EPRI

BWR Vessel and Internals Project Jet Pump Repair Design Criteria (BWRVIP-51NP)

REPORT SUMMARY

The Boiling Water Reactor Vessel and Internals Project (BWRVIP), formed in June, 1994, is an association of utilities focused exclusively on BWR vessel and internals issues. This BWRVIP report documents criteria which can be used to design a repair for the jet pumps in a BWR.

Background
In the event that significant degradation is observed in BWR jet pumps, repair to those commponents may be required. Utilities need criteria which can be used in the development of those repair designs.

Objectives
To compile the appropriate design criteria for jet pump repairs into a document which can be used by utility personnel performing the design and which could be submitted to appropriate regulatory agencies for approval of the generic design process.

Approach
The contractor assembled a draft document which discussed all elements which need to be considered in designing a jet pump repair. Items discussed include: design objectives; structural evaluation; system evaluation; materials, fabrication and installation considerations; and, required inspection and testing. The resulting draft was reviewed in depth by BWRVIP utility representatives as well as third party contractors. The final report incorporates comments received during those reviews.

Results
The document provides general design acceptance criteria for the repair of jet pumps. Repairs designed to meet these criteria will maintain the structural integrity of the component under normal operation as well as under postulated transient and design basis accident conditions.

EPRI Perspective
The criteria listed in the report define a standard set of considerations which are important in designing a jet pump repair. It is intended that these criteria will be submitted to the USNRC, and possibily non-US regulators, for their approval. Regulatory acceptance of these generic criteria will significantly reduce the utility effort required to obtain approval for plant-specific repairs.

PROJECT
WOB501
EPRI Project Manager: Warren Bilanin
Nuclear Power Group
Contractor: Sargent and Lundy

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TR-108718NP

Interest Categories
Piping, reactor, vessel and internals
Licensing and safety assessment

Key Words
Boiling water reactor
Repair
Stress corrosion cracking
Jet pump
Vessel and internals

BWR Vessel and Internals Project

Jet Pump Repair Design Criteria (BWRVIP-51NP)

TR-108718NP
Research Project B501

Final Report, February 2000

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BWRVIP Repair Committee

Prepared for

BOILING WATER REACTOR VESSEL & INTERNALS PROJECT and **EPRI**

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ORDERING INFORMATION

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ACKNOWLEDGMENTS

The members of the BWRVIP Jet Pump Repair Team, listed below, are gratefully acknowledged for their efforts which led to the successful completion of this document.

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JET PUMP REPAIR DESIGN CRITERIA

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JET PUMP REPAIR DESIGN CRITERIA
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Executive Summary

The Boiling Water Reactor Vessel and Internals Project (BWRVIP) was formed in June 1994 as a utility-directed initiative to address BWR vessel and internals issues. This criteria document was developed by the Repair Technical Subcommittee of the BWRVIP.

This document provides the general design acceptance criteria for permanent or temporary repair of jet pump assemblies. It is provided to assist BWR owners in designing repairs which maintain the structural integrity and system functionality of the jet pump assemblies during normal operation and under postulated transient and design basis accident conditions for the remaining plant life or other service life as specified by the plant owner.

Issuance of this document is not intended to imply that repair of jet pump assemblies is the only viable method for resolving cracking or excessive gaps in components. Due to variations in the material, fabrication, environment and as-found condition of individual components, and depending upon which component is degraded, repair is only one of several options that are available. The action to be taken for individual plants will be determined by the plant licensee.

1.0 INTRODUCTION

1.1 Background

Recently, the BWR Vessel and Internals Project (BWRVIP) prepared a safety assessment of BWR internals [1]. The evaluation of the jet pump assembly included consideration of the consequence of failure of several jet pump sub-assemblies. It was determined that inspection and evaluation procedures have a role in assuring the long term integrity of the jet pump safety functions. Subsequently, an inspection and flaw evaluation guideline [16]. for the jet pump assembly was prepared by the BWRVIP to provide a prioritized inspection strategy and guidance for evaluation of flaws.

In conjunction with inspection and flaw evaluation guidelines, a repair design criteria is outlined here for cases in which repair of jet pump components is warranted.

1.2 Purpose

The purpose of this document is to provide general design guidance and acceptance criteria for permanent and temporary repair ofjet pump assemblies. It is expected that individual licensees and vendors will adhere to these criteria in the application of plant-specific repairs.

The issuance of this document is not intended to imply that repair ofjet pump assemblies is the only viable approach to resolution of the cracking/degradation issue.

