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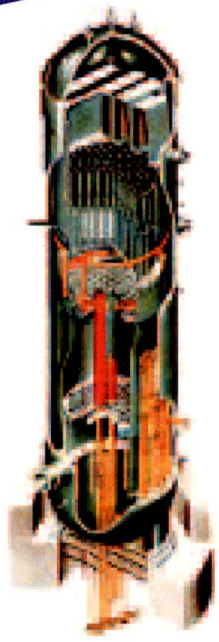
2016 TECHNICAL REPORT

BWRVIP-84NP, Revision 2-A: BWR Vessel and Internals Project

Guidelines for Selection and Use of Materials for Repairs to BWR Internal Components



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BWRVIP-84NP, Revision 2-A: BWR Vessel and Internals Project

Guidelines for Selection and Use of Materials for Repairs to BWR Internal Components

3002007385NP

Final Report, April 2016

EPRI Project Manager
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The Electric Power Research Institute (EPRI) prepared this report.

Principal Investigator
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This report describes research sponsored by EPRI and its BWRVIP participating members.

The report is based on the following previously published report:

BWRVIP-84-Revision 2: BWR Vessel and Internals Project, Guidelines for Selection and Use of Materials for Repairs to BWR Internal Components. EPRI, Palo Alto, CA: 2012. 1026603.

This publication is a corporate document that should be cited in the literature in the following manner:

BWRVIP-84NP, Revision 2-A: BWR Vessel and Internals Project, Guidelines for Selection and Use of Materials for Repairs to BWR Internal Components. EPRI, Palo Alto, CA: 2016. 3002007385NP.

REPORT SUMMARY

Between 1994 and 1998, the BWR Vessel and Internals Project (BWRVIP) developed a set of Repair Design Criteria guidelines for a number of BWR internal components. This BWRVIP report can help utilities properly specify and use materials in designing repairs to BWR internal components, particularly in the ex-core environment. A previous version of this report was published as BWRVIP-84 (1000248). A subsequent report (BWRVIP-84, Revision 1) incorporated changes proposed by the BWRVIP in response to U.S. Nuclear Regulatory Commission (NRC) Requests for Additional Information and recommendations in the NRC Safety Evaluation (SE) on the original BWRVIP report and also included additional changes, not yet reviewed by the NRC. This report (BWRVIP-84, Revision 2) includes additional revisions.

Background

The BWRVIP, formed in 1994, is an association of utilities focused on BWR vessel and internals issues. The BWRVIP Repair Design Criteria guidelines contain specifications for the procurement and application of materials for component repairs. While the material specifications in the guidelines were based on the best industry information available at the time, several of the referenced specifications for repair materials were not entirely appropriate for the intended application and environment. In some cases, the guidelines were overly restrictive and unnecessarily specified conditions that were difficult to meet. In other instances, the specifications required tightening to ensure the long-term integrity of a repair. The BWRVIP Repair Committee elected to develop a set of material guidelines better suited to the BWR ex-core environment.

Objective

To develop a materials guideline that does not contain overly restrictive specifications and can be used with the BWRVIP Repair Design Criteria for designing repairs to BWR internal components in the ex-core environment.

Approach

The project team reviewed the technical bases for the materials specifications contained in the BWRVIP Repair Design Criteria with respect to the best currently available information on materials performance. The sources for these technical bases included NUREG guidance, EPRI reports, and other industry guidance documents. In some cases, the BWRVIP guidance was appropriate for a particular material for a wider range of environments than would be seen in the intended applications. In other cases, the guidance was overly restrictive due to excessive conservatism applied during development of the original specifications. Based on these reviews, the BWRVIP formulated a set of specifications that represent minimum requirements for satisfactory material performance. Utility engineers, reactor repair vendors, and EPRI reviewed the resulting specifications.

Results

This BWRVIP report provides guidelines for the four specific material types used for in-vessel repairs—300 Series austenitic stainless steel, Alloy X-750, Type XM-19 and Alloy 718. For each of these materials, the report presents guidance on procurement, design and welding requirements, fabrication limitations, and numerous other issues.

