February 28, 2005

Bill Eaton, BWRVIP Chairman
Entergy Operations, Inc.
Echelon One
1340 Echelon Parkway
Jackson, MS 39213-8202

SUBJECT: SAFETY EVALUATION OF THE NON-PROPRIETARY EPRI REPORT, "BWR VESSEL AND INTERNALS PROJECT, BWR CORE SHROUD REPAIR DESIGN CRITERIA, REVISION 2 (BWRVIP-02NP)" (TAC NO. MB8969)

Dear Mr. Eaton:

The NRC staff has completed its review of the Electric Power Research Institute (EPRI) non-proprietary report, "BWR Vessel and Internals Project, BWR Core Shroud Repair Design Criteria, Revision 2 (BWRVIP-02NP)," dated February 2000. This report was submitted by letter dated March 7, 2000, for NRC staff review and approval. The BWRVIP-02, Revision 2, report provides the general design acceptance criteria for permanent mechanical repair that ensures that the shroud will meet its design basis safety functions in the event of cracking in circumferential or vertical shroud welds.

The NRC provided its safety evaluation of the BWRVIP-02, Revision 1 report, “Boiling Water Reactor Core Shroud Repair Design Criteria,” by letter dated September 29, 1994, which addressed general design criteria and acceptance criteria for permanent core shroud repairs. This current revision, BWRVIP-02, Revision 2, incorporates the most recent lessons learned from the core shroud inspections and repairs performed since the fall of 1994. It also incorporates criteria related to the repair and assessment of cracking in the vertical welds.

The NRC staff has reviewed your submittal and finds that the report presents an acceptable technical justification of its proposed general design acceptance criteria for a permanent repair of the 304 stainless steel circumferential and vertical welds in BWR reactor pressure vessel shrouds. It should be noted that these criteria are based on the premise that a repair for the circumferential welds would be implemented either prior to, or at the same time as a vertical weld repair, as stated in the BWRVIP-02, Revision 2 report.

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, Chief
Materials and Chemical Engineering Branch
Division of Engineering
Office of Nuclear Reactor Regulation

Enclosure: As stated

cc: BWRVIP Service List

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, Chief
Materials and Chemical Engineering Branch
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Office of Nuclear Reactor Regulation

Enclosure: As stated

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cc:

Tom Mulford, EPRI BWRVIP
Integration Manager
Raj Pathania, EPRI BWRVIP
Mitigation Manager
Ken Wolfe, EPRI BWRVIP
Repair Manager
Larry Steinert, EPRI BWRVIP
Electric Power Research Institute
P.O. Box 10412
3412 Hillview Ave.
Palo Alto, CA 94303

George Inch, Technical Chairman
BWRVIP Assessment Committee
Constellation Nuclear
Nine Mile Point Nuclear Station (M/S ESB-1)
348 Lake Road
Lycoming, NY 13093

William C. Holston, Executive Chairman
BWRVIP Integration Committee
Constellation Generation Group
Nine Mile Point Nuclear Station
P. O. Box 63
Lycoming, NY 13093

Jim Meister, BWRVIP Vice-Chairman
Exelon Corp.
Cornerstone II at Cantera
4300 Winfield Rd.
Warrenville, IL 60555-4012

Al Wrape, Executive Chairman
BWRVIP Assessment Committee
PPL Susquehanna, LLC
2 N. 9th St.
Allentown, PA 18101-1139

H. Lewis Sumner, Executive Chairman
BWRVIP Mitigation Committee
Vice President, Hatch Project
Southern Nuclear Operating Co.
M/S BIN B051, P.O. BOX 1295
40 Inverness Center Parkway
Birmingham, AL 35242-4809

Robert Carter, EPRI BWRVIP
Assessment Manager
Greg Selby, EPRI BWRVIP
Inspection Manager
EPRI NDE Center
P.O. Box 217097
1300 W. T. Harris Blvd.
Charlotte, NC 28221

Robin Dyle, Technical Chairman
BWRVIP Integration Committee
Southern Nuclear Operating Co.
42 Inverness Center Parkway (M/S B234)
Birmingham, AL 35242-4809