1.3 Scope

This document is applicable to General Electric BWR/3-6 plants (BWRD plants do not contain jet pumps). Table 1 shows the plant configurations that were specifically evaluated in preparing this Guideline. Configuration and material information included in the guideline is based on the best information available. Plants are advised to confirm the accuracy of this information when designing repairs. Plants not listed in Table 1 should obtain their configuration and material information elsewhere, but are not excluded from the scope of this Guideline.

Table 1: Plant Configurations Evaluated

Plant Type	Plant Names
BWR/3	Millstone, Pilgrim, Monticello, Quad Cities 1,2, Dresden 2,3, Santa Maria de Garoña
BWR/4	Vermont Yankee[1] Fermi 2, Hope Creek 1, Limerick 1,2, Susquehanna 1, ,2, Browns Ferry 1,2,3, Peach Bottom 2,3, Brunswick 1,2, Hatch 1,2, Cooper, Fitzpatrick, Duane Arnold
BWR/5	LaSalle 1,2, Laguna Verde 1,2, Nine Mile Point 2, WNP2
BWR/6	Perry 1, Grand Gulf 1, River Bend, Clinton 1, Cofrentes

(1) Vermont Yankee is a hybrid BWR/3 and BWR/4 design.

2.0 DEFINITIONS

Replacement	Replacement as used in the context of this document constitutes removal of components of the jet pump assembly that are subject to cracking and installation of new components in their place. The material and design shall be resistant to the cracking mechanisms that have been experienced in these components.
Repair	Repair as used in the context of this document is a broad term that applies to actions taken to design, analyze, fabricate and install hardware that restores the structural and functional integrity of the jet pump assembly. Repairs differ from replacement primarily in that the flaws are left in place. Weld overlay, without removal of the defect, as well as removal of flaws by a qualified machining process are also considered repairs in the context of this document. The repairs may be temporary, i.e. designed for a specified amount of time, e.g. months of operation, or permanent, i.e. designed for the remaining life of the plant.
Jet Pump Assembly	Figure 1 shows a typical jet pump assembly. Each jet pump assembly is composed of two jet pumps and a common riser assembly. The riser assembly is a pipe, internal to the RPV, which connects the recirculation pump discharge line to the jet pump pair. A riser brace attaches the riser pipe to the vessel wall to provide lateral support.
Safety Analysis Report	Safety Analysis Report (SAR) is used throughout this design criteria to refer to the current licensing document for the plant (e.g., FSAR, UFSAR, etc.).

3.0 JET PUMP ASSEMBLY CONFIGURATION AND SAFETY FUNCTION

3.1 Generic Physical Description

The jet pumps are located in the annulus region between the core shroud and the vessel wall and provide core flow to control reactor power. Between 6 and 12 pairs of jet pumps are found in the BWR/3 through BWR/6 plants; depending on plant rating. BWR/2 plants do not contain jet pumps. During normal operation, each pair of jet pumps is driven by flow from a common riser pipe. The jet pump drive flow is pumped through the recirculation system through the riser and into each jet pump. Additional fluid from the annulus regino is entrained into the jet pump flow which is then directed to the lower plenum region.

Figure 1 shows a typical jet pump assembly. Figures 2 to 12 show typical component details. Each jet pump assembly is composed of two jet pumps and a common riser assembly. The riser assembly is a pipe, internal to the RPV, which connects the recirculation pump discharge line to the jet pump pair. A riser brace attaches the riser pipe to the vessel wall to provide lateral support.

Each jet pump consists of an inlet-mixer assembly and a diffuser assembly. The inlet-mixer assembly consists of a 180" elbow, a nozzle section with suction inlets, and a mixing section. The inlet-mixer assembly is clamped to the riser transition piece by the beam-bolt assembly, and fits into a slip joint at the top of the diffuser assembly. A restrainer bracket attached to the riser provides lateral support for each mixer section to increase the stiffness of the assembly and reduce the effects of vibration. The diffuser assembly consists of a conical section terminating in a straight cylindrical section at the lower end which is welded to the shroud support plate. Instrumentation monitors jet pump flow through the diffiser to ascertain individual and collective jet pump flow rates under operating conditions.

3.2 Safety Design Bases

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3.3 Event Analvses

As previously stated, the purpose of this document is to provide general design criteria for repairs of degraded jet pump assembly components. Accordingly, various events and operational conditions must be considered to ensure that the repair does not inhibit the ability of the jet pump assembly to perform the basic safety and operational functions. The following general load cases shall be considered in design of the proposed repair.

