor. This is accomplished via injection of sodium pentaborate into the bottom head region of the vessel.

In Appendix B, the BWRVIP identified the passive and long-lived components as required by 10 CFR 54.21(a)(1). The BWRVIP noted that the $\Delta P/SLC$ vessel penetration/nozzle and safe-end extensions are subject to aging management review.

2.2 Effects of Aging

The BWRVIP identified the aging mechanisms and aging effects for the $\Delta P/SLC$ vessel penetration/nozzle and safe-end extensions 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 $\Delta P/SLC$ vessel penetration/nozzle and safe-end extensions.

In Section 2.0 of the BWRVIP-27 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's review of the degradation history determined that there have been no leaks due to cracking at penetration welds.

2.3 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.

In Section 3.0 of the BWRVIP-27 report, the BWRVIP discussed the inspection strategy to be used for ensuring that cracks that might occur in the ΔP /SLC vessel penetration/nozzle and safe-end extensions are detected in a timely manner. The program specifies an ASME Section XI VT-2 visual inspection for leakage and ASME Section XI, IWB-2500, Category B-D volumetric inspections (for low alloy steel nozzle configurations). 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.

2.4 Time-Limited Aging Analyses (TLAAs)

10 CFR 54.21(1)(c) requires that each application for license renewal contain an evaluation of time-limited aging analyses (TLAA) as defined in 10 CFR 54.3. The TLAAs considered in the BWRVIP-27 report are those licensee calculations and analyses that:

- (1) involve the ΔP /SLC penetrations within the scope of license renewal,
- (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 ΔP /SLC penetrations to perform their intended function, and
- (6) are contained or incorporated by reference in the CLB.

With respect to BWRVIP-27, 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 susceptibility of the ΔP /SLC penetrations to fatigue results in a potential TLAA issue. The BWRVIP evaluated this issue under 10 CFR 54.21(c)(1)(ii) by projecting the analysis to the end of the period of extended operation. The BWRVIP found that the typical cumulative usage factors are below the 0.4 threshold specified in NUMARC 90-02 for all the nozzle designs during the current and extended operating periods.

3.0 STAFF EVALUATION

The staff's safety evaluation of the BWRVIP-27 report for the current operating term was transmitted by letter dated April 27, 1999, to Carl Terry, BWRVIP Chairman. The NRC staff determined that the contents and recommendations in the BWRVIP-27 report, when coupled with the BWRVIP's responses to the specific information requests in the staff's December 14, 1997, RAI, provides a sufficient and acceptable basis for performing examinations of the ΔP /SLC internals and for evaluating postulated flaw indications in the SLC systems. The NRC staff concluded that licensee implementation of the guidelines in the BWRVIP-27 report will

provide an acceptable level of quality for inspection and flaw evaluation of the components addressed.

The staff has further reviewed the BWRVIP-27 report to determine if it demonstrated 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, Part 54 requires an evaluation of TLAAs in accordance with 10 CFR 54.21(c). The staff reviewed the BWRVIP-27 report to determine if the TLAAs 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

The staff agrees that the Δ P/SLC vessel penetration/nozzle and safe-end extensions are subject to aging management review 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 functions of the core plate Δ P/SLC system are as stated. The function is to provide direct redundancy to the control rod system to achieve safe shutdown of the reactor. This is accomplished via injection of sodium pentaborate into the bottom head region of the vessel.

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 B of BWRVIP-27. 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 Δ P/SLC vessel penetration/nozzle and safe-end extensions. If the industry report concluded that the aging mechanism is significant then the aging mechanism was included in the aging management review. Using this methodology it was determined that crack initiation and growth is 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. For the reasons stated in NUREG-1557, the staff agrees that this mechanism is the only one applicable to the penetrations.

3.4 Aging Management Programs

The staff evaluated the BWRVIP's aging management program, as specified in Appendix B to the BWRVIP-27 report, to determine if it contains the following 10 elements constituting an adequate aging management program for license renewal: scope of program, preventive actions, parameters monitored or inspected, detection of aging effects, monitoring and trending,

acceptance criteria, corrective actions, confirmation process, administrative controls, and operating experience.

