February 22, 2002

Carl Terry, BWRVIP Chairman
Niagara Mohawk Power Company
Post Office Box 63
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SUBJECT: SAFETY EVALUATION OF THE "BWRVIP VESSEL AND INTERNALS PROJECT, LPCI COUPLING REPAIR DESIGN CRITERIA (BWRVIP-56)," EPRI REPORT TR-108717, NOVEMBER 1998 (TAC NO. MA4203)

Dear Mr. Terry:

The NRC staff has completed its review of the Electric Power Research Institute (EPRI) proprietary report TR-108717, "BWR Vessel and Internals Project, LPCI Coupling Repair Design Criteria (BWRVIP-56)," dated November 1998. Both proprietary and non-proprietary versions of the BWRVIP-56 report were submitted to the U. S. Nuclear Regulatory Commission for staff review by letter dated November 16, 1998. The BWRVIP-56 report provides general design acceptance criteria for the temporary and permanent repair of BWR low pressure coolant injection (LPCI) couplings. These guidelines are intended to maintain the structural integrity of the LPCI couplings during normal operation and under postulated transient and design basis accident conditions. The BWRVIP provided the BWRVIP-56 report to support generic regulatory efforts related to the repair of BWR LPCI couplings.

The NRC staff has reviewed the BWRVIP-56 report, and has found in the enclosed safety evaluation (SE) that the BWRVIP-56 report is acceptable for providing guidance for permanent or temporary repair of BWR LPCI couplings. With the exception of the noted items, the staff has concluded that licensee implementation of the BWRVIP-56 report is acceptable for providing an adequate repair design criteria of the safety-related components, except where the staff's conclusion differs from the BWRVIP's, as discussed in the enclosed SE. This finding, based upon the information submitted, is consistent with NRC approved methodology.

The BWRVIP-56 report is considered by the staff to be applicable for licensee usage, as modified and approved by the staff, at any time during either the current operating term or during the extended license period.

The staff requests that the BWRVIP review and resolve the issues raised in the enclosed SE, and incorporate the staff's conclusions into a revised BWRVIP-56 report. Please inform the staff within 90 days of the date of this letter as to your proposed actions and schedule for such a revision.

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

Sincerely

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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U.S. NUCLEAR REGULATORY COMMISSION

OFFICE OF NUCLEAR REACTOR REGULATION

SAFETY EVALUATION OF THE "BWRVIP VESSEL AND INTERNALS PROJECT,

LPCI COUPLING REPAIR DESIGN CRITERIA

BWRVIP-56, EPRI REPORT TR-108717

1.0 INTRODUCTION

1.1 Background

By letter dated November 16, 1998, the Boiling Water Reactor Vessel and Internals Project (BWRVIP) submitted the Electric Power Research Institute (EPRI) proprietary Report TR-108717, "BWR Vessel and Internals Project, LPCI Coupling Repair Design Criteria (BWRVIP-56)," dated November 1998, for NRC staff review. The BWRVIP-56 report provides general repair criteria for the temporary and permanent repair of BWR low pressure coolant injection (LPCI) couplings. These guidelines are intended to maintain the structual integrity of the LPCI couplings during normal operation and under postulated transient and design-basis accident conditions. The BWRVIP provided the BWRVIP-56 report to support generic regulatory efforts related to the repair of BWR LPCI couplings.

1.2. Purpose

The staff reviewed the BWRVIP-56 report to determine whether it will provide an acceptable repair design criteria of the subject safety-related reactor pressure vessel (RPV) 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-56 report is proprietary, this SE was written not to repeat proprietary 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 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-56 report.

ENCLOSURE

2.0 SUMMARY OF BWRVIP-56 REPORT

The BWRVIP-56 report addresses the following topics in the following order:

- Component Configurations and Safety Functions - The LPCI couplings for the various models of BWRs are described in detail with brief descriptions of each configuration's function and characteristics. Differences among the various models of BWRs (BWR/4, BWR/5 and BWR/6) are identified. The safety design basis for the LPCI coupling is given. An event analysis is also provided for various operational conditions to ensure the component safety functions are maintained.

- Scope of Repairs - The scope of the proposed repairs is given, which primarily addresses cracking and/or leaking in IGSCC susceptible stainless steel and nickel-chrome-iron alloy components of the LPCI coupling assembly.

