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BWR Vessel and Internals Project

Assessment of BWR Jet Pump Riser Elbow to Thermal Sleeve Weld Cracking (BWRVIP-28)

Prepared by
GE Nuclear Energy

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BWR Vessel and Internals Project

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TR-107667
Research Project B301

Final Report, December,1996

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1. INTRODUCTION

During a recent refueling and maintenance outage of a BWR plant cracks were detected in two jet pump riser pipe elbows located inside of the reactor pressure vessel. The cracks are on the elbow side of the field fabricated circumferential weld joining the riser elbow to the recirculation inlet thermal sleeve. The root cause has not yet been established as the evaluation is still in progress; however, the indications are characteristic of intergranular stress corrosion cracking (IGSCC) in that they show evidence of branching. This represents the first time that indications have been observed in jet pump riser pipe circumferential welds.

The purpose of this report is to document the safety assessment of the implications of the observed cracking and to develop operating recommendations for owners of GE BWRs with jet pumps. The specific analysis contained in this report was performed for the plant in which the cracking was found, referred to as the reference plant; however, the generic applicability of the safety assessment to other BWRs is discussed as well.

2. BACKGROUND

2.1. Configuration

Jet pumps are used as part of the reactor coolant recirculation system in BWR/3-6 plants. They are installed in the annulus between the core shroud and the reactor pressure vessel (RPV), and each vessel contains between 12 and 24 jet pumps. Most BWRs have 20 jet pumps. There are several BWR jet pump designs; however, the basic jet pump configuration is the same for all plants. The jet pump geometry is shown in Figure 1.

Each jet pump assembly consists of a riser assembly, two inlet-mixer assemblies, two diffuser assemblies, and a riser brace. The riser assembly elbow is a 10 inch, 90 degree short radius elbow, fabricated from Type 304 stainless steel. It is welded to the recirculation inlet nozzle thermal sleeve. The riser assembly is supported near the top by the riser brace, which is welded to the riser pipe and to pads on the RPV wall (some plants have two riser braces for each riser). Lateral support is also provided by the jet pump restrainer brackets which attach the adjacent jet pump inlet mixers to the riser. The entrance end of each inlet-mixer assembly is clamped to the top of the riser transition piece by the beam-bolt assembly. The exit end of the inlet-mixer forms a slip joint with the entrance end of the diffuser. This interface between the inlet mixers and the diffusers provides some additional lateral support to the riser. The top of the slip joint is located near the bottom of the fuel; the exact elevation of the slip joint is plant specific. All components of the riser pipes at the reference plant were manufactured by GE and assembled at the site during original plant construction using GE approved procedures.

The jet pump assemblies are non-ASME Code components. They are classified as Safety Related, as the structural integrity of the jet pump assembly is important for assuring core refloodability following a postulated recirculation line break Loss of Coolant Accident (LOCA).

2.2. Inspection Considerations

Through the service life of jet pump assemblies, degradation of jet pump components has occurred which warranted industry notification and recommendations by GE Nuclear Energy (GENE). Although there are no specific requirements to perform inservice inspection of the jet pump riser piping circumferential welds, there are several GENE documents (References 2 through 12) which recommend inspections to verify the integrity of various jet pump assembly components. Jet pump assembly integrity is monitored frequently in accordance with the BWR Owner's inservice inspection programs.

The inspection efforts at plants have continually addressed many internal components. These include the jet pump rams head, the inlet mixers, the jet pump set screws, jet pump riser brace, and the jet pump sensing lines. The in-vessel visual inspection (IVVI) efforts

also include inspection of other areas of the jet pump diffusers and can at times include limited areas of the jet pump riser piping. These inspections vary with different utilities and with each outage. However, the visual inspection of internal components in the annulus region at different elevations provides assurance that significant cracking in the riser piping is unlikely.

Requirements and recommendations for inspection of jet pump assemblies are documented in several industry publications which are listed in the reference section. The examinations recommended in these reference documents are summarized below:

- Periodic volumetric examination of jet pump beams to verify structural integrity of the beam bolt and radius areas.
- Periodic visual examination of jet pump assemblies to verify overall condition and structural integrity.
- Periodic visual examination of jet pump sensing lines and support brackets for integrity of bracket welds.
- Periodic visual examination of the throat area of the jet pump mixers to detect the presence of crud deposits which could inhibit flow.
- Periodic visual examination of jet pump riser brace arm welds (both the reactor vessel and riser pipe connections).
- Periodic visual examination of jet pump gap adjusting screws and the adjusting screw tack welds.