Denver Atwood, Technical Chairman
BWRVIP Repair Focus Group
Southern Nuclear Operating Co.
Post Office Box 1295
40 Inverness Center Parkway (M/S B031)
Birmingham, AL 35242-4809

Jeff Goldstein, Technical Chairman
BWRVIP Mitigation Committee
Entergy Nuclear NE
440 Hamilton Ave. (M/S K-WPO-11c)
White Plains, NY 10601

Dale Atkinson, BWRVIP Liason to EPRI
Nuclear Power Council
Energy Northwest
Columbia Generating Station (M/S PEO8)
P. O. Box 968
Snake River Complex
North Power Plant Loop
Richland, WA 99352-0968

Richard Ciemiewicz, Technical Vice Chairman
BWRVIP Assessment Committee
Exelon Corp.
Peach Bottom Atomic Power Station
M/S SMB3-6
1848 Lay Road
Delta, PA 17314-9032

Charles J. Wirtz, Chairman
BWRVIP Inspection Focus Group
FirstEnergy Corp.
Perry Nuclear Power Plant (M/S A250)
10 Center Road
Perry, OH 44081

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SAFETY EVALUATION OF EPRI REPORT

"BWR VESSEL AND INTERNALS PROJECT, BWR CORE SHROUD REPAIR DESIGN CRITERIA, REVISION 2 (BWRVIP-02NP)"

1.0 INTRODUCTION

1.1 Background

The “BWR Core Shroud Repair Criteria, Revision 1" (BWRCSRC) report was developed by the Repair Technical Subcommittee for the BWR Vessel and Internals Project (BWRVIP). This document provided the general design basis safety functions in the event of cracking in circumferential shroud welds. It was provided to assist BWR owners in designing a permanent mechanical repair which maintains the structural integrity of the core shroud for the remaining plant life during normal operation and under postulated transient and design-basis accident conditions. This document was applicable to General Electric (GE) BWR/2, BWR/3-5, and BWR/6 plants which plan to implement a permanent repair of the 304 stainless steel horizontal circumferential shroud welds that are found to be cracked or that may be sensitized, and therefore, subject to cracking. The staff approved the BWRCSRC report by a safety evaluation dated September 29, 1994.

By letter dated March 7, 2000, the BWRVIP submitted the non-proprietary report, "BWR Vessel and Internals Project, BWR Core Shroud Repair Design Criteria, Revision 2 (BWRVIP-02NP)," to provide general design acceptance criteria for the repair of vertical and circumferential welds in core shrouds. This current revision incorporates the lessons learned from the core shroud inspections and repairs performed since the fall of 1994. It also incorporates criteria related to the repair and assessment of cracking in the vertical welds. It should be noted, however, that this document does not include criteria for the repair of vertical welds alone. These criteria are based on the premise that a repair for the circumferential welds would be implemented either prior to, or at the same time as, a vertical weld repair. Following staff approval, it is expected that individual licensees and repair vendors will adhere to these criteria in the development of plant-specific repair designs.

The approval of this document by the NRC does not imply that a repair is the only viable method of resolving the core shroud cracking issue. If a utility elects to repair one or more of the circumferential and vertical shroud welds, it is expected that the designs will meet the requirements of the BWRVIP-02, Revision 2 report. For shroud welds that are not encompassed by the repair, it is expected that the BWRVIP requirements for continued inspection and assessment would be utilized.

ENCLOSURE

1.2 Purpose

The staff reviewed the BWRVIP-02, Revision 2 report to determine whether the report presents an acceptable technical justification of the proposed general design acceptance criteria for a permanent repair of the 304 stainless steel circumferential and vertical welds in BWR core shrouds.

1.3 Organization of this Report

A brief summary of the contents of the subject 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-02, Revision 2 report.

2.0 SUMMARY OF THE BWRVIP-02 REPORT

The BWRVIP-02, Revision 2 report addresses topics in the following order:

2.1 Shroud Characteristics and Safety Function - The various events and operational conditions which must be considered to ensure that the repaired core shroud will perform its safety functions and meet its power generation objectives have been specified. The load cases which should be considered include normal, upset, emergency, and faulted conditions. The loads associated with the design-basis accidents include a design-basis earthquake in conjunction with a recirculation discharge line break or a main steamline break. All components of these loads are to be considered.