Specifically, the program scope, preventive actions, parameters monitored or inspected, and operating experience, as described in the proprietary BWRVIP-27 report and its Appendix B, provides reasonable assurance that crack initiation and growth will be adequately managed such that the intended functions of the subject RPV internal components will be maintained consistent with the CLB in the period of extended operation.

3.5 Time Limited Aging Analyses

One of the mechanisms that can cause degradation of the low alloy steel nozzle designs is fatigue. During the initial design process, the influence of fatigue on the nozzle designs was considered. In a majority of instances, the nozzle designs were determined to be exempt from the requirements of a detailed ASME Code Section III fatigue analysis. In those instances where a fatigue analysis was required, the fatigue cumulative usage factors were extended to 60 years and determined to be very low when compared to the Code allowable (CUF) of 1.0. The analysis complies with 10 CFR 54.21 (c)(1)(ii) in order to satisfy the TLAA issue. Due to the susceptibility of the subject components to fatigue, applicants referencing the BWRVIP-27 report for license renewal should identify and evaluate the projected fatigue cumulative usage factors as a potential TLAA issue.

4.0 CONCLUSIONS

The staff has reviewed the subject BWRVIP-27 report and its Appendix B, "Demonstration of Compliance with the Technical Information Requirements of the License Renewal Rule (10 CFR 54.21)," to determine if it demonstrated 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). The BWRVIP-27 program for the current operating term, as supplemented, which was reviewed in the staff's April 27, 1999, safety evaluation, was found to provide a sufficient and acceptable basis for performing examinations of the ΔP /SLC internals and for evaluating postulated flaw indications in the SLC systems, and provides an acceptable level of quality for inspection and flaw evaluation of the components addressed.. This program is identical for both the current operating term and the extended license renewal term.

On the basis of its review, as set forth above, the staff concludes that the BWRVIP-27 report provides an acceptable demonstration that licensees 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 ΔP /SLC vessel penetration/nozzle and safe-end extensions will perform their intended functions in accordance with the CLB during 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 reactor vessel components within the scope of this report 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 ΔP /SLC vessel penetration/nozzle and safe-end extensions 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-27 and its Appendix B 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-27 report in a renewal application:

- (1) The license renewal applicant is to verify that its plant is bounded by the report. Further, the renewal applicant is to commit to programs described as necessary in the BWRVIP report to manage the effects of aging on the functionality of the Δ P/SLC vessel penetration/nozzle and safe-end extensions during the period of extended operation. 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 this BWRVIP 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-27 report for the Δ P/SLC vessel penetration/nozzle and safe-end extensions shall ensure that the programs and activities specified as necessary in the BWRVIP-27 document 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 B to the BWRVIP-27 report, the BWRVIP stated that there are no generic changes or additions to technical specifications associated with the Δ P/SLC vessel penetration/nozzle and safe-end extensions 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 BWRVIP-27 for the Δ P/SLC vessel penetration/nozzle and safe-end extensions shall ensure that the inspection strategy described in the BWRVIP-27 document 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) Due to the susceptibility of the subject components to fatigue, applicants referencing the BWRVIP-27 report for license renewal should identify and evaluate the projected fatigue cumulative usage factors as a potential TLAA issue. TLAA is discussed in more detail in Section 3.5 of this report.

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, BWR Standby Liquid Control System / Core Plate ΔP Inspection And Flaw Evaluation Guidelines (BWRVIP-27)," EPRI Report TR-107286, dated April 1997.
3. C. E. Carpenter, USNRC, to Carl Terry, BWRVIP, "Propriety Request for Additional Information - Review of BWR Vessel and Internals Project Report, BWR Standby Liquid Control System / Core Plate ΔP Inspection And Flaw Evaluation Guidelines (BWRVIP-27)," dated December 14, 1997.
4. Carl Terry, BWRVIP, to USNRC, "BWRVIP Response to NRC Request for Additional Information on BWRVIP-27," July 13, 1998.
5. C. E. Carpenter, USNRC, to Carl Terry, BWRVIP, "Safety Evaluation of BWR Vessel and Internals Project Report, BWR Standby Liquid Control System / Core Plate ΔP Inspection And Flaw Evaluation Guidelines (BWRVIP-27)," dated April 27, 1999.

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