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BWR Vessel and Internals Project Internal Core Spray Piping and Sparger Repair Design Criteria (BWRVIP-19NP)

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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 cracks which have been known to occur in BWR core spray piping.

Background
A number of BWR plants have experienced stress corrosion cracking in the core spray piping which is located internal to the reactor pressure vessel. A variety of mechanical and welded techniques have been proposed to repair the cracks. Since a large number of concerns need to be addressed in designing such a repair, it is useful to have these criteria set down in a comprehensive document.

Objective
To compile a core spray piping and sparger repair design criteria that can be used to perform repair design and that can be submitted to the appropriate regulatory agencies for approval of a generic design process.

Approach
The project team assembled a draft document that discussed all elements which need to be considered in designing a repair to the core spray piping or spargers. These items include: design objectives; structural evaluation; system evaluation, materials, fabrication and installation considerations; and, required inspection and testing. The draft was then reviewed in depth by BWRVIP utility representatives as well as third party contractors. The final report incorporates comments received during that review.

Results
The document provides general design acceptance criteria for the temporary or permanent repair of core spray piping and spargers. Repairs designed to meet these criteria will maintain the structural integrity of the core spray system 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 core spray piping repair. It is intended that these criteria will be submitted to the USNRC and, possibly, 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.

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Internal Core Spray Piping and Sparger Repair Design Criteria (BWRVIP-19NP)

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ABSTRACT

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 temporary and permanent repair of internal core spray piping and spargers. It is provided to assist BWR owners in designing repairs which maintain the structural integrity of the internal core spray piping and spargers 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 internal core spray piping and spargers is the only viable method for resolving cracking in internal core spray piping and spargers. Due to variation in the material, fabrication, environment and as-found condition of individual internal core spray piping and spargers, 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.

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1. INTRODUCTION

1.1 Background

Core spray line/sparger cracking was first detected in 1978 during routine in-vessel visual inspections. As the cracking was found to be more widespread in subsequent years, and recognizing the nature of stress corrosion cracking, the NRC issued IE Bulletin 80-13, requiring that visual inspections be done of a better quality than those required by the ASME Code. Plants have been performing inspections to the IE Bulletin 80-13 requirements for many years, and have continued to find and address core spray line/sparger cracking.

Recently, the BWRVIP prepared a safety assessment of BWR internals as a follow-on to the activities completed on shroud cracking. In the evaluation of internal core spray piping and spargers and the consequences of internal core spray pipe cracking, it was clear that inspection is an important part of assessing internal core spray piping integrity, and thus the ability to achieve safe shutdown for worst case scenarios. As a result, the BWRVIP made development of the core spray inspection and evaluation guidelines a high priority for 1996.

In parallel, field cracking at creviced locations was found by visual inspection of the outside surfaces of internal core spray piping in the shroud annulus. Supplemental ultrasonic inspection showed that actual cracking could be considerably more severe than was shown by the outside visual indications. This field experience raised the priority of BWRVIP internal core spray piping and spargers assessment and repair activities culminating in the requirements set forth in this document.

1.2 Purpose

The purpose of this document is to provide general design acceptance criteria for permanent and temporary repair of 300 series stainless steel (SS) internal core spray piping and spargers.

The issuance of this document is not intended to imply that a repair of 300 series SS internal core spray piping and spargers is the only viable approach to resolution of the cracking issue for BWR internal core spray piping.

1.3 Scope

This document is applicable to General Electric BWR/2, BWR3-5, and BWR/6 plants which plan to implement repairs of the 300 series SS internal core spray

piping and spargers (including their supports) that are subject to cracking. Other RPV internals repairs are not within the scope of this document.

2. DEFINITIONS

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 all or a portion of the internal core spray piping and spargers. Weld overlay, without removal of the defect, is also considered a repair in the context of this criteria.
Internal Core Spray Piping	Internal Core Spray Piping is defined to include all of the core spray piping internal to the reactor vessel including: the core spray nozzle thermal sleeve (but not including the nozzle safe end), the piping which runs from the thermal sleeve to the shroud (including the connection to the core shroud) sometimes referred to as the core spray line (CSL).
Core Spray Sparger	For the purpose of this criteria, the core spray spargers are taken to be either the upper or lower core spray spargers which are entirely within the core shroud. The upper and lower sparger consists of two sparger halves which extend approximately 180 degrees around the inside of the shroud.

