June 20, 2000

Mr. Carl Terry, BWRVIP Chairman
Niagara Mohawk Power Company
Post Office Box 63
Lycoming, NY 13093

SUBJECT: INITIAL SAFETY EVALUATION REPORT, “BWR VESSEL AND INTERNALS PROJECT, BWR JET PUMP ASSEMBLY INSPECTION AND FLAW EVALUATION GUIDELINES (BWRVIP-41),” (TAC NO. M99870)

Dear Mr. Terry:

The NRC staff has completed its review of the Electric Power Research Institute (EPRI) proprietary report TR-108728, "BWR Vessel and Internals Project, BWR Jet Pump Assembly Inspection and Flaw Evaluation Guidelines (BWRVIP-41)”. This report was submitted by letter dated October 15, 1997, and was supplemented by letter dated August 4, 1999, in response to a staff’s request for information dated February 12, 1999. This report provides generic guidelines intended to present the appropriate inspection recommendations to ensure the integrity and safety function of the subject safety-related jet pump assembly.

The staff has reviewed the BWRVIP-41 report and finds, in the enclosed safety evaluation (SE), that the guidance of the BWRVIP-41 report is acceptable for inspection and flaw evaluation of the subject safety-related RPV internal components, except where the staff’s conclusions differ from BWRVIP’s, as discussed in the enclosed SE. Licensee implementation of the guidelines in the BWRVIP-41 report, with modifications to address the staff’s conclusions in the enclosed SE, will provide an acceptable level of quality for inspection and flaw evaluation of the safety-related components addressed.

The staff requests that BWRVIP review and resolve the issues raised in the enclosed SE and incorporate the staff’s conclusions into the revised BWRVIP-41 report. Please inform the staff within 90 days of the date of this letter of your proposed actions and schedule for revisions.

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/

Jack R. Strosnider, Director
Division of Engineering
Office of Nuclear Reactor Regulation

Project No. 704

Enclosure: Initial Safety Evaluation Report

cc: See next page

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/

Jack R. Strosnider, Director
Division of Engineering
Office of Nuclear Reactor Regulation

Project No. 704

Enclosure: Initial Safety Evaluation Report

cc: See next page

ML 003725033
Template NRR 106

DISTRIBUTION:

EMCB R/F	GHolahan	WDLanning, R1	JSWermeil/RCaruso
File Center	MEMayfield	BSMallet, R2	KAKavanagh
ACRS	TYChang	JGrobe, R3	EImbro/KAManoly
	KRWichman	AHowell, R4	JRRajan

Document Name: G:\BWRVIP\BWRVIP41 LTR-ISER.WPD

INDICATE IN BOX: "C"=COPY W/O ATTACHMENT/ENCLOSURE, "E"=COPY W/ATT/ENCL, "N"=NO COPY

EMCB:LPM	E	EMCB:SLS	E			EMCB:BC	E
CECarpenter:cec		RAHermann				WHBateman:whb	
05/03/2000		05/07/2000				05/22/2000	
EMEB:BC	E	SRXB:BC	E	DE:DD	N	DE:D	N
Eimbro:kam f/		Jwermiel:rc f/		RHWessman:rhw		JRStrosnider:jrs	
06/13/2000		06/13/2000		05/26/2000		06/20/2000	

OFFICIAL RECORD COPY

U.S. NUCLEAR REGULATORY COMMISSION

OFFICE OF NUCLEAR REACTOR REGULATION

SAFETY EVALUATION OF EPRI TOPICAL REPORT TR-108728

BWR VESSEL AND INTERNALS PROJECT, BWR JET PUMP ASSEMBLY

INSPECTION AND FLAW EVALUATION GUIDELINES (BWRVIP-41)

1.0 INTRODUCTION

1.1 Background

By letter dated October 15, 1997, as supplemented by letter dated August 4, 1999, the Boiling Water Reactor Vessel and Internals Project (BWRVIP) submitted both the proprietary and non-proprietary versions of the Electric Power Research Institute (EPRI) Topical Report TR-108728, "BWR Vessel and Internals Project, BWR Jet Pump Assembly Inspection and Flaw Evaluation Guidelines (BWRVIP-41)" for staff review and approval. The staff requested additional information (RAI) in a letter dated February 12, 1999, which BWRVIP responded to in a letter dated August 4, 1999.

The BWRVIP-41 report contains generic guidelines to BWRVIP members on inspection and flaw evaluation of BWR jet pump assemblies. These guidelines considered degradation susceptibility and mechanisms, loads, and inspection strategies for jet pump assemblies. The intent of the report, when approved by the NRC, is to provide inspection and flaw evaluation guidance to BWRVIP members that can be used to assure adequate integrity of the BWR jet pump assemblies.