- Design Objectives - The following design objectives are presented and briefly discussed: design life, safety design basis, safety analysis events, structural integrity, retained flaw(s), loose parts considerations, physical interfaces with other reactor internals and installation considerations to minimize in-vessel time.

- Design Criteria - The design criteria of the LPCI couplings are presented. In summary, all repair designs shall meet the individual plant safety analysis report (SAR) as well as NRC established methodology for reactor pressure vessel (RPV) and internals mechanical design. The ASME Code is generally used for the design stress requirements of the LPCI couplings.

- Structural and Design Evaluation - Terms (e.g., hydraulic loads, differential pressure loads, etc.) associated with applied loads on the reactor vessel internals are briefly discussed. The various events and operational service level conditions are also considered to ensure 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 are discussed: leakage impact and acceptance criteria for normal operation and accident conditions, LPCI coupling pressure drop, flow distribution impact, emergency operating procedure (EOP) calculations 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 discussed, as well as, minimization of crevices. Installation considerations included indicating the as-built dimensional tolerance the repair can accommodate as well as the minimization of in-vessel debris generation. Reducing radiation exposure using ALARA practices and qualification of critical design parameters (e.g., preload in tensioned members, critical tolerances) was presented.

- Inspection and Testing - Inspection and testing of the reactor internal components are addressed in the following topics: inspection access, and pre- and post-installation inspection.

3.0 STAFF EVALUATION

The LPCI operating mode of the residual heat removal (RHR) system is part of the BWR emergency core cooling system (ECCS). The purpose of the LPCI mode is to restore and maintain desired water level inside the reactor shroud following a postulated loss-of-coolant accident (LOCA). The LPCI mode can also be used to provide alternate shutdown cooling. The purpose of the LPCI coupling is to provide a hydraulic path for the LPCI flow through a flexible joint between the RHR/LPCI nozzle on the reactor vessel and the shroud cylinder. The component would not generally be used during normal plant operations. The shroud opening for the LPCI coupling is located above the two-thirds core height elevation; therefore, the coupling is not part of the post-LOCA refloodable volume. The LPCI coupling is included in the design of the newer BWR/4 plants (Hope Creek and Limerick Units 1 and 2), BWR/5 and BWR/6 plants. This component is not part of the design of the BWR/2, BWR/3, or the older BWR/4 plants.

The BWRVIP-56 report provides guidance on evaluating the impact of leakage from the LPCI coupling into the annulus outside the core shroud during normal and accident conditions. The BWRVIP-56 report recommends that the evaluation of the quantity of the leakage from the LPCI coupling be based on the system temperature, pressure, and system flow conditions consistent with the licensee's existing licensing basis LOCA analysis. The BWRVIP report also provides recommendations on evaluating LPCI coupling pressure drop, flow distribution, emergency operating procedure calculations, and power uprate.

The staff has reviewed the guidance provided in the BWRVIP-56 report and finds it consistent with other existing guidance on the evaluation of potential leakage sources. With the exception of the below noted items, the staff has concluded that licensee implementation of the BWRVIP-56 report is acceptable for providing an adequate repair design criteria of the safety-related components, except where the staff's conclusion differs from the BWRVIP's, as discussed below. This finding, based upon the information submitted, is consistent with NRC approved methodology.

The BWRVIP-56 report is considered by the staff to be applicable for licensee usage, as modified and approved by the staff, anytime during either the current operating term or during the extended license period.

3.1 Structural and Design Evaluation

A structural evaluation was performed to determine the acceptability of the repair methodology for the LPCI coupling. The hydrodynamic loadings considered in the evaluation included the dead weight, seismic inertia and anchor displacements, safety relief valve (SRV) opening, main vent clearing, annulus pressurization, pool swell, condensation oscillation and chugging, flow induced vibration and thermal and pressure anchor displacement.

The service level conditions assumed were for normal operating conditions, upset conditions (i.e., loads due to anticipated operational occurrences that have the potential to increase the

loads acting on the reactor internal components above those experienced during normal operation), emergency conditions (i.e., the combination of all sustained normal operation loads in conjunction with loads from the design basis pipe break (DBPB) other than a design basis loss of coolant accident (LOCA), main steam line break (MSLB) or feedwater pipe break), and faulted conditions (i.e., the combination of all sustained normal operation loads in conjunction with several combinations of design basis events, including the DBPB/LOCA or the DBPB/LOCA and safe shutdown earthquake (SSE), where applicable).