An appropriate seismic analysis must be considered when analyzing accidents and transients. If the addition of the repair hardware and/or inclusion of the weld cracks do not significantly affect the structural/dynamic characteristics of the shroud, then the existing, current licensing basis seismic analysis may be used, if technically justified. However, if the inclusion of the repair hardware and/or the cracks affect the structural/dynamic characteristics of the shroud, then a new seismic analysis will be required in support of the repair design. The treatment of the combined accident and seismic loads should be consistent with the current plant licensing basis.

2.2 Scope of Repairs - A shroud repair addresses cracking in the circumferential and vertical welds of 304 stainless steel shrouds that are sensitized. The scope and extent of a repair shall be clearly defined and will include the entire length of a circumferential weld. These criteria were developed to address a repair of any one or all of the circumferential welds. The incorporation of a repair of the vertical welds can be implemented subsequent to the circumferential weld repair or in combination with a circumferential weld repair within the same outage. This criteria does not address a vertical weld repair independent of a circumferential weld repair. The design concept shall either structurally replace or provide for verification of adequate structural integrity of all design reliant features and hardware.

These design criteria are applicable for the repair of circumferential and vertical welds from H-1 down through the bimetallic weld where the shroud was welded to the shroud support.

2.3 Design Criteria

2.3.1 General Design Requirements

[ ] If a repair is not intended to last for the remaining life of the plant plus life extension beyond the current operating license, then all design requirements must be met in accordance with BWRVIP-02, Revision 2 with the exception of the design life requirements.

The repair shall be designed such that the safety bases described in Section 3.2 of the BWRVIP-02, Revision 2, report are demonstrated. In addition, safety analysis event scenarios described in the individual plant Final Safety Analysis Reports (FSARs) remain valid and unaltered by the criteria contained in the BWRVIP-02, Revision 2 report.

[ ]

The report also addresses load combinations, flow-induced vibration, loading on existing internal components, annulus flow distribution, core bypass flow distribution, and emergency operating procedure calculations.

[ ]

2.3.2 Design Basis

2.3.2.1 Structural Integrity

[ ]

2.3.2.2 Design Analysis

The report addresses specific design analyses requirements. There is a set of criteria that apply to all shroud repair options. There are additional criteria that apply to circumferential weld repairs only. Likewise, there are criteria that are applicable only to the vertical weld repair aspects of the design.

2.3.2.2.1 [ ]

2.3.2.2.2 [ ]

2.3.2.2.3 [ ]

2.3.3 Functional Requirements

2.3.3.1 Circumferential Weld Repairs

[ ]

2.3.3.2 Vertical Weld Repairs

[ ]

2.3.4 Critical Design Parameters, Thermal Cycles, Chemistry/Flux, Loose Parts Considerations, Inspection Access, and Crevices

The BWRVIP-02, Revision 2 report also addresses design criteria with respect to qualification of critical design parameters, thermal cycles, chemistry/flux, loose parts considerations, inspection access, and crevices. A brief description of these design criteria is provided below.

[ ]

2.3.5 Materials

[ ]

The BWRVIP-02, Revision 2 report also provides criteria for the use of Alloy X-750, Type XM-19, and 300 series austenitic stainless steel.

2.3.6 Welding and Fabrication

The welding and fabrication guidelines that are provided in the BWRVIP-02, Revision 2 report include the following:

[ ]

2.3.7 The BWRVIP-02, Revision 2 report addresses pre-installation as-built inspection and installation cleanliness.

2.3.8 Pre- and Post-Installation Inspection

The BWRVIP-02, Revision 2 report provides specific criteria of the type and scope of inspections that are required prior to, during, and after the installation of the repair hardware. However, reinspection requirements are not addressed in the BWRVIP-02, Revision 2 report. Reinspection requirements for both repairs and unrepaired shrouds are provided in BWRVIP-07, “Guidelines for Reinspection of BWR Core Shroud.”