The BWRVIP-41 report allows for plant-specific analysis to be performed for a given weld location. These plant-specific analyses are not addressed in the scope of this report, and the NRC approval must be obtained on a case-by-case basis.

1.2 Purpose

The staff reviewed the BWRVIP-41 report to determine whether its guidance would provide an acceptable level of quality for inspection and flaw evaluation to provide assurance of the integrity of the jet pump assemblies.

1.2 Organization of the Report

Because the BWRVIP-41 report is proprietary, this safety evaluation (SE) was written to ensure that proprietary information was not compromised. The SE gives a brief summary of the general contents of the report in Section 2.0 and the detailed evaluation in Section 3.0 below. Because of proprietary information concerns, the SE does not discuss in any detail the provisions of the guidelines nor the parts of the guidelines that the staff finds acceptable.

2.0 SUMMARY OF BWRVIP-41 REPORT

The BWRVIP-41 report addresses the following topics in the following order:

- Jet Pump Assembly Analysis - The jet pump assemblies are described in detail by a series of illustrations and differences among the various models of BWRs (BWR/3 through BWR/6) are identified. The various types of jet pump assemblies susceptibility factors and material degradation mechanisms (e.g., intergranular stress corrosion cracking, IGSCC, which has factors that include environment, materials and stress state; fatigue by flow induced vibration and/or thermal cycling; and, thermal (aging) embrittlement) that could impact the jet pump assemblies are described in general terms. Potential failure locations are addressed from the standpoint of inspection priority, susceptibility to degradation, and consequences of failures in terms of component functions and plant safety.

- Inspection Strategy - The BWRVIP-41 report recommends the specific locations, NDE methods, and inspection frequencies for examinations of the jet pump assemblies. The report also describes the inspection basis and methods, the recommended baseline inspection scope, the reinspection frequency, scope expansion, and reporting of inspection results.

- Loads and Load Combinations - The various types of loads (e.g., pressure, seismic, etc.) of concern and the load combinations are listed and load combinations are described. Consideration for degraded assemblies are also detailed.

- Structural Evaluation Methodologies - This section presents methods which can be used to determine allowable flaw size determinations for different parts of the assemblies, set screw gap evaluation, and the ability of the riser brace to prevent jet pump disassembly.

The BWRVIP-41 report also contains an Appendix A on Demonstration of Compliance with the Technical Information Requirements of the License Renewal Rule, (10 CFR 54.21). Appendix A to the BWRVIP-41 report is not evaluated in this SE report, but will be evaluated under a separate license renewal review.

3.0 STAFF EVALUATION

3.1 System Considerations

Jet pump assemblies are classified as safety related components. The structural integrity of the jet pump assembly is relied upon for assuring the ability to reflood the core, up to two-thirds core height, following a design-basis accident (DBA) loss of coolant accident (LOCA) for BWR/3s through BWR/6s. Jet pump assemblies are not part of the BWR/2 plant design. An additional safety function of the jet pumps is to provide a flow path for low pressure coolant injection (LPCI) into the core. This safety function is applicable to all BWR/3s and BWR/4s except Hope Creek and Limerick Units 1 and 2. For these three plants and the BWR/5s and BWR/6s, LPCI injection occurs through the LPCI coupling which provides a flow path between the reactor vessel nozzle thermal sleeve and the core shroud.

The BWRVIP-41 report prioritized the different jet pump assembly weld locations as high, medium or low depending on the potential safety consequences from the failed location. The consequences of a failed location considered whether the failure would cause the jet pump to disassemble, the impact of the failure on maintaining 2/3 core height following a LOCA, and the impact of the failure on LPCI injection through the jet pump assembly. These factors were combined using a weighting system to prioritize the welds as high, medium or low. Tables 1 and 2 present the jet pump weld locations that were categorized as high and medium inspection priority, respectively. The adequacy of the inspection guidelines and frequency are discussed later in the evaluation.