3.3.1 Normal Operation

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3.3.2 Anticipated Operational Occurrences (Upset Conditions)

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3.3.3 Desiqn Basis Accidents (EmerQencv/Faulted Conditions)

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3.3.4 Loadinq Combinations

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4.0 SCOPE OF REPAIRS

4.1 This criteria applies to all of the jet pump assembly components except the flow sensing lines, the holddown beam and bolt assemblies, and the riser brace weld to the RPV. The holddown beam and bolt assemblies are readily replaceable and should be replaced rather than repaired if flaws are detected.

4.2 This criteria is not applicable to "like for like" replacement of components. Removal from the vessel to facilitate repairs of components would, however, be within the scope of this criteria.

4.3 The jet pump assembly repairs may address cracking in IGSCC susceptible components by a number of options. Local repairs such as weld overlays or mechanical devices which leave the flaws in place but structurally replace the flawed area may be used, or the flaw may be removed by a qualified machining process if it is not through-wall, with subsequent weld repair if required. Repairs include the hardware necessary to connect the new components to the existing assembly.

4.4 When either the vessel nozzle safe end or a weld attaching the nozzle thermal sleeve to the nozzle safe end is involved in the repair (the riser brace weld to the RPV is not in the scope of this criteria), ASME Class 1 requirements shall be invoked for the repair design within the ASME Section III and reactor pressure vessel jurisdiction.

4.5 Use of part circumferential weld overlays for repair of circumferential components shall follow the guidelines of Reference 17, previously developed for repair of RF'V internal core spray piping. This repair procedure may be applied to any circumferential weld in the jet pump assembly except welds to the RFW or nozzle safe end. The weld overlays may be made to the ID or OD of the component in wet or dry conditions provided the guidelines of Reference 17 are followed.

4.6 Repairs to reduce gaps at the interface of the restrainer bracket and inlet mixer such as auxiliary restrainer bracket wedges are within the scope of this repair criteria. See Section 7.12 for further guidelines.

4.7 For repairs where the structural integrity of a flawed section is restored to its original level, the supporting structural evaluation can be limited to a comparison between the original and repaired structural parameters such as cross-sectional area, moment of inertia and section modulus, provided the root cause of the degradation is not the result of inadequacy in the original structural design. For this type of repair, e.g. a sleeve-type mechanical repair or a weld repair, a detailed evaluation of loads and stresses would not be required.

5.0 DESIGN OBJECTIVES

5.1 Desim Life

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5.2 Safetv Desim Bases

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5.3 Safetv Analysis Events

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Service Level B (Upset Conditions):

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Service Level C (Emergency Conditions):

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Service Level D (Faulted Conditions):

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11.0 QUALITY ASSURANCE PROGRAM

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12.0 DESIGN BASIS DOCUMENTATION

The following documentation shall be prepared and forwarded to the plant owner and maintained as permanent records:

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13.0 REFERENCES

1. BWR Vessel and Internals Project, Safety Assessment of BWR Reactor Internals (BWRVIP-06), EPRI Report TR-105707, October 1995.

2. ASME Boiler and Pressure Vessel Code Section II, 1989 Edition

3. ASME Boiler and Pressure Vessel Code Section III, 1989 Edition

4. ASME Boiler and Pressure Vessel Code Section V, 1989 Edition

5. ASME Boiler and Pressure Vessel Code Section XI, 1989 Edition

6. Regulatory Guide 1.85, Materials Code Case Acceptability - ASME Section III, Division I

7. 10 CFR 50.55a, Codes and Standards

8. Regulatory Guide 1.44, Control of the Use of Sensitized Stainless Steel

9. EPRI Document NP-7032, Material Specification for Alloy X-750 for Use in LWR Internal Components, Revision 1

10. ASTM A-262, Detecting Susceptibility to Intergranular Attack in Stainless Steel

11. Regulatory Guide 1.3 1, Control of Ferrite Content in Stainless Steel Weld Metal

12. EPRI Document 84-MG-18, Nuclear Grade Stainless Steel Procurement, Manufacturing and Fabrication Guidelines

13. ASME Code Case N-516, Underwater Welding, Section XI, Division 1, approved August 9, 1993

14. ASME Code Case N-516-1, Underwater Welding, Section XI, Division 1, approved December 3 1, 1996

15. 10 CFR 50, Appendix B

16. EPRI Document, "BWR Jet Pump Assembly Inspection and Flaw Evaluation Guidelines" BWRVIP-4 1, October 1997

17. EPRI Document TR-108 198, "Technical Basis for Part Circumference Weld Overlay Repair of Vessel Internal Core Spray Piping", BWRVIP-34, May 1997