The report also specifies that welds that are structurally replaced by the repair will not require pre-installation or post-installation inspections. However, the structural integrity of the anchorage is to be ensured.

2.3.8.1 Circumferential Welds

[ ]

2.3.8.2 Vertical Welds and Ring Segment Welds

[ ]

2.4 Codes and Standards

[ ]

3.0 STAFF EVALUATION

3.1 Shroud Characteristics and Safety Function

The staff finds that the BWRVIP adequately addressed the various events and operational conditions to ensure that a core shroud repair which meets the criteria discussed in the BWRVIP-02, Revision 2 report will not inhibit the ability of the core shroud to perform its basic safety functions and meet its power generation objectives. In addition, the staff determined that the BWRVIP adequately addressed the consideration of loads during normal operation, upset conditions, and emergency/faulted conditions.

3.2 Scope of Repairs

As stated in Section 2.2 of this SE, a shroud repair design shall address cracking in the circumferential and vertical welds of 304 stainless steel shrouds that are sensitized. Typically, these welds include welds from the uppermost (H-1) weld down through the bimetallic weld where the shroud is welded to the shroud support. The staff finds that a repair designed to the criteria established in the BWRVIP-02, Revision 2 report will be acceptable because its scope will include all potentially sensitized shroud welds.

3.3 Design Criteria

The staff finds that the BWRVIP-02, Revision 2 report provides appropriate and comprehensive guidelines with respect to the general design requirements, design basis assumptions, functional requirements (which include displacements of cracked welds), and qualification of critical design parameters for core shroud repairs. In addition, the report also provides appropriate and comprehensive guidelines regarding the consideration of the effects of thermal cycling, use of existing and anticipated water chemistry control measures for BWRs, consideration of neutron flux on materials used in the repair, loose parts considerations, inspection access, criteria for crevices immune to SCC acceleration, and welding and fabrication for core shroud repairs.

During a meeting that was held between the BWRVIP and the NRC on August 25, 2004, the staff requested that the BWRVIP address bypass leakage with respect to the BWRVIP-02, Revision 2 report. The BWRVIP indicated that with respect to the core shroud, the shroud repair would be based on loads that would be carried by the repair,

assuming a 360E through-wall flaw. For the circumferential welds, the BWRVIP indicated that loads are developed to prevent separation from occurring; and as a minimum, the design ensures that cracked circumferential welds do not separate under normal operation.

It was further stated that for repairs that preload the vertical welds, there is no separation between the welds under normal operation, because the crack faces are held together, and therefore, significant leakage is not a concern. For repairs that do not preload the vertical welds, the licensee evaluates the separation of the clamps and the results of the bypass leakage. The staff noted that repairs to the core shroud are not required to prevent leakage from the core region into the downcomer annulus. Minor separation of the vertical welds is acceptable, provided all design basis requirements are satisfied. The repair design is to account for leakage from the region inside the shroud into the annulus region during normal operation. This leakage is not to exceed the minimum subcooling required for proper jet pump and/or recirculation pump operation, and the core bypass flow leakage requirements assumed in the reload fuel safety analysis are to be maintained. Repair designs are to include verification that the leakage through the flow partition, resulting from weld separation during accident and transient events, is acceptable to meet the normal operational requirements for recirculation system performance and core bypass flow.

The staff noted that the repair criteria requires that a circumferential weld that is structurally replaced by the repair is assumed to have a 360E through-wall crack. Therefore, the staff agrees with the BWRVIP that structural integrity will be maintained if cracking progresses to that condition. In addition, the report addresses that welds that are not structurally replaced by the repair, must be inspected and evaluated consistent with the BWRVIP BWR Core Shroud Inspection and Flaw Evaluation Guidelines. This is appropriate and, therefore, acceptable to the staff.

The BWRVIP-02, Revision 2 report specifies the type and scope of the weld and repair inspections that are required prior to the installation of the core shroud repair hardware, and during or after the installation of the repair within the same outage. The staff finds these inspections comprehensive and, therefore, acceptable. Inspections of the welds and repair hardware that are required in subsequent outages are delineated in the BWRVIP-76 report, which supersedes the BWRVIP-01, BWRVIP-07, and BWRVIP-63 reports. The staff will review these inspection guidelines as part of its review of the BWRVIP-76 report.