Table 1: High Inspection Priority Welds

Weld Location	Description
BB-1 & BB-2	Jet Pump Hold-down Beam and Bolt
RS-1& RS-2	Riser Pipe Elbow (applicable to plants with LPCI injection through the jet pumps)
RS-3	Riser Pipe to Transition Piece
DF-2 & DF-3	Diffuser and Tailpipe (applicable to plants with LPCI injection through the jet pumps)
AD-1 & AD-2	Adaptor/Lower Ring (applicable to plants with LPCI injection through the jet pumps and plants with curved adaptors - Fermi Unit 2 and LaSalle Unit 1)
AD-3	Adaptor/Lower Ring (applicable to plants with LPCI injection through the jet pumps)

Table 2: Medium Inspection Priority Welds

Weld Location	Description
RB-1 & RB-2	Riser Brace
RB-3, RB-4, & RB-5	Riser Brace (Dresden 2 only)
TS-1 through TS-4	Nozzle Thermal Sleeve (applicable to plants with LPCI injection through jet pumps)
RS-1 & RS-2	Riser Pipe Elbow (applicable to plants without LPCI injection through jet pumps)
RS-4 through RS-11	Riser Pipe fillet welds
TR-1 through TR-5	Transition Piece
IN-1, IN-2, IN-4, & IN-5	Inlet (Elbow & Nozzle) (not applicable to BWR/3s and BWR/4s)
MX-1 through MX-4	Mixer (Throat) (applicable to plants with LPCI injection through jet pumps)
RK-1 through RK-5, WD-1& WD-2, & AS-1& AS-2	Restrainer Bracket Assembly (includes restrainer bracket, wedge, and adjusting set screws)

Table 2: Medium Inspection Priority Welds

Weld Location	Description
DF-1	Diffuser and Tailpipe (applicable to plants with LPCI injection through jet pumps)
DF-2 & DF-3	Diffuser and Tailpipe (applicable to plants without LPCI injection through jet pumps)
AD-3	Adaptor/Lower Ring (applicable to plants without LPCI injection through jet pumps)

The BWRVIP-41 report stated that the low inspection priority welds were given the same inspection requirements as the medium inspection priority welds. This could be re-evaluated in the future. Based on the safety consequences of the postulated failures, the staff finds the inspection prioritization of the potential failure locations acceptable.

The staff requested a description of the plant-specific analysis that could be done to alleviate or reduce the inspection requirements of the thermal sleeve welds, TS-1 through TS-4, the riser pipe welds, RS-1, RS-2, and RS-4 through RS-7, the diffuser and tailpipe welds, DF-1 through DF-3, and the adaptor/lower ring welds, AD-1 through AD-3a,b. With respect to the safety consequences, BWRVIP stated that a plant-specific analysis could be done to show that the failure location would not compromise the jet pump's ability to maintain the water level at 2/3 core height. A plant-specific analysis could also show that the failure does not allow the jet pump to disassemble. For other locations, the plant-specific analysis could focus on the redundancies of the core cooling system. Since some of these welds are classified as high priority inspection welds, the staff has concluded that the description of the plant-specific analyses of the safety consequences should be included in the appropriate sections of the BWRVIP-41 report.

The BWRVIP-41 report also provided guidance on evaluating the potential leakage from a crack in the jet pump assembly. The staff notes that any leakage from the jet pump into the reactor pressure vessel (RPV) annulus is potentially unavailable for core cooling during an event when LPCI operation in required. The BWRVIP-41 report recommended that the acceptability of the leakage be based on plant-specific analyses of the reduction in core flow for normal operations and the increase in peak clad temperature (PCT) for accident conditions for BWR/3 and BWR/4s. The evaluation of the quantity of leakage through the jet pump assemblies should be based on the system temperature, pressure and flow conditions that are consistent with the licensee's existing licensing basis LOCA analysis. The total leakage should also account for other leakage sources such as a cracked shroud, core spray piping flaws, repair modifications, etc. The staff has reviewed the guidance provided in the BWRVIP-41 report and finds it consistent with other existing guidance on the evaluation of potential leakage sources.

3.2 Inspection Guidelines

The inspection guidelines provided by the BWRVIP-41 report are comprehensive in dealing with the in-service inspection requirements of the jet pump assemblies. Differences in the design and operating experience for the various types of BWR reactors (BWR/2, BWR/3-5 and

BWR/6) are reviewed and taken into account as part of the inspection strategy. Implementation of the recommendations are intended to provide a basis for baseline inspections, re-inspections, and structural evaluations of the shroud support structure.

With the exception of the issue described below, as requested in Question 6 of the staff's February 12, 1999, RAI, and stated in BWRVIP's August 4, 1999, response, this review finds that the inspection guidance provided in the subject report to be acceptable:

1. If analysis cannot be provided to alleviate the weld inspections, what type of recommended inspections are being considered for the thermal sleeve welds? Will the inspections be performed over two inspection cycles with at least 50% of the inspections being performed in the first cycle?

