August 20, 2004

Bill Eaton, BWRVIP Chairman
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Echelon One
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SUBJECT: SUPPLEMENT TO SAFETY EVALUATION OF THE “BWRVIP VESSEL AND INTERNALS PROJECT, STANDBY LIQUID CONTROL LINE REPAIR DESIGN CRITERIA (BWRVIP-53),” EPRI REPORT TR-108716, JULY 1998 (TAC NO. MC3129)

Dear Mr. Eaton:

In a letter dated January 19, 2004, the Boiling Water Reactor Vessel and Internals Project (BWRVIP) provided responses to the Nuclear Regulatory Commission (NRC) Safety Evaluation (SE) for the Electric Power Research Institute (EPRI) proprietary report TR-108716, “BWR Vessel and Internals Project, Standby Liquid Control Line Repair Design Criteria (BWRVIP-53),” dated July 1998. Both proprietary and non-proprietary versions of the BWRVIP-53 report were submitted to the U. S. NRC for staff review by letter dated July 2, 1998, and an expanded non-proprietary version of the BWRVIP-53 report was submitted by letter dated March 24, 2000. The BWRVIP-53 report was supplemented by a letter dated December 6, 1999, which was in response to the NRC staff’s request for additional information (RAI), dated April 7, 1999. The staff’s initial SE is contained in a letter to C. Terry, BWRVIP Chairman, dated October 26, 2000.

The BWRVIP-53 report provides general design acceptance criteria for the temporary and permanent repairs of the standby liquid control (SLC) and core differential pressure (CDP) nozzles and internal lines. These guidelines are intended to maintain the structural integrity of the SLC and CDP nozzles and internal lines during normal operation and under postulated transient and design basis accident conditions.

The NRC staff has reviewed the BWRVIP-53 report and the BWRVIP’s associated RAI responses and finds, as documented in the enclosed SE supplement, that the BWRVIP-53 report is acceptable for providing guidance for permanent or temporary repairs of the cracked or leaking SLC and CDP nozzles and cracked or broken SLC and CDP lines inside the reactor vessel . The staff has concluded that implementation of the guidelines in the BWRVIP-53 report will provide an acceptable repair design criteria for the safety-related components addressed. The BWRVIP-53 report is considered by the staff to be applicable for licensee usage at any time during either the current operating term or during an extended license period. Licensees should note that when applying the repair design criteria to components that, according to the licensing basis of the plant, are classified as American Society for Mechanical Engineers (ASME) Code components, a submittal to the NRC, pursuant to 10 CFR 50.55a(a)(3) is required to request authorization of the repair as an acceptable alternative to the ASME Code.

In accordance with the procedures established in NUREG-0390, "Topical Report Review Status," the staff requests that the BWRVIP publish the accepted version of the BWRVIP-53 report within 90 days after receiving this letter. In addition, the published version shall incorporate this letter and the enclosed SE supplement, between the title page and the abstract.

Please contact Meena Khanna of my staff at (301) 415-2150 if you have any further questions regarding this subject.

Sincerely,

/RA/

William H. Bateman, Branch Chief
Materials and Chemical Engineering Branch
Division of Engineering
Office of Nuclear Reactor Regulation

Enclosure: As stated

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William H. Bateman, Branch Chief
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U.S. NUCLEAR REGULATORY COMMISSION
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SUPPLEMENT TO SAFETY EVALUATION OF THE "BWRVIP VESSEL AND INTERNALS PROJECT, STANDBY LIQUID CONTROL LINE REPAIR DESIGN CRITERIA (BWRVIP-53)," EPRI REPORT TR-108716

1.0 INTRODUCTION

1.1 Background

In a letter dated January 19, 2004, the Boiling Water Reactor Vessel and Internals Project (BWRVIP) provided responses to the Nuclear Regulatory Commission (NRC) Safety Evaluation (SE) for the Electric Power Research Institute (EPRI) proprietary report TR-108716, "BWR Vessel and Internals Project, Standby Liquid Control Line Repair Design Criteria (BWRVIP-53)," dated July 1998. The BWRVIP-53 report was submitted to the U. S. NRC for staff review by letter dated July 2, 1998, as supplemented by letter dated December 6, 1999. The supplemental information was in response to the staff's request for additional information (RAI), dated April 7, 1999. Both proprietary and non-proprietary versions of the BWRVIP-53 report were submitted for NRC staff review by letter dated July 2, 1998, and an expanded non-proprietary version of the BWRVIP-53 report was submitted by letter dated March 24, 2000. The staff's initial SE is contained in an October 26, 2000, letter to C. Terry.