The resulting specification can be used by utilities for designing repairs to the following internal components that fall within the scope of the BWRVIP program: core shroud, shroud support, core spray, top guide, core plate, standby liquid control line, jet pumps, low-pressure coolant injection (LPCI) couplings, control rod drive (CRD) components, instrument penetrations, and vessel brackets. Use of the specification for repairs to other internal components may be appropriate, but must be evaluated and justified on a case-by-case basis. It is BWRVIP intent to revise all existing Repair Design Criteria in order to eliminate specific references to material specifications and refer the designer instead to this guideline for material-related considerations.

EPRI Perspective

These guidelines provide an appropriate set of utility specifications for the selection and use of materials in designing repairs to BWR internal components—based on current industry understanding of material performance in the assumed ex-core environment. Use of these guidelines, in conjunction with the BWRVIP Repair Design Criteria, will help ensure the lasting structural integrity of repaired components.

Keywords

BWR
Repair specifications
Materials specifications
Stress corrosion cracking
Vessels
BWR internals

NRC SAFETY EVALUATION

In accordance with an NRC request, the NRC Safety Evaluation immediately follows this page.

2015-110A

August 24, 2015

Tim Hanley
Senior Vice President West Operations, Exelon
Chairman, BWR Vessel and Internals Project
3420 Hillview Avenue
Palo Alto, CA 94304-1395

SUBJECT: SAFETY EVALUATION OF "BWRVIP-84, REVISION 2: BWR VESSEL AND INTERNALS PROJECT, GUIDELINES FOR SELECTION AND USE OF MATERIALS FOR REPAIRS TO BWR INTERNALS" (EPRI REPORT 1026603, FERUARY 2013 (TAC NO. MF1456)

Dear Mr. Hanley:

By letter dated March 13, 2013 (Agencywide Documents Access and Management System (ADAMS) Accession Package No. ML131050057) as supplemented by letter dated February 17, 2015 (ADAMS Accession No. ML15142A755), the Boiling Water Reactor Vessel (BWR) and Internals Project (BWRVIP) submitted for U.S. Nuclear Regulatory Commission (NRC) staff review and approval the Electric Power Research Institute (ERPI) proprietary topical report (TR) 1026603, "BWRVIP-84, Revision 2: BWR Vessel and Internals Project, Guidelines for Selection and Use of Materials for Repairs to BWR Internals."

In an e-mail dated May 22, 2015, Mr. Chuck Wirtz, representing EPRI, commented on the draft safety evaluation (SE). The only comments provided were that there was no proprietary information in the draft SE and its content accurately reflected BWRVIP-84, Revision 2.

Based on its review of the information submitted by the BWRVIP, the NRC staff finds the TR acceptable for referencing subject to the limitations specified in the TR and in the NRC SE. The final SE sets the basis for our acceptance of the TR.

Our acceptance applies only to material provided in the subject TR. When the TR appears as a reference in license applications, our review will ensure that the material presented applies to the specific plant involved. License amendment requests that deviate from this TR will be subject to a plant-specific review in accordance with applicable review standards.

In accordance with the guidance provided on the NRC website, we request that the BWRVIP publish accepted versions of each TR within three months of receipt of this letter. The accepted

SAFETY EVALUATION OF "BWR [BOILING WATER REACTOR] VESSEL AND INTERNALS PROJECT, GUIDELINES FOR SELECTION AND USE OF MATERIALS FOR REPAIRS TO BWR INTERNALS (BWRVIP-84, REVISION 2)"

1.0 INTRODUCTION

1.1 History

The initial version of the document "BWR [Boiling Water Reactor] Vessel and Internals Project, Guidelines for Selection and Use of Materials for Repairs to BWR Internals (BWRVIP-84)," was submitted to the U.S. Nuclear Regulatory Commission (NRC) staff for review and approval on November 1, 2000 (Agencywide Document Access and Management System (ADAMS) Accession No. ML003768819). The initial safety evaluation (SE) was issued by the NRC staff on September 6, 2005 (ADAMS Accession No. ML052500529), followed by a final SE on September 23, 2008 (ADAMS Accession No. ML082321084). The final SE and responses to requests for additional information (RAI) were incorporated in BWRVIP-84, Revision 1, dated August 2011.

A second revision was completed in September 2012 and submitted by the Boiling Water Reactor Vessel and Internals Project (BWRVIP) to the NRC on March 13, 2013 (ADAMS Accession No. ML131050057). The new revision includes an additional material-specific appendix (Appendix D) as well as additional minor changes. BWRVIP-84, Revision 2 is applicable to General Electric BWRs/2-6's that are implementing reactor vessel internals component repairs or replacements consistent with the BWRVIP repair design criteria.