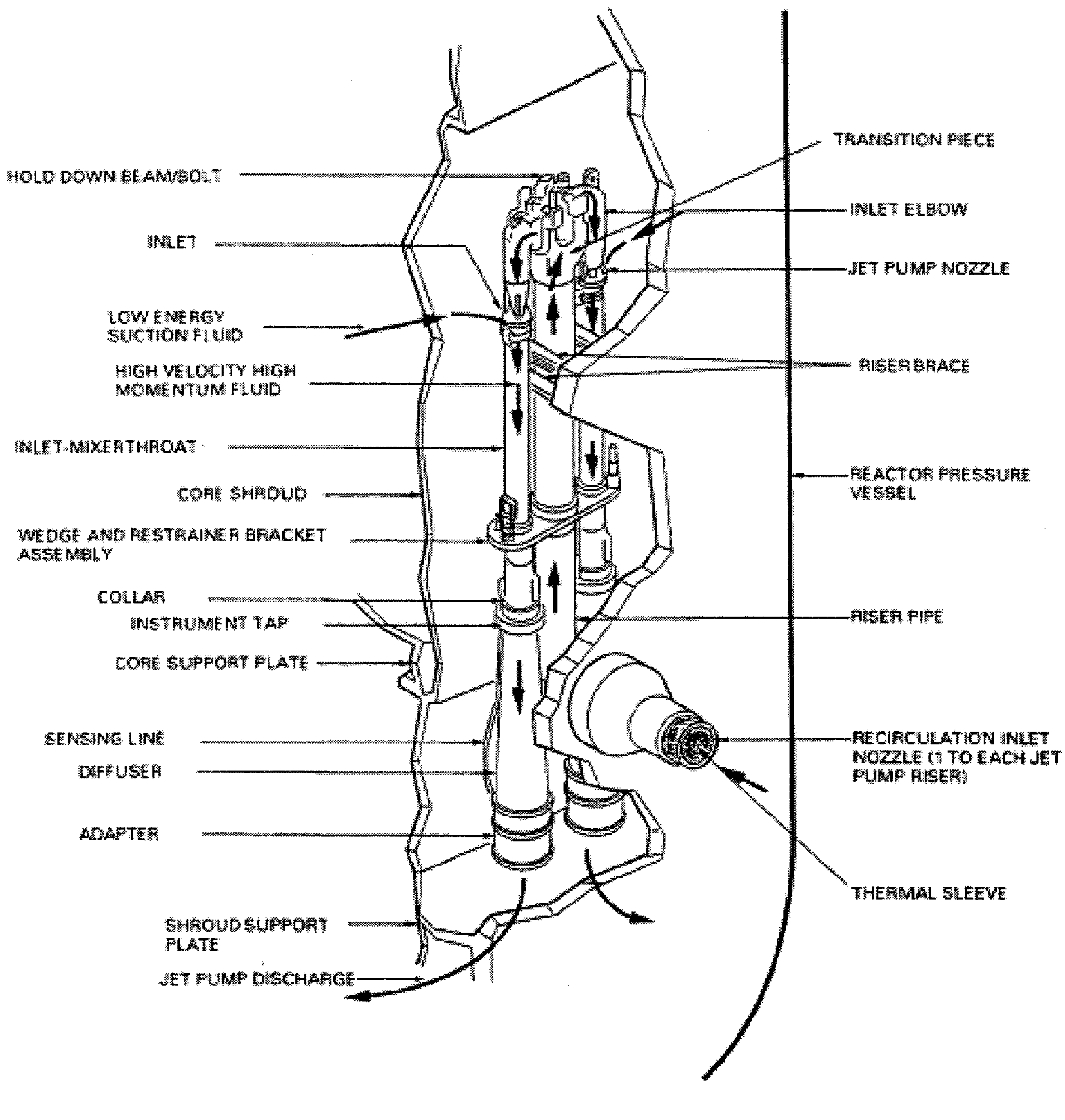

Figure 1: Typical Jet Pump Assembly

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Figure 2A: Typical Primary Single-Leaf Riser Brace

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Figure 2B: Typical Primary Double-Leaf Riser Brace

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Figure 3B: BWR/4-6 Beam-Bolt Assembly and Beam Top View

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Figure 7B: Inlet with Five-Hole Hozzle

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Figure 9C: Solid Ring Restrainer Bracket Design Typical of Most BWR/4-6s

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Figure 11D: Typical BWR/5 Diffuser Assembly

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Figure 11E: Typical BWR/6 Diffuser Assembly

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Figure 12B: Curved Adapter Assembly

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Figure 12C: Straight Adapter Assembly with Overlap

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Figure 12D: Lower Ring Connection to Shroud Support Plate
Typical of Most BWR/5s and 6s

Target:
Nuclear Power

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TR-108718NP

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