The BWRVIP-53 report provides general repair criteria for the temporary and permanent repair of the standby liquid control (SLC) and core differential pressure (CDP) nozzles and internal lines. These guidelines are intended to maintain the structural integrity of the SLC and CDP nozzle and internal lines during normal operation and under postulated transient and design basis accident conditions.

1.2 Purpose

The staff reviewed the BWRVIP-53 report, as supplemented, to determine whether its proposed guidance, along with the response to the staff's SE, will provide an acceptable repair design criteria of the subject safety-related reactor vessel (RV) internal components. The review assessed the design objectives, structural evaluation, system evaluation, materials, fabrication and installation considerations, as well as the required inspection and testing requirements.

1.3 Organization of this Report

Because the BWRVIP report is proprietary, this SE was written not to repeat information contained in the report. The staff does not discuss, in any detail, the provisions of the guidelines, nor the parts of the guidelines it finds acceptable. A brief summary of the contents of the BWRVIP-53 report is given in Section 2 of this SE, with the evaluation presented in Section 3. The conclusions are summarized in Section 4. The presentation of the evaluation is structured according to the organization of the BWRVIP-53 report.

2.0 SUMMARY OF BWRVIP-53 REPORT

The BWRVIP-53 report addresses the following topics in the following order:

- Component Description and Safety Function - The SLC and CDP nozzles and internal line configurations are described in detail with brief descriptions of each configuration's function and characteristics. Differences among the various models of BWRs (BWR/2 through BWR/6) are identified. The safety design bases for the SLC and CDP nozzles are to: (1) support the SLC system delivery of sodium pentaborate solution to the lower plenum whenever required, and (2) to provide a portion of the primary pressure boundary. The specific safety design features are subsequently addressed. An event analysis is also provided for various operational conditions to ensure that the components' safety functions are maintained.
- Scope of Repairs - The SLC and CDP nozzles and internal lines' susceptibility to intergranular stress corrosion cracking (IGSCC) is briefly discussed. Appendices A, B, and C further address repair concepts of the subject safety-related components, as well as alternate operational approaches in case of impairment of the core plate ΔP (differential pressure) signal.
- Design Objectives - The following design objectives are presented and briefly discussed: design life, safety design bases, safety analysis events, structural integrity, retained flaw(s), loose parts considerations, and physical interfaces with other reactor internals. Two features of component repair also considered in order to minimize in-vessel time for installations are vessel drain down (in order to support repair of the SLC and CDP nozzles and internal lines without draining the vessel) and repair accessibility.
- Design Criteria - The design criteria of the SLC and CDP nozzles and internal components are presented in the BWRVIP-53 report. In summary, all repair designs should meet the individual plant safety analysis report (SAR), as well as NRC and American Society of Mechanical Engineers (ASME) Code established methodology for RPV and internals mechanical design.
- Structural and Design Evaluation - Terms (e.g., hydraulic loads, fuel lift loads, etc.) associated with applied loads on the RV and RV internals are briefly discussed. The various events and operational service level conditions are also considered to ensure that the repairs do not inhibit safety and operational functions of the internal components. Other structural and design topics addressed are: load combinations, functional evaluation criteria, allowable stresses, flow-induced vibration, repair impact on existing internal components, radiation effects on repair design, analysis codes, thermal cycles, and corrosion allowance.
- System Evaluation - The following system evaluations, performed in support of the SLC and CDP nozzles and internals repairs and modifications, are briefly discussed: SLC solution distribution, loss of the above core plate pressure reading, and power uprate.

- Materials, Fabrication and Installation - The materials specifications are given along with the regulatory requirements pertaining to austenitic stainless steel alloys. Welding and fabrication guidelines are also discussed. Installation considerations include the indication of the as-built dimensional tolerances that the repair can accommodate, as well as the minimization of the in-vessel debris generation. Reducing radiation exposure using ALARA practices and qualification of critical design parameters (e.g., preload in tensioned members, critical tolerances) were presented.