The load combinations used were consistent with the requirements of the plant specific final safety analysis report (FSAR), or other related licensing basis documentation. Load combinations fall into two main plant categories: those with Mark II or III containments where hydrodynamic events cause vessel internal loads, and those with Mark I containments where hydrodynamic events in the torus do not cause significant loads on vessel internals.

Allowable stresses under the loading combinations were required to be consistent with the current plant FSAR. The repair was designed to address the potential for, and to minimize the effects of, flow induced vibrations, with testing allowed as an alternative to, or supplement of, the vibration analysis. The design of the repair was required to take into account the effects of irradiation relaxation utilizing end-of-life (including license renewal period, if applicable) fluence on the materials. All thermal-hydraulic and structural codes utilized in the design analysis were appropriately benchmarked and demonstrated to be conservative and bounding for the application. The design and analysis of the repairs considered the operating conditions and events specified in the design basis documents (DBD) and assumed thermal cycle events equal to or greater than the number originally assumed in the DBD. Fatigue loading was also considered in the design, along with other design vibratory loads. Changes to the LPCI coupling resulting from repairs were evaluated to demonstrate that the entire system (e.g., piping, anchors and supports) satisfies design basis stress limits and did not adversely impact other existing internal components.

Based on its review as discussed above, the staff finds the structural evaluation reasonable and acceptable.

3.2 General Comments:

1. In order to be consistent with other BWRVIP repair procedures, such as the BWRVIP-16 and BWRVIP-19 reports, the following requirements should be added or changed in Section 9.1.2, Materials, of the BWRVIP-56 report: “Repair and replacement designs for plants which were not designed and constructed in accordance with ASME Section III (and components not subject to Section XI) must meet the individual plant SAR and other plant commitments for RPV internals mechanical design, as stated in Section 6. In that instance, materials must meet the requirements of ASME Section II specifications, ASME Code Cases, ASTM specifications, or other material specifications that have been previously approved by the regulatory authorities. This would include material specifications/criteria submitted by BWRVIP and approved by NRC. Otherwise, it is recognized that a repair or replacement design that uses a material not meeting these criteria must be submitted on a case by case basis to the regulatory authorities for approval, on a plant specific basis.”

2. The staff finds Section 5.6 to be generally acceptable; however, the staff requires licensees to determine the weldability of all materials to be welded since some fasteners may be made of generally unweldable materials or require very special conditions to weld them, such as AISI 4140, 4340 (B7) low alloy materials or 410 (B6) type stainless steel alloys. Alternatively BWRVIP could just eliminate all welding on fasteners in this document.

4.0 CONCLUSION

The NRC staff has reviewed the BWRVIP-56 report and found that the BWRVIP-56 report, as modified and clarified to incorporate the staff's comments above, is acceptable for providing guidance for permanent or temporary repair of cracked or leaking LPCI couplings. This finding, based upon the information submitted in the subject report is consistent with NRC approved methodology. Therefore, the staff has concluded that licensee implementation of the guidelines in BWRVIP-56, as modified, will provide an acceptable repair design criteria of the safety-related components addressed in the BWRVIP-56 document. The modifications addressed above should be incorporated in Revision 1 of the BWRVIP-56 report.

The BWRVIP-56 report is considered by the staff to be acceptable for licensee usage, as modified and approved by the staff, anytime during either the current operating term or during the extended license period. If it is determined during the course of implementing these repair guidelines that implementation cannot be achieved as described in the guideline or that meaningful results are not obtained, then the staff requests that the user notify BWRVIP with sufficient details to support development of alternative actions. These notifications, as well as planned actions by the BWRVIP, should be summarized and reported to the NRC. It should be noted that an Owner is responsible for reviewing regulatory requirements for the system. If the repair is an alternative repair to that specified in the regulations, i.e., 10 CFR 50.55a, the Owner may need to pursue the appropriate regulatory action.

5.0 REFERENCES

1. Carl Terry, BWRVIP, to USNRC, "BWR Vessel and Internals Project, LPCI Coupling Repair Design Criteria (BWRVIP-56)," EPRI Report TR-108717, dated November 16, 1998.

2. Carl Terry, BWRVIP, to USNRC, "BWRVIP Response to NRC Safety Evaluation on BWRVIP-16 and BWRVIP-19," December 6, 1999.