BWRVIP Response:

> It is currently anticipated that, if the analyses are not successful, the inspections recommended for the thermal sleeve welds would have to be capable of detecting IGSCC: EVT-1 or UT exams. Since the thermal sleeve is identified as a Medium/Low Priority location, the inspections would be performed over two cycles with at least 50% inspected during the first cycle.
>
> At present, inspection techniques are not available to inspect the inaccessible thermal sleeve welds. These welds are in an extremely difficult position to reach with inspection equipment. The Inspection Committee is investigating the feasibility of developing inspection tooling to reach these welds. An engineering feasibility study will be completed by the BWRVIP. Inspection requirements will be recommended once a technique becomes available.

This issue is unresolved pending BWRVIP's submittal of the above inspection methodology for the thermal sleeve welds.

3.3 Loadings

The potential weld failure locations discussed in Section 2.3 of the BWRVIP-41 report are based on the potential failure locations for the jet pump assembly identified in BWRVIP-06. In assessing the consequences of failure of a particular location, consideration was given to whether a failure will cause jet pump disassembly. Consideration was also given to the impact that a failure would have on the ability to maintain 2/3-core coverage. In addition, the impact that a failure would have on the ability to inject LPCI flow through the jet pumps was considered. The above factors were combined using a weighting system which resulted in a prioritization of the various failure locations as High, Medium or Low. Not all plants rely on the jet pump for LPCI injection. Consequently, a given location may have a different prioritization depending on whether the plant utilizes the jet pumps for LPCI. The staff finds the method of prioritization reasonable and acceptable.

Twelve potential jet pump weld failure locations were divided into three classifications based on their failure consequences. The first classification of failures can result in immediate jet pump disassembly. Since this poses the most significant challenge to plant safety, this condition was given a high weighting. A second classification consisted of failures which in and of themselves, do not cause disassembly, but can result in significantly increased vibration loading and cause eventual fatigue failure of a location which may lead to disassembly. These were given a relatively-lower weighting. A third classification with the lowest weighting is given to those locations at which failure will not lead to jet pump disassembly and will not cause an increase in vibration loading. The resulting weighting was increased appropriately if the failure would affect the ability to maintain 2/3-core height or would impair the LPCI function.

The result of this evaluation technique was a ranking of the jet pump weld locations based on their potential impact on plant safety. The locations were divided into three priorities: high (H), medium (M), and low (L) priority. These priority rankings were used to determine the sequence in which the recommended baseline inspections are to be performed. The locations prioritized as low were given the same inspection requirements as those prioritized as medium even though the failure consequences of low priority locations are less severe; however, this may be re-evaluated at a future date. The recommended procedure is to perform the baseline inspections of the high priority locations during the first six years following the inception of the implementation of this guideline. At least 50% of the locations are to be inspected in the first refueling outage. The medium and low priority locations are to be inspected over the first two inspection cycles where at least 50% are to be inspected in the first inspection cycle, with subsequent re-inspections performed every six years. In both cases, scope expansion is addressed in this report for the case where one or more flaws are found during a baseline inspection or subsequent re-inspections. Based on its review, the staff finds the recommended inspection procedure, as discussed above, reasonable and acceptable

For each jet pump location, a discussion of its function, configurations, loading, (pertaining to crack initiation and/or crack growth during normal operation), susceptibility, failure consequences, inspection history, and inspection recommendation, with the appropriate technical basis, has been discussed. Since the weld failure locations are based on typical plant configurations, some locations shown may not be applicable to all plants. The licensees should verify their plant-specific configurations for applicability with respect to the component description, figures, and materials shown in the report.

Loading information on vulnerable sub-components such as the riser brace, jet pump hold-down beam and bolts, nozzle thermal sleeve, riser pipe, inlets and mixer have been provided to give a generic description of the types of loads such as thermal, hydraulic and vibration loads at specific locations of the sub-components. In addition, loadings which occur during specific accident scenarios have also been discussed. For example, during a postulated recirculation suction line LOCA, the diffusers nearest to the broken recirculation suction line would experience a large, but short-term, lateral load due to the presence of strong acoustic waves generated by the instantaneous pipe break. Despite the short duration of the loading, this lateral load can be quite large if an instantaneous full-area recirculation line break is postulated. In addition, steady-state blowdown loads will also induce lateral displacements. The partial failure of a sub-component in some cases can result in an increase in certain types of loading on the sub-component. Thus, for example, failure of the riser brace would cause a significant change in the response of the jet pump assembly to flow-induced vibration. It is possible that this change in vibration response could result in increased fatigue loading, and potential fatigue failure of other components in the assembly, such as the riser pipe or jet pump beam. Failure of these other components could result in jet pump disassembly.