The staff requests that the BWRVIP revise the BWRVIP-02, Revision 2 report to reflect that the BWRVIP-76 report addresses the inspection guidelines for the circumferential, vertical, and ring segment welds when the -A version of the BWRVIP-02, Revision 2 report is issued.

Because the material requirements have been updated and included in the BWRVIP-84 report, the BWRVIP has committed to delete the information provided in Section 5.10 of the BWRVIP-02, Revision 2 report, “Materials,” and provide a note of reference that the material requirements for core shroud repair designs are addressed in the BWRVIP-84 report. This will be reflected in the -A version of the BWRVIP-02, Revision 2 report.

Based on its review, the staff finds that the BWRVIP has adequately addressed the design criteria for the repair of core shrouds.

3.4 Codes and Standards

The BWRVIP-02, Revision 2 report lists the Codes and Standards that are to be used when considering the shroud repair designs. The report states that the repairs are to be performed as an alternative to the ASME Code Section XI requirements, as addressed by 10 CFR 50.55a(a)(3), and that the repairs would require NRC review and approval. In addition, the BWRVIP-02, Revision 2 report requires that the repairs are to meet the individual plant FSAR and other NRC commitments in regard to reactor pressure vessel internals design, and delineates applicable ASME Code, Section III requirements where commitments exist or have been made to meet the "intent" of ASME Code, Section III. The report states that the use of ASME Code Editions and Addenda not endorsed by 10 CFR 50.55a will be evaluated by the NRC on a case-by-case basis. The staff finds the Codes and Standards, as listed in the BWRVIP-02, Revision 2 report that are to be used when considering shroud repair designs to be acceptable because they are contained within the regulations.

3.5 Functional Testing

The BWRVIP-02, Revision 2 report indicates that post installation functional testing is not required for the repair assemblies. The staff finds this acceptable as the repair assemblies are designed as passive components.

3.6 Quality Assurance Program

The BWRVIP-02, Revision 2 report includes guidelines that require that shroud repair design, fabrication, and installation activities are to be performed in accordance with the requirements of 10 CFR Part 50, Appendix B. The staff finds this acceptable because this is in accordance with regulations for quality assurance of safety-related components.

4.0 CONCLUSIONS

The NRC staff has completed its review of the BWRVIP-02, Revision 2 report. The staff notes that these shroud repair design criteria are based on the premise that a repair for the circumferential welds would be implemented either prior to or at the same time as a vertical weld repair. The staff has found that the guidance of the report is acceptable for providing general design acceptance criteria for a permanent repair of the 304 stainless steel circumferential and vertical welds in BWR reactor core shrouds. Therefore, the staff has concluded that licensee implementation of the guidelines in the BWRVIP-02, Revision 2 report will provide an acceptable repair design criteria of the core shroud. However, it should be noted that plants seeking license renewal must comply with 10 CFR Part 54, in that any applicable aging management programs and time-limited aging analyses with respect to the core shroud should be addressed in the license renewal application.

5.0 REFERENCES

1. Carl Terry, BWRVIP, to USNRC, “BWR Vessel and Internals Project, Core Shroud Repair Design Criteria, Revision 2 (BWRVIP-02),” EPRI Report TR-112642, March 1999.

2. Carl Terry, BWRVIP, to USNRC, “BWR Vessel and Internals Project, BWR Core Shroud Inspection and Flaw Evaluation Guidelines, Revision 2 (BWRVIP-01),” October 1996.

3. Carl Terry, BWRVIP, to USNRC, “BWR Vessel and Internals Project, Guidelines for Reinspection of BWR Core Shroud (BWRVIP-07),” February 1996.

4. Carl Terry, BWRVIP, to USNRC, “BWR Vessel and Internals Project, Core Shroud Vertical Weld Inspection and Evaluation Guidelines (BWRVIP-63),” February 1996.

5. “Justification for Allowable Displacement of the Core Plate and Top Guide-Shroud Repair,” GENE-771-44-0894, Revision 1.