The original manufacturing drawing nomenclature (titles) differs from the above definitions in that the Sparger, as shown on the sparger or shroud drawing, extends through the shroud, includes an upward directed elbow, a short vertical spool section and female coupling which are located in the annulus. The decision to use the shroud wall as the dividing line between Internal Core Spray Piping and Core Spray Sparger was made to simplify the definition of repair criteria.

3. INTERNAL CORE SPRAY PIPING AND SPARGER CHARACTERISTICS AND SAFETY FUNCTION

3.1 Generic Physical Description

The internal core spray piping and sparger assemblies are constructed of austenitic stainless steel. The internal core spray piping provides the flow path for core cooling water from the vessel nozzle, through the shroud (BWR 2-5) or top guide (BWR 6) to the core spray spargers that provide distribution of core spray flow over the core to assure long-term cooling when the core cannot be reflooded. The assembly consists of junction or T-box connections that route flow to different piping runs, welded joints needed to construct the individual piping segments in the assembly and spray nozzles in the spargers that provide the spray distribution over the core. Internal brackets are used to support internal core spray piping and spargers at different locations along the piping runs. Figures 3-1 through 3-3 show the overall configuration of the internal core spray piping assembly for each of the main categories of plants: BWR 2, BWR 3-5 and BWR 6. Figures 3-4 and 3-5 show a typical core spray sparger configuration.

3.2 Safety Design Bases

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3.3 Event Analyses

As previously stated, the purpose of this document is to provide general design criteria for repairs for 300 series SS internal core spray piping and spargers susceptible to cracking. Accordingly, various events and operational conditions must be considered to ensure that the repair does not inhibit the ability of the internal core spray piping and core spray spargers to perform their basic safety 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 Design Basis Accidents (Emergency/Faulted Conditions)

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3.3.4 Loading Combinations

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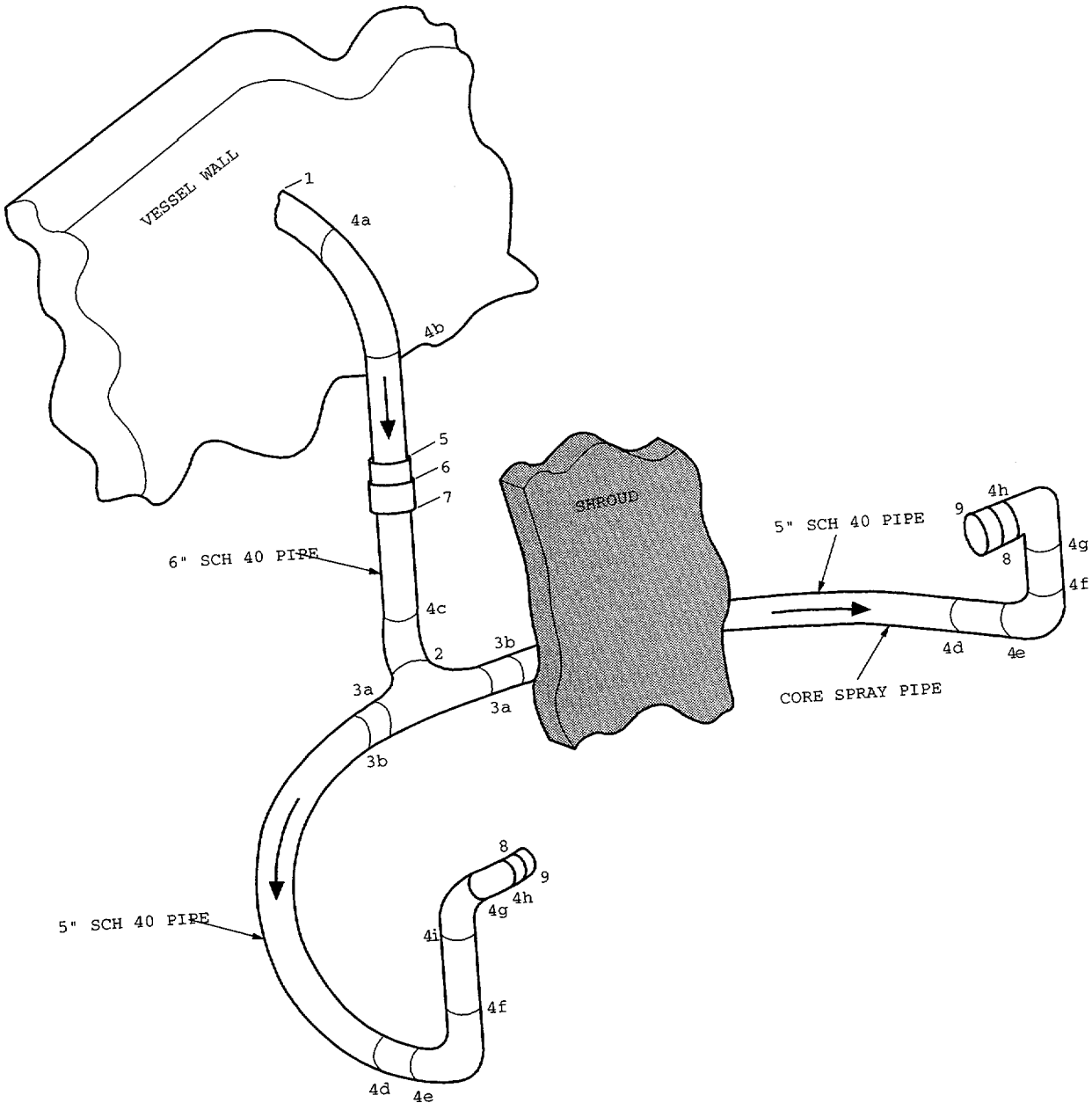

Figure 3-1 BWR 2 Core Spray Piping Configuration

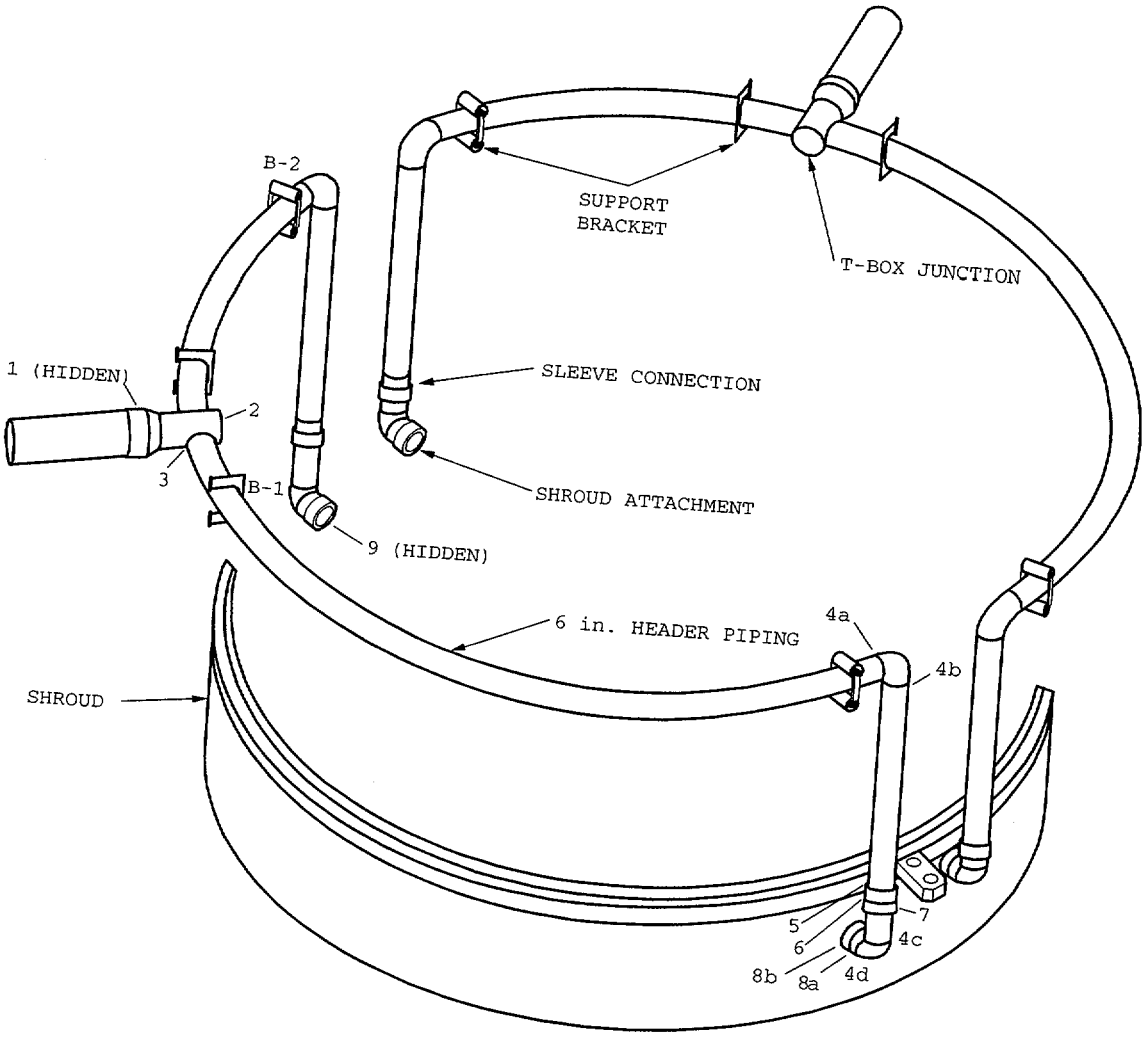

Figure 3-2 Typical BWR 3 - 5 Core Spray Piping Configuration

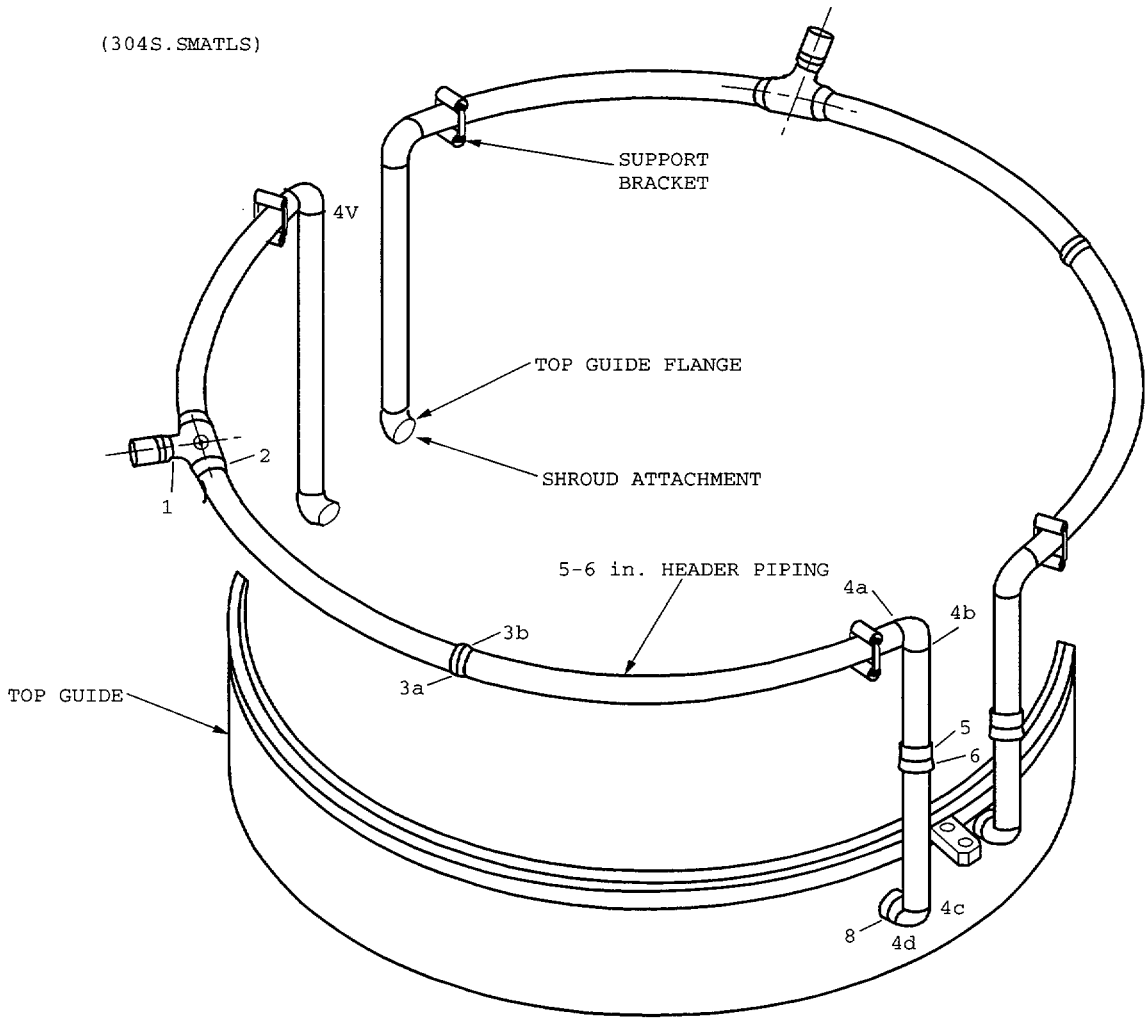

Figure 3-3 Typical BWR 6 Core Spray Piping Configuration

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Figure 3-4 Elevation View of Typical BWR Showing Core Spray Spargers and BWR3/4/5 Coupling

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Figure 3-5 Plan View of Typical Core Spray Spargers

4. SCOPE OF REPAIR

The internal core spray piping and sparger repair will address cracking in IGSCC susceptible stainless steel internal core spray piping and spargers by local repair(s) which leave the flaw(s) in place. Repair of internal piping supports (on the vessel wall or the shroud) is also included with the repair of internal core spray piping and spargers.

When the vessel nozzle safe end, a weld attaching the nozzle thermal sleeve to the nozzle safe end or a support attachment weld to the reactor pressure vessel is involved in the repair of internal core spray piping, ASME Class 1 Vessel requirements must be invoked for the portion within the ASME Section III vessel jurisdiction.

5. DESIGN OBJECTIVES

5.1 Repair Design Life

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5.2 Safety Design Bases

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5.3 Safety Analysis Events

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5.4 Structural Integrity

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5.5 Retained Flaw(s)

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5.6 Loose Parts Considerations

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5.7 Physical Interfaces with Other Reactor Internals

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5.8 Installation

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7.1 Significant Loads

7.1.1 Significant Loads - Internal Core Spray Piping and Supports

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Dead Weight (DW) **Content Deleted -**
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Seismic Inertia

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Seismic Anchor Displacement

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Fluid Drag

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Core Spray Injection Loading (CSIN)

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Pressure/Thermal Loads and Anchor Displacements:

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7.1.2 Significant Loads - Core Spray Spargers and Supports

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7.2 Load Combinations

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7.2.1 Load Combinations - Internal Core Spray Piping and Supports

The following are a suggested set of load combinations that may be used for the Normal/Upset conditions:

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7.2.2 Load Combinations - Core Spray Spargers and Supports

The following are a suggested set of load combinations that may be used for the Normal/Upset condition:

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7.3 Allowable Stresses

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7.4 Consideration of Shroud Repair or Cracking

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7.5 Flow Induced Vibration

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7.6 Repair Impact on Existing Internal Components

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7.7 Radiation Effects on Repair Design

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7.8 Analysis Codes

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7.9 Thermal Cycles

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7.10 Corrosion Allowance

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8.1 Leakage

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8.1.1 Leakage Impact - Normal Operation

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8.1.2 Leakage Impact - Accident Conditions

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8.1.3 Leakage Acceptance Criteria - Internal Core Spray Piping

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8.1.4 Leakage Acceptance Criteria - Core Spray Spargers

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8.2 Internal Core Spray Piping Pressure Drop

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8.3 Impact to Flow Distribution

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8.4 Emergency Operating Procedure (EOP) Calculations

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8.5 Power Uprate

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8.6 Internal Core Spray Piping High Point Vent

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8.7 Sparger Spray Distribution

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9. MATERIALS, FABRICATION AND INSTALLATION

9.1 Materials

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9.2 Crevices

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9.3 Welding and Fabrication

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9.4 Pre-Installation As-Built Inspection

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9.5 Installation Cleanliness

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9.6 ALARA

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9.7 Qualification of Critical Design Parameters

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10.1 Inspection Access

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10.2 Pre and Post Installation Inspection

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The following documentation shall be prepared and maintained as permanent records:

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