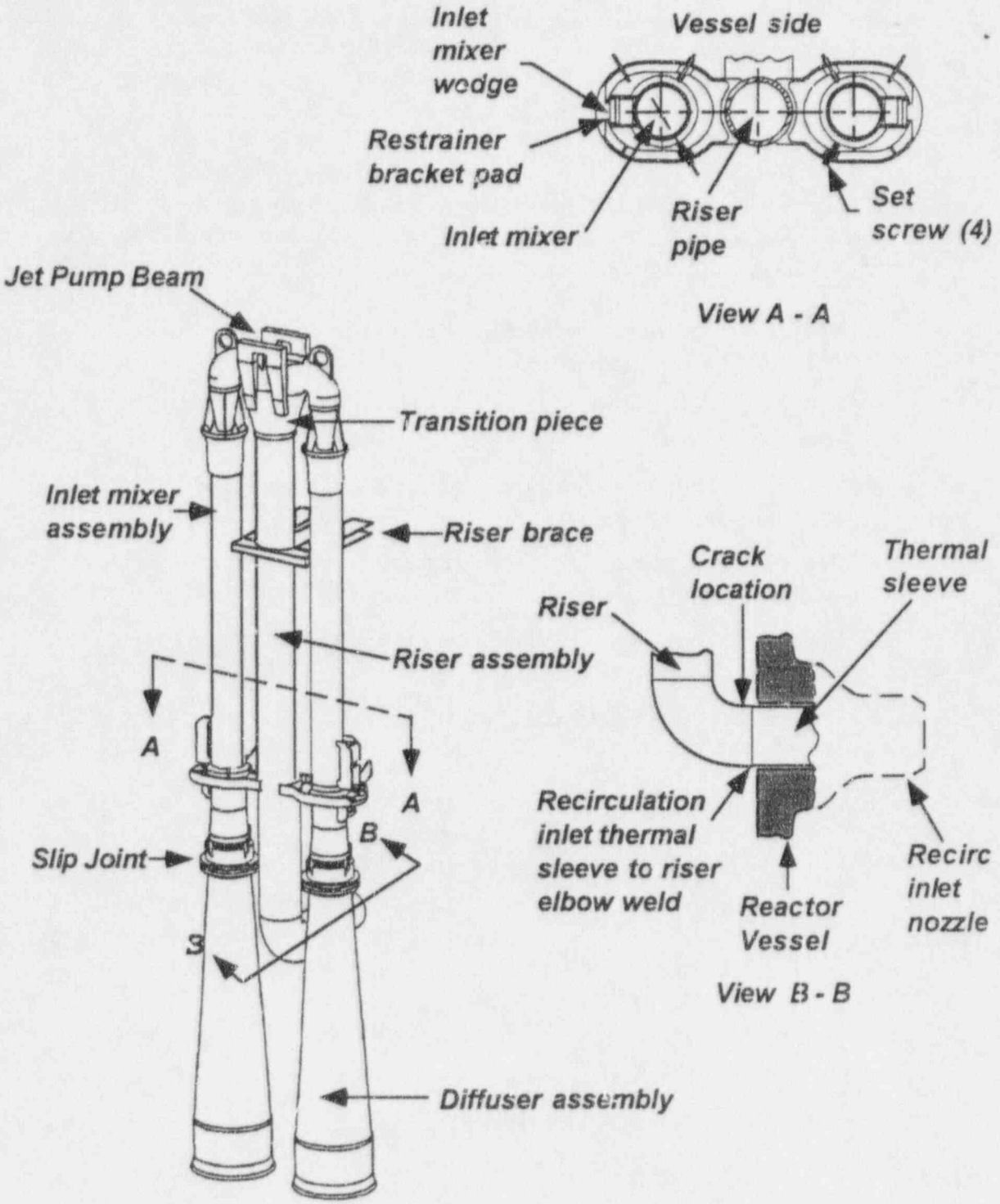

Figure 1. Jet Pump Configuration

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8. RECOMMENDATIONS

Specific recommendations are as follows:

- The jet pump M ratio should be added to the jet pump surveillance program. Deviation of more than 10% in the jet pump M ratio from its characteristic value can be an indication of jet pump riser degradation.
- If it is determined that performance of a jet pump is significantly degraded, the reactor should be brought to a safe shutdown condition.
- Prior IVVI videotapes from the jet pump region should be reviewed to establish, to the degree possible, the current condition of the riser welds.
- Consideration should be given to inspection of the riser welds at the next normal refueling outage, factoring in plant age, operating history, water chemistry, etc.

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