1.2 Purpose

The NRC staff reviewed BWRVIP-84, Revision 2 to determine the acceptability of the changes relative to BWRVIP-84, Revision 1-A. The review was limited to the new Appendix D related to the application of Alloy 718 because the other changes to BWRVIP-84, Revision 1-A are editorial in nature and do not need to be reviewed. Because BWRVIP-84, Revision 2.0 is proprietary, this SE does not include proprietary information from the report. The staff does not discuss, in detail, the provisions of the guidelines it finds acceptable. A brief summary of Appendix D is given in Section 2.0 of this SE, with the evaluation presented in Section 3.0. The conclusions are summarized in Section 4.0.

Enclosure

2.0 SUMMARY OF APPENDIX D

BWRVIP-84, Revision 2, Appendix D is titled, "Design, Procurement, Fabrication, and Installation of Alloy 718 for BWR Internals," and addresses the following topics:

- Applicable Documents
- Design
- Material Procurement
- Solution and Precipitation Hardening Heat Treatments
- Mechanical Requirements
- Fabrication and Installation
- Material Traceability, Identification, and Marking

3.0 STAFF EVALUATION

The NRC staff has reviewed Appendix D of the March 13, 2013, submittal and notes that the majority of the appendix is clearly written and follows the basic outline for other similar materials included in BWRVIP-84, Revision 2. The chemical composition, modified heat treatment, and final hardness are described and the mechanical properties from tensile testing are the same as specified in American Society of Mechanical Engineers Section XI, Code Case N-60-6 for Grade 718 Type 2. The one notable difference between Appendix D for Alloy 718 and Appendix B for Alloy X-750 would be the absence of a requirement to perform a rising load test on each lot of material to demonstrate adequate resistance to stress corrosion cracking (SCC) like that found in Section B.7 of BWRVIP-84, Revision 2.

The use of Alloy 718 with the modified heat treatment as described in Appendix D has already been approved for Nine Mile Point, Unit 2 on April 13, 2011 (ADAMS Accession No. ML120940373). In approving the license amendment request (LAR) for Alloy 718, the staff indicated that the microstructure was a key part of the material's resistance to SCC, and assurance through microstructural characterization of a relatively uniform microstructure (an average grain size of American Society for Testing Materials No. 2 to No. 6) was part of the basis for the staff's approval. In addition to tensile testing and SCC testing to document the resistance to SCC crack initiation, the licensee had performed a microstructural characterization on the lot of material used for all of the mechanical testing and subsequent jet pump beam replacement. The staff was concerned that without verification of grain size, the final microstructure of the component fabricated from Alloy 718 may not be as resistant to SCC initiation as the original lot of material approved for Nine Mile Point, Unit 2 on April 13, 2011. Therefore, the staff requested in RAI-1 that the licensee provide a technical justification for why a microstructural characterization is not included as a quality control check on each lot of heat treated components.

By letter dated February 17, 2015 (ADAMS Accession No. ML15142A755), the BWRVIP noted that a microstructural characterization is appropriate to verify for each lot of heat treated material. Therefore, a paragraph describing an examination of the heat treated microstructure to be performed on each lot of material was proposed to be included as Section D.5.4 in the approved version of BWRVIP-84, Revision 2.

X

The staff has reviewed the RAI response and finds the proposed addition acceptable as the microstructural examination will verify that the grain structure for each heat treated lot of material is consistent with that found in the material originally used in the approval for the use of Alloy 718 with the modified heat treatment. Therefore, with the addition of Section D.5.4, the staff's concern expressed in the RAI is resolved and the staff finds the BWRVIP-84, Revision 2 report acceptable.

4.0 CONCLUSION

The NRC staff has reviewed the BWRVIP-84, Revision 2 report and the February 17, 2015, RAI response and found that the report, modified as described in the RAI response, provides adequate guidance for the selection and use of materials for repair and/or replacement of any BWR internal component. The modification addressed in the RAI response should be incorporated in a "-A" version of the document.