- Inspection and Testing - Inspection and testing of the reactor internal components are addressed in the following topics: inspection access, pre- and post-installation inspection, system hydrostatic test, flow test, and instrumentation checks.

3.0 STAFF EVALUATION

The BWRVIP-53 report provides the general design acceptance criteria for permanent and temporary repairs of the BWR SLC and CDP nozzles and internal lines. While it does not present specific designs to effect repairs of the subject safety-related BWR internal components, it does present a methodology for BWR licensees to follow in designing repairs which maintain the structural integrity and system functionality of the SLC and CDP nozzles and internal lines during normal operation and under postulated transient and design basis accident conditions for the specified service life of the components.

The SLC system is designed to shut down a reactor from full power by injecting sodium pentaborate, a neutron absorber, into the reactor core. This is done when the normal method of controlling core reactivity with control rods cannot be accomplished. In most BWR/2 through BWR/6's, a line from the SLC and CDP nozzles in the vessel bottom head supplies liquid sodium pentaborate solution to a standpipe or sparger inside the RPV. The standpipe or sparger then distributes the liquid through holes to the coolant entering the core.

However, five plants (Hope Creek, Limerick Units 1 and 2, Nine Mile Point Unit 2, and Perry) are configured such that the sodium pentaborate solution is injected through the core spray piping. For these plants, the BWRVIP-53 report states that the repair criterion are not applicable to the repair of the standby liquid control hardware used for injection through the core spray piping. The repair criteria does, however, apply to the repair of the SLC and CDP nozzles and internal hardware in the lower plenum of these five plants.

3.1 BWRVIP Response to Staff's Open Items

The staff's October 26, 2000, letter identified five open items. The BWRVIP, in its letter of January 19, 2004, addressed these items, which are discussed below.

Item 1: As was previously stated in the staff's SE of EPRI's November 1996 proprietary report TR-106712, "BWR Vessel and Internals Project, Roll/Expansion Repair of Control Rod Drive and In-core Instrument Penetrations in BWR Vessels (BWRVIP-17)," dated March 13, 1998, the staff determined that roll expansion is not a structural repair but is only leak limiting. Further, the staff found that the corrective action intended by the ASME Code requirements, upon discovery of a flaw in an ASME Code Class 1 pressure boundary component, is to either repair the flaw or replace the flawed component in order to return it to a condition of ASME Code compliance. An ASME Code-acceptable repair of a crack in a control rod drive (CRD) stub tube or in-core penetration would require a weld repair. Although the roll/expansion method may, for some time period, control the symptom of the flaw (leakage), it does not reestablish structural integrity by repairing or replacing the degraded item consistent with 10 CFR 50.55a. Therefore, the NRC staff determined that the BWRVIP-17 report did not provide a sufficient generic technical basis and criteria for performing a non-ASME Code repair to an ASME Code component to warrant a generic alternative to the ASME Code. The same reasoning holds for roll expansion of the SLC and CDP nozzles.

However, as described above, roll expansion can control leakage for a short period of time. A licensee may utilize the BWRVIP-53 report as part of the technical basis for a plant-specific request for an alternative repair per 10 CFR 50.55a(a)(3) to utilize roll expansion to temporarily repair the SLC and CDP nozzles for no more than one operating cycle. The request will be reviewed by the staff on a plant-specific basis prior to its implementation.

BWRVIP Response to Staff Evaluation of Item 1: The report will be revised to clarify that the NRC has not accepted roll-expansion as an acceptable method for permanent repair and that use of roll-expansion by a licensee requires prior review and approval by the NRC.

Staff Evaluation of BWRVIP Response to Item 1: Since the report will be revised to indicate roll expansion is not an acceptable method for permanent repair and the use of roll-expansion by a licensee will require prior review and approval by the NRC staff, the BWRVIP has adequately addressed this item.