Riser brace degradation or complete failure is not immediately detectable during normal operation. Therefore, cracking of the riser brace welds put the jet pump assembly in a vulnerable state. The loads generated by a postulated recirculation line LOCA can be large enough to severely damage a jet pump assembly with a significantly degraded riser brace, resulting in a potential safety concern. Similar consequences of failure have been discussed for each of the vulnerable sub-components listed earlier.

The staff reviewed the generic loading descriptions and failure consequences for each of the sub-components in Section 2.3 of the report. Based on its review, the staff finds these loading descriptions reasonable and acceptable.

The NRC sponsored a study of the synergistic failure of BWR internals at the Idaho National Engineering and Environment Laboratory (INEEL) to evaluate the effects, if any, of cascading failures on other components in the reactor. This program was conducted by the Office of Nuclear Reactor Research (RES), and the results of the program have been documented in draft NUREG/CR-XX, “Evaluation of Risk Associated with Intergranular Stress Corrosion Cracking in Boiling Water Reactor Internals,” dated December 1999. The consequences of failures discussed in the subject report are generally consistent with the failure scenarios identified in the INEEL preliminary findings. In the event that plant-specific flaw evaluations are required, loads and load combinations must be defined. Details of the various loading and the load combinations that need to be considered to determine the primary and secondary stress levels appropriate for various operating conditions, are discussed in Section 4.0 of the topical report. The applied loads on the jet pump assembly consist of deadweight, hydraulic loads, seismic inertia, seismic anchor displacements, safety relief valve opening, annulus pressurization, condensation oscillation, chugging, fluid drag, loads due to flow-induced vibration, and thermal anchor displacements.

3.4 Structural Evaluation Methodologies

The staff finds the methodology provided for determination of allowable flaw size for the riser, inlet-mixer and diffuser and the set screw evaluation method to be acceptable. Methodology is not provided for the jet pump beam, the riser brace or for an evaluation of the ability of the riser brace to prevent jet pump disassembly. Plant-specific analyses will be needed for evaluation of degradation that is identified for all of the jet pump components, and should be provided to the staff for evaluation.

4.0 CONCLUSION

The staff reviewed the BWRVIP-41 report and RAI response. The staff concluded that the BWRVIP-41 report has appropriately categorized the consequences of a failed location due to jet pump disassembly, the impact of the failure on maintaining the reactor core water level at 2/3 core height following a LOCA, and the impact of the failure on LPCI injection through the jet pump assembly. The staff finds this categorization to be acceptable. The staff has concluded that the description of the plant-specific analyses of the safety consequences to alleviate or reduce inspections of high priority welds should be included in the appropriate sections of the BWRVIP-41 report. The staff also concluded that the BWRVIP-41 report provides adequate guidance for evaluating the potential leakage from a crack in a jet pump assembly.

The inspection guidelines provided by the BWRVIP-41 report are acceptable for the jet pump components with the exception of the thermal sleeve welds, as stated above in Section 3.2. The thermal sleeve welds inspection guidelines are an open item.

The methodology provided for determination of allowable flaw size for the riser, inlet-mixer and diffuser and the set screw evaluation method is acceptable. However plant-specific evaluations will be required for any degraded jet pump components identified, and should be provided to the staff for evaluation.

The staff has reviewed the discussions in Section 4.0 of the report, including the various loading combinations during normal upset, emergency and faulted plant conditions. These loads and load combinations are consistent with those previously reviewed and approved by the staff in several safety evaluations related to previously-published BWR internal repair documents. The staff finds the loads and load combinations in the subject topical report consistent with NUREG-0800 requirements and are, therefore, acceptable.

5.0 REFERENCES

1. Terry, C., BWRVIP, to USNRC, “BWR Vessel and Internals Project: BWR Jet Pump Assembly Inspection and Flaw Evaluation Guidelines (BWRVIP-41),” EPRI TR-108728, October 15, 1997.

2. Carpenter, C.E., USNRC, to C. Terry, BWRVIP, “Proprietary Request for Additional Information - Review of “BWR Vessel and Internals Project, Jet Pump Assembly Inspection and Flaw Evaluation Guidelines (BWRVIP-41)” (TAC No. M99870),” February 12, 1999.

3. Wagoner, V., BWRVIP, to USNRC, “BWRVIP Response to NRC Request for Additional Information on BWRVIP-41 (Reference Project 704),” August 4, 1999.