Principal Contributor: Patrick Purtscher

Date: August 24, 2015

RECORD OF REVISIONS

Revision Number	Revisions
BWRVIP-84	Original Report (1000248).
BWRVIP-84-Revision 1	The report as originally published (1000248) was revised to incorporate changes proposed by the BWRVIP in response to U.S. Nuclear Regulatory Commission (NRC) Requests for Additional Information and recommendations in the NRC Safety Evaluation (SE) on the original BWRVIP report. Additional changes, not yet reviewed by the NRC are also included. All changes except typographical errors are marked with margin bars. NRC correspondence is included as appendices. Non-essential format changes were made to comply with the current EPRI publication guidelines. Details of the revision can be found in Appendix G.
BWRVIP-84, Revision 2	BWRVIP-84, Revision 1 was revised to include an additional material-specific appendix (Appendix D) as well as additional minor changes. Details of the revisions can be found in Appendix H.
BWRVIP-84, Revision 2-A	BWRVIP-84, Revision 2 was revised to incorporate the NRC Safety Evaluation. All changes are marked with margin bars. Details of the revision can be found in Appendix I.

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INTRODUCTION

1.1 Background

The BWRVIP Repair Committee has issued Repair and/or Replacement Design Criteria for the RPV Internal Components that may require a repair or replacement. Each repair design criteria contains a materials section that provides guidance in the selection and use of materials consistent with the design objective of a permanent repair that requires a minimum of inspection for the life of the repair. Since the specific configuration of future repairs is unknown, this guidance reflects good materials application practice that is independent of repair design.

The materials guidance incorporated, either directly or by reference, industry guidance that was intended to cover a broad range of LWR materials applications. This industry guidance enveloped, but was not specific to, the ex-core BWR environment.

As the repair design criteria have been developed, subjected to NRC review, and utilized by the BWRVIP membership, some material issues have surfaced:

- NRC questions and positions on the materials guidance have evolved as the repair design criteria reviews have progressed.
- Repair vendors have taken a number of exceptions to materials specifications during the repair bidding process - some due to valid material availability issues, and some for commercial advantage. This has made it difficult to get competitive bids.
- New information on material performance has become available.

The BWRVIP Repair Committee has elected to conduct a comprehensive review of the materials guidance references, and to focus the requirements on the BWR ex-core environment. The material guidance is being issued in one document, and will be deleted from the individual repair design criteria documents.

The original version of this report was published as BWRVIP-84 (1000248). A subsequent report (BWRVIP-84, Revision 1) incorporated changes proposed by the BWRVIP in response to U.S. Nuclear Regulatory Commission (NRC) Requests for Additional Information and recommendations in the NRC Safety Evaluation (SE) on the original BWRVIP report. Revision 1 also included additional changes not reviewed by the NRC. Revision 2 includes additional changes beyond those included in Revision 1 and all changes from Revision 1, except typographical errors, are marked with margin bars. This revision (BWRVIP-84, Revision 2-A) incorporates the NRC Safety Evaluation on Revision 2 and includes changes proposed by the BWRVIP in the response to NRC Request for Additional Information. NRC correspondence is included as appendices E and F. Details of the revisions can be found in Appendices G, H, and I.

1.2 Purpose

The purpose of this document is to provide guidance for the selection and use of materials for repair and/or replacement of specific BWR internal components. The issuance of this document will:

- Facilitate consistent NRC review and approval of repair material guidance
- Permit removal of conservatisms not necessary for use of material in the ex-core BWR environment
- Permit owners to obtain repair bids with minimal exceptions, utilizing materials currently commercially available
- Enhance consistency and simplify revision as experience is gained

1.3 Scope and Applicability

This document is applicable to General Electric BWR/2-6 plants that are implementing repairs or replacements consistent with the BWRVIP Repair or Replacement Design Criteria for that component, and are operated in compliance with the BWRVIP Water Chemistry Guidelines. These material guidelines may be utilized for other in-vessel component repairs, if desired by the plant owner; however they have not been specifically evaluated for use on any components other than those addressed by the BWRVIP repair design criteria.

1.4 Exceptions

In the development and use of this guide, it must be recognized that innovation and improvement are not precluded, and therefore exceptions are permitted under the following conditions:

- Exceptions to this document are considered exceptions to the repair design criteria.
- Establishment of more stringent (conservative) requirements by the plant owner is