RAI Item 6: Appendix C, "Repair Concepts For SLC and CDP Nozzles"

RAI Item 6 identified three concerns with the repair methods discussed in Appendix C. They are:

a) The staff requested that either a separate topical report or an additional appendix to this report be provided to support approval of the Japanese welding repair methods, described in Section C.2.1.2, “Japanese Owners Group In-core Repair.”

b) The staff requested that the use of the method of repair described in Section C.2.3, "Non-Structural Thermal Spray Leakage Barriers," be considered only on a case-by-case basis.

c) The staff identified that additional detailed analyses would need to be submitted for staff approval by the BWRVIP of the mechanical nozzle seal assemblies as an alternative repair technique for SLC and CDP line nozzles. This repair technique is described in Section C.2.5, "Mechanical Seals," of the report.

The staff indicated that Appendix C should state that it is for "Information Only," and the use of the repair methods and concepts described therein will need to be submitted for staff approval as an alternative to 10 CFR 50.55a on a case-by-case basis.

BWRVIP Response to Item 6: The repair concepts discussed in Appendix C are intended to provide the repair designer with a number of potential repair approaches. They were not included in the report for the purpose of obtaining NRC acceptance or approval. The introduction to Appendix C will be clarified to indicate that the potential repair approaches have not necessarily been accepted by the NRC. Appendix C will be revised as requested.

Staff Evaluation of BWRVIP Response to Item 6: Since Appendix C will be revised as requested, the BWRVIP has adequately addressed this item.

RAI Item 7: Section 1.1, Background, states that, "there has only been one report of cracking in any BWR SLC and CDP nozzles or internals." This refers to the 1965 failure of an SLC sparger in an overseas BWR/1. However, in response to the SE on BWRVIP-53, the BWRVIP indicated that Big Rock Point found the discharge piping of the SLC line severed during decommissioning (Report dated April 24, 1998). The staff requested that the BWRVIP identify this incident and evaluate its significance in a revision to the BWRVIP-53 report.

BWRVIP Response to Staff Evaluation of Item 7: The failure at Big Rock Point is documented in a 2000 ICONE paper by Polaski, et al. entitled, “The Big Rock Point Sampling and Condition Assessment Project." The observed piping failures were confined to the interior of the SLC supply tank. This location is not within the scope of the BWRVIP repair or inspection documents. Therefore, a discussion of the event is not relevant to BWRVIP-53.

Staff Evaluation of BWRVIP Response to Item 7: Since the Big Rock Point piping failure was confined to the interior of the SLC supply tank and this location is not within the scope of the BWRVIP repair or inspection documents, it does not need to be described in Section 1.1 and the BWRVIP has adequately addressed this item.

RAI Item 10: Appendix A.1, "Abandoning in Place," states that "...liquid control injection into the lower head, without the liquid control piping and sparger, is acceptable; a review of plant-specific analyses would be appropriate to document this." The staff disagrees with this statement. The staff does not believe that this has been shown to be acceptable. The staff requested that the BWRVIP-53 document should provide guidance on the plant-specific analysis that could be done to show acceptable results on a plant-specific basis.

BWRVIP Response to Item 10: The primary basis for "Abandoning in Place" as a repair option is the testing and analysis of boron mixing as referenced in the response to Item 8 (Item 8 referenced analysis and testing that demonstrated that the SLC sparger was not required to assure proper boron mixing, ed.). A plant-specific analysis would be required to address other concerns such as potential vibration and loose parts from SLC and CDP internal components known to be cracked.

The third sentence in Section A.1 currently reads, "Damaged or suspect internal SLC & CDP piping should be evaluated as potential loose parts. " The sentence will be revised to read, "Damaged or suspect internal SLC & CDP piping can lead to loose parts concerns. Plant-specific analyses should be conducted to evaluate the potential to generate loose parts (e.g., due to vibration) and the potential consequences."

Staff Evaluation of BWRVIP Response to Item 10: Item 8, boron mixing under various postulated accident conditions and power levels is addressed in BWRVIP-27 and the technical basis for the analysis is contained in Reference 4. Item 8 was reviewed by the staff and found acceptable in the initial SE for BWRVIP-53. Therefore, additional plant-specific analysis for boron mixing is not required. Since Section A.1 will be revised to indicate a plant-specific analyses should be conducted to evaluate the potential to generate loose parts (e.g., due to vibration) and the potential consequences, the BWRVIP has adequately addressed this item.

