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BWRVIP BWR Vessel & Internals Project 2000-147

PROJ704

May 19, 2000

Document Control Desk
U. S. Nuclear Regulatory Commission
11555 Rockville Pike
Rockville, MD 20852

Attention: C. E. Carpenter

Subject: Project 704 - Transmittal of "BWR Vessel and Internals Project, Shroud Support and Vessel Bracket Repair Design Criteria (BWRVIP-52NP)," EPRI Report TR-108720NP, May 2000.

Reference: Letter from C. Terry to C. E. Carpenter, June 26, 1998: Transmittal of "BWR Vessel and Internals Project, Shroud Support and Vessel Bracket Repair Design Criteria (BWRVIP-52)," EPRI Report TR-108720, June 1998.

Enclosed are two (2) copies of the subject report "BWR Vessel and Internals Project, Shroud Support and Vessel Bracket Repair Design Criteria (BWRVIP-52NP)," EPRI Report TR-108720NP, May 2000. This is the non-proprietary version of the document submitted to the NRC by the letter referenced above.

If you have any questions on this subject please call Steve Lewis of Entergy, BWRVIP Assessment Committee Chairman, at (601) 368-5444.

Sincerely,

Carl Terry
Niagara Mohawk Power Company
Chairman, BWR Vessel and Internals Project

Enclosure

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BWR Vessel and Internals Project Shroud Support and Vessel Bracket Repair Design Criteria (BWRVIP-52NP)

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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 the shroud support structure or the vessel attachment brackets in a BWR.

Background
In the event that significant degradation is observed in BWR shroud supports or vessel brackets, repair to those components may be required. Utilities need criteria which can be used in the development of designs for those repairs.

Objective
To compile the appropriate repair design criteria 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 repair. Items discussed include: design objectives; structural evaluation; system evaluation; materials, fabrication and installation consideration; 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 shroud supports and vessel brackets. 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 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.

PROJECT
WOB501
EPRI Project Manager: Warren Bilanin
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Contractor: Structural Integrity Associates, Inc.

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TR-108720NP

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

Key Words
Boiling water reactor
Repair
Stress corrosion cracking
Vessel and internals
Shroud support
Vessel brackets

BWR Vessel and Internals Project

Shroud Support and Vessel Bracket Repair Design Criteria (BWRVIP-52NP)

TR-108720NP
Research Project B501
Final Report, May 2000

Prepared by:

Structural Integrity Associates, Inc.

BWRVIP Repair Committee

Prepared for

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

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Organization(s) that prepared this report:

Structural Integrity Associates, Inc.

BWRVIP Repair Committee

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Requests for copies of this report should be directed to the BWRVIP Program Manager, 3412 Hillview Ave., Palo Alto, Ca. 94304, (650) 855-2340.

ACKNOWLEDGMENTS

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

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Table of Contents

Page

1.0 INTRODUCTION: 1-1
- 1.1 Background 1-1
- 1.2 Purpose 1-1
- 1.3 Scope 1-1

2.0 DEFINITIONS 2-1

3.0 CONFIGURATION AND SAFETY FUNCTION 3-1
- 3.1 Shroud Support Structure Configuration 3-1
  - 3.1.1 Conical Shroud Support Plate (BWR/2) 3-1
  - 3.1.2 Thick Shroud Support Plate (Hatch Unit 2) 3-2
  - 3.1.3 Shroud Support Plate with Legs 3-2
  - 3.1.4 Shroud Support Plate with Gussets 3-2
- 3.2 Vessel Internal Attachments Configuration 3-3
- 3.3 Safety Design Bases 3-4
  - 3.3.1 Shroud Support Structure 3-4
  - 3.3.2 Vessel Internal Attachments 3-4

4.0 SCOPE OF REPAIRS 4-1
- 4.1 Mechanical Repairs 4-1
- 4.2 Welded Repairs 4-1
- 4.3 Flaw Removal Only 4-1

5.0 DESIGN OBJECTIVES 5-1
- 5.1 Design Life 5-1
- 5.2 Safety Design Bases 5-1
- 5.3 Safety Analysis Events 5-1
- 5.4 Structural Integrity 5-1
- 5.5 Retained Flaw(s) 5-1
- 5.6 Loose Parts Considerations 5-1
- 5.7 Physical Interfaces with Other Reactor Internals 5-2
- 5.8 Installation 5-2
- 5.9 Shroud Support Structure Leakage 5-2
- 5.10 Design Verification 5-3

6.0 GENERAL DESIGN CRITERIA 6-1
- 6.1 RPV Pressure Boundary 6-1
- 6.2 Shroud Support Structure 6-1

Table of Contents (continued)

Page

7.0 STRUCTURAL AND DESIGN EVALUATION 7-1
7.1 Applied Loads 7-1
7.1.1 Applicability of Hydrodynamic Loads 7-1
7.1.2 Deadweight (DW) 7-1
7.1.3 Hydraulic Loads (F) 7-1
7.1.4 Differential Pressure (DP) 7-1
7.1.5 Fuel Lift Loads (FL) 7-2
7.1.6 Seismic Inertia 7-2
7.1.7 Seismic Anchor Displacements 7-3
7.1.8 Safety Relief Valve Opening (SRV) 7-3
7.1.9 Main Vent Clearing (MVC) 7-3
7.1.10 Annulus Pressurization (AP) 7-4
7.1.11 Pool Swell, Condensation Oscillation, and Chugging (PS, CO, CHG) 7-4
7.1.12 Flow Induced Vibration (FIV) 7-4
7.1.13 Thermal and Pressure Anchor Displacement 7-5
7.1.14 Hydrodynamic Mass 7-5
7.1.15 Handling Loads 7-5
7.2 Service Level Conditions 7-5
7.2.1 Service Level A (Normal Conditions) 7-6
7.2.2 Service Level B (Upset Conditions) 7-6
7.2.3 Service Level C (Emergency Conditions) 7-6
7.2.4 Service Level D (Faulted Conditions) 7-6
7.3 Load Combinations 7-6
7.3.1 Mark I Plants 7-7
7.3.2 Mark II and III Plants 7-7
7.4 Functional Evaluation Criteria 7-7
7.5 Allowable Stresses 7-7
7.6 Consideration of Repair or Cracking of Other Internals 7-8
7.7 Consideration of Flow Induced Vibration and Hydraulic Loads 7-8
7.8 Impact on Existing Internal Components 7-8
7.9 Thermal and Radiation Effects on Repair Design 7-9
7.10 Analysis Codes 7-9
7.11 Thermal Cycles 7-9
7.12 Corrosion Allowance 7-9

8.0 SYSTEM EVALUATION 8-1
8.1 Leakage 8-1
8.1.1 Leakage Impact and Acceptance Criteria - Normal Operation 8-1
8.1.2 Leakage Impact and Acceptance Criteria (Accident Conditions) 8-1
8.1.3 Leakage Evaluation Methodology (Accident Conditions) 8-1

Table of Contents (continued)

Page

8.2 Impact to Core Flow Distribution 8-2
8.3 Emergency Operating Procedure (EOP) Calculations 8-2
8.4 Power Uprate 8-2

9.0 MATERIALS, FABRICATION AND INSTALLATION 9-1
9.1 Materials 9-1
9.2 Crevices 9-2
9.3 Welding and Fabrication 9-2
9.4 Pre-Installation As-Built Inspection 9-3
9.5 Installation Cleanliness 9-4
9.6 ALARA 9-4
9.7 Qualification of Critical Design Parameters and Process 9-5

10.0 INSPECTION 10-1
10.1 Inspection Access 10-1
10.2 Pre and Post Installation Inspection 10-1
10.3 Inservice Inspection Requirements 10-1
10.4 Vessel Inspection 10-2

11.0 QUALITY ASSURANCE PROGRAM 11-1

12.0 DESIGN BASIS DOCUMENTATION 12-1

13.0 REFERENCES 13-1

APPENDIX A REPRESENTATIVE CONFIGURATIONS OF SHROUD SUPPORT STRUCTURE AND VESSEL INTERNAL ATTACHMENTS A-0

List of Tables

Page

Table 1-1: Plant Configurations Considered in This Criteria Document 1-2
Table 6-1: Summary of Recommended ASME Code Design Guidance 6-2
Table 7-1: Load Combinations for Mark I Plants 7-10
Table 7-2: Load Combinations for Mark II and III Plants 7-11
Table 7-3: Loading Term Definitions for Tables 7-1 and 7-2 7-12

List of Figures

Page

Figure A-1: BWR/2 Shroud Support Configuration A-1
Figure A-2: Hatch Unit 2 Shroud Support Configuration A-2
Figure A-3: Shroud Support Plate With Legs Configuration (CBIN BWR/4, 5, 6 Design) A-3
Figure A-4: Shroud Support Plate With Legs Configuration (B&W BWR/3, 4 Design) A-4
Figure A-5: Shroud Support Plate With Gussets Configuration (CE BWR/3, 4, and 5 Design) A-5
Figure A-6: Vessel Internal Attachment Configuration #1 ..... A-6
Figure A-7: Vessel Internal Attachment Configuration #2 ..... A-7
Figure A-8: Vessel Internal Attachment Configuration #3 ..... A-8

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. The Repair Technical Subcommittee of the BWRVIP developed this repair criteria document.

This document provides the general design acceptance criteria for permanent or temporary repair of the shroud support structure and vessel internal attachments. It is provided to assist BWR owners in designing repairs which maintain the structural integrity and system functionality of the shroud support structure and vessel internal attachments 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 the shroud support structure or vessel internal attachments is the only viable method for resolving cracking in these 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 Boiling Water Reactor (BWR) Vessel and Internals Project (BWRVIP) prepared a safety assessment of BWR internals [1]. The evaluation of the shroud support structure and vessel internal attachments included consideration of the consequence of failure of these components. It was determined that inspection and evaluation procedures have a role in assuring the long-term integrity of the shroud support structure and vessel internal attachments safety functions. Subsequently, inspection and flaw evaluation guidelines for the shroud support structure [2] and vessel internal attachments [3] were prepared by the BWRVIP to provide a prioritized inspection strategy and guidance for evaluation of flaws in these components.

In conjunction with inspection and flaw evaluation (I&E) guidelines, repair design criteria are outlined herein for cases where repair of the shroud support structure and vessel internal attachments is warranted. Internal attachments considered here are those locations where internal components are welded to the vessel inside diameter (ID) surface.

1.2 Purpose

The purpose of this document is to provide general design guidance and acceptance criteria for permanent and temporary repair of the shroud support structure and vessel internal attachments. 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 of the shroud support structure and/or vessel internal attachments is the only viable approach to resolution of the cracking/degradation issue.

1.3 Scope

The shroud support structure and vessel internal attachment configurations used in GE BWR/2-6 plants are described in Section 3.0. These configurations were derived from consideration of the plants shown in Table 1-1.

The scope of this repair design criteria document for BWR/2 through BWR/6 plants includes all welds associated with the shroud support structure and vessel internal attachments, as identified in Section 3.0. The attachment welds for the flow baffle in BWR/2s are also covered by these criteria. The welds connecting the jet pump adapters to the shroud support structure, and the access hole cover welds, are excluded. The weld connecting the jet pump adapter to the shroud support structure is addressed in BWRVIP-51 [6], and the access hole cover welds will be addressed by future efforts to be undertaken by the BWRVIP.

Table 1-1: Plant Configurations Considered in This Criteria Document

Plant Type	Plant Names
BWR/2	Nine Mile Point 1, Oyster Creek
BWR/3	Millstone 1, Pilgrim, Monticello, Quad Cities 1,2, Dresden 2,3, Santa Maria de Garoña
BWR/4	Vermont Yankee[1], Fermi 2, Hope Creek, 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, Nine Mile Point 2, WNP-2, Laguna Verde 1,2
BWR/6	Perry, Grand Gulf, River Bend, Clinton, Cofrentes

[1] Vermont Yankee is a hybrid BWR/3 and BWR/4 design.

2.0 DEFINITIONS

The following definitions apply to the criteria defined in this document:

Replacement	Replacement, as used in the context of this document, constitutes removal of all or portions of the shroud support structure and/or vessel internal attachments that are subject to cracking, and installation of new components in their place.
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 shroud support structure and/or vessel internal attachments. Repairs differ from replacements primarily in that the flaws may be left in place. Weld overlay, without removal of the defect, as well as removal of flaws by a qualified machining process, are also considered to be 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).

3.0 CONFIGURATION AND SAFETY FUNCTION

The general configuration and safety function of the shroud support structure and vessel internal attachments are discussed in this section.

3.1 Shroud Support Structure Configuration

The shroud support structure for most BWRs is defined as the structure below the core shroud stainless steel to Alloy 600 weld joint, commonly defined as the H7 weld (for example, see Figure A-1). The shroud support structure generally consists of a series of sections of different thickness and materials integrally welded to the reactor pressure vessel (RPV) inside surface. The shroud support structure consists of the shroud support plate and cylinder, and generally gussets or legs. In general, the wrought materials of construction for the shroud support structure consist of Alloy 600, except for WNP-2 and Hatch 2. In the BWR/2s, however, the shroud support ring was fabricated from Type 304 stainless steel. This ring was welded to Alloy 600 material using Alloy 82/182 weld material.

In many cases, the shroud support structure was fabricated and postweld heat treated along with the RPV. Because of this construction sequence, as well as the importance of the shroud support to the BWR core configuration, this component was typically included in the original ASME Code, Section III, Class 1 stress and fatigue analysis of the RPV.

There are several shroud support designs present in GE BWR plants. These designs differ among BWR types, as well as among RPV manufacturers. Fundamentally, there are four shroud support types, as identified below:

- Conical Shroud Support Plate (BWR/2)
- Thick Shroud Support Plate (Hatch Unit 2)
- Shroud Support Plate with Legs
- Shroud Support Plate with Gussets

There are also some variations within the support types, most notably the design for the shroud support plate with legs. Each shroud support type and its specific variations are described in the following sections.

3.1.1 Conical Shroud Support Plate (BWR/2)

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3.1.2 Thick Shroud Support Plate (Hatch Unit 2)

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3.1.3 Shroud Support Plate with Legs

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3.1.4 Shroud Support Plate with Gussets

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3.2 Vessel Internal Attachments Configuration

In addition to the shroud support structure described in Section 3.1, this repair design criteria document is also applicable to the following other vessel internal attachments:

- Core spray piping bracket attachments
- Jet pump riser brace attachments
- Guide rod bracket attachments
- Steam dryer support bracket attachments
- Steam dryer holddown bracket attachments
- Feedwater sparger bracket attachments
- Surveillance sample holder bracket attachments

The specific configurations of the vessel internal attachments are shown in Figures 2.13.2.1 through 2.13.2.51 of BWRVIP-15 [4] for a number of BWR plants.

The vessel internal attachment I&E guidelines document (BWRVIP-48 [3]) also identifies the configurations of these vessel internal attachments, along with the BWR type and the reactor vessel fabricator. As discussed in BWRVIP-48 [3], the jet pump riser brace and core spray piping bracket attachments are the only safety-related attachments (other than the shroud support attachments) in the BWR. (Note that BWR/2 plants do not have core spray piping brackets on the reactor vessel and do not have jet pumps.)

Representative configurations for the vessel internal attachments (other than the shroud support) are shown in Figures A-6 through A-8. The specific features of the attachments are summarized as follows:

- Weld buildup pads of either Alloy 182 or E308L/309L materials are applied to the RPV. Alternatively, in some cases, E308L pads are built up on the ER308L/309L RPV cladding.

- The attachments are attached to the weld buildup pad using either Alloy 182 or E308L/309L weld material.

- The attachment material is 300 series stainless steel, either 304, 304L, or 316L.

- In some plants, an overlay was applied to the weld buildup pad, attachment weld, and adjacent areas of the RPV cladding (see Figure A-8). The overlay was done after vessel final postweld heat treatment as an intergranular stress corrosion cracking (IGSCC) mitigation measure, and used E308L/309L weld material.

3.3 Safety Design Bases

3.3.1 Shroud Support Structure

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3.3.2 Vessel Internal Attachments

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4.0 SCOPE OF REPAIRS

The repairs for the shroud support structure and vessel internal attachments may address cracking in susceptible locations 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 with subsequent weld repair if required.

4.1 Mechanical Repairs

Repairs include all hardware and processes necessary to connect the new or existing components to existing portions of the RPV, shroud support structure, vessel internal attachments, or other internal components.

4.2 Welded Repairs

Repairs include all welds necessary to repair and/or replace existing portions of the shroud support structure and/or vessel internal attachment welds.

4.3 Flaw Removal Only

Repairs include all processes and evaluations associated with the removal of any flaws found in the shroud support structure and/or vessel internal attachments.

5.0 DESIGN OBJECTIVES

5.1 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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5.9 Shroud Support Structure Leakage

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5.10 Design Verification

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6.0 GENERAL DESIGN CRITERIA

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6.1 RPV Pressure Boundary

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6.2 Shroud Support Structure

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Table 6-1: Summary of Recommended ASME Code Design Guidance

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7.0 STRUCTURAL AND DESIGN EVALUATION

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7.1 Applied Loads

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7.1.1 Applicability of Hydrodynamic Loads

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7.1.2 Deadweight (DW)

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7.1.3 Hydraulic Loads (F)

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7.1.4 Differential Pressure (DP)

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7.1.5 Fuel Lift Loads (FL)

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7.1.6 Seismic Inertia

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7.1.7 Seismic Anchor Displacements

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7.1.8 Safety Relief Valve Opening (SRV)

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7.1.10 Annulus Pressurization (AP)

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7.1.11 Pool Swell, Condensation Oscillation, and Chugging (PS, CO, CHG)

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7.1.12 Flow Induced Vibration (FIV)

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7.1.13 Thermal and Pressure Anchor Displacement

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7.1.14 Hydrodynamic Mass

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7.1.15 Handling Loads

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7.2 Service Level Conditions

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7.2.1 Service Level A (Normal Conditions)

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7.2.2 Service Level B (Upset Conditions)

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7.2.3 Service Level C (Emergency Conditions)

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7.2.4 Service Level D (Faulted Conditions)

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7.3 Load Combinations

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7.3.1 Mark I Plants

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7.3.2 Mark II and III Plants

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7.4 Functional Evaluation Criteria

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7.5 Allowable Stresses

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7.6 Consideration of Repair or Cracking of Other Internals

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7.7 Consideration of Flow Induced Vibration and Hydraulic Loads

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7.8 Impact on Existing Internal Components

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7.9 Thermal and Radiation Effects on Repair Design

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7.10 Analysis Codes

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7.11 Thermal Cycles

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Table 7-1: Load Combinations for Mark I Plants

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Table 7-2: Load Combinations for Mark II and III Plants

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Table 7-3: Loading Term Definitions for Tables 7-1 and 7-2

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8.0 SYSTEM EVALUATION

8.1 Leakage

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8.1.1 Leakage Impact and Acceptance Criteria - Normal Operation

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8.1.2 Leakage Impact and Acceptance Criteria (Accident Conditions)

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8.1.3 Leakage Evaluation Methodology (Accident Conditions)

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8.2 Impact to Core Flow Distribution

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8.3 Emergency Operating Procedure (EOP) Calculations

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8.4 Power Uprate

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9.0 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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9.7 Qualification of Critical Design Parameters and Process

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10.1 Inspection Access

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10.2 Pre and Post Installation Inspection

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10.3 Inservice Inspection Requirements

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10.4 Vessel Inspection

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11.0 QUALITY ASSURANCE PROGRAM

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12.0 DESIGN BASIS DOCUMENTATION

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APPENDIX A

REPRESENTATIVE CONFIGURATIONS OF SHROUD SUPPORT STRUCTURE AND VESSEL INTERNAL ATTACHMENTS

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Figure A-1: BWR/2 Shroud Support Configuration

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Figure A-2: Hatch Unit 2 Shroud Support Configuration

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Figure A-3: Shroud Support Plate With Legs Configuration (CBIN BWR/4, 5, 6 Design)

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Figure A-4: Shroud Support Plate With Legs Configuration (B&W BWR/3, 4 Design)

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Figure A-5: Shroud Support Plate With Gussets Configuration (CE BWR/3, 4, and 5 Design)

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Figure A-6: Vessel Internal Attachment Configuration #1

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Figure A-7: Vessel Internal Attachment Configuration #2

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Figure A-8: Vessel Internal Attachment Configuration #3

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Printed on recycled paper in the United States of America

TR-108720NP

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