RAI Item 11: The staff requested that the BWRVIP-53 report should be modified to identify the frequency of periodic flushing of the SLC internal line which could be used to determine if the line is pinched or not.

BWRVIP Response to Item 11: The BWRVIP proposes to add the following text at the end of the second paragraph in Section A.1:

> "In cases where internal lines are known or suspected to be pinched, flushing tests shall be developed using plant-specific design requirements and conducted prior to startup from the outage of discovery and shall be repeated every two subsequent outages. Alternate flushing schedules are acceptable as approved by the NRC."

Staff Evaluation of BWRVIP Response to Item 11: Since the BWRVIP report will be revised to indicate that the flushing tests shall be developed using plant-specific design requirements, should be conducted prior to startup, shall be repeated every two subsequent outages, and any alternative flushing schedules must be approved by the NRC, the BWRVIP has adequately addressed this item.

Additional Item: In Section 3.0 of the SE, the staff states, "Inspections of the repaired components should be in accordance with the BWRVIP-27 guidance, as approved by the staff." As previously discussed with the staff, in relation to other repair design criteria, the specific inspection requirements in the inspection and evaluation guidelines (e.g., BWRVIP-27), may not be appropriate for a repaired component.

Locations specified for inspection in the inspection and evaluation guidelines may be, for example, structurally replaced by a repair and will not require further inspection. However, it is an appropriate response to the SE for BWRVIP-53, in that the intent of the I&E guidelines will be met in future inspections of the repaired component. Therefore, the following paragraph will be added to Section 10.2: "Inservice inspections shall be defined consistent with the intent of the inspections defined in BWRVIP-27."

Staff Evaluation of Additional Item: Since the inservice inspection of repaired components will be consistent with the intent of the inspections defined in BWRVIP-27, the proposed guidance is acceptable.

4.0 CONCLUSION

The NRC staff has reviewed the BWRVIP-53 report, the associated RAI responses and the responses to the staff's initial SE. The staff finds that the BWRVIP-53 report, as modified and clarified to incorporate the staff's comments above, is acceptable for providing guidance for permanent or temporary repairs of the cracked or leaking SLC and CDP nozzles and cracked or broken SLC and CDP lines inside the reactor vessel. Therefore, the staff has concluded that implementation of the guidelines in the BWRVIP-53 report, as modified, will provide an acceptable repair design criteria for the safety-related components addressed. The BWRVIP-53 report is considered by the staff to be applicable for licensee usage at any time during either the current operating term or during an extended license period. The modifications stated in the RAI and addressed above should be incorporated in the A-version of the BWRVIP-53 report. Licensees should note that when applying the repair design criteria to components that, according to the licensing basis of the plant, are classified as ASME Code components, a submittal to the NRC, pursuant to 10 CFR 50.55a(a)(3) is required to request authorization of the repair as an acceptable alternative to the ASME Code.

5.0 REFERENCES

1. Carl Terry, BWRVIP, to USNRC, “BWR Vessel and Internals Project, Standby Liquid Control Line Repair Design Criteria (BWRVIP-53),” EPRI Report TR-108716, dated July 1998.

2. C. E. Carpenter, USNRC, to Carl Terry, BWRVIP, “Propriety Request for Additional Information - Review of BWR Vessel and Internals Project Report, Standby Liquid Control Line Repair Design Criteria (BWRVIP-53),” dated April 7, 1999.

3. Carl Terry, BWRVIP, to USNRC, “BWRVIP Response to NRC Request for Additional Information on BWRVIP-53,” December 6, 1999.

4. Eckert, E.C., "Summary of BWR Boron Remixing," GE Report GENE-AOO- 05652-03, Prepared for the BWR Owners' Group, February 1996 (GE proprietary).

5. Carl Terry, BWRVIP, to USNRC, “BWR Vessel and Internals Project, Standby Liquid Control Syatem/Core Plate ΔP Inspection and Flaw Evaluation Guidelines (BWRVIP-27),” dated April 1997.

6. William A. Eaton, BWRVIP, to USNRC, “Project No. 704–BWRVIP Response to NRC Safety Evaluation of the BWR Vessel and Internals Project BWRVIP-53 Report,” dated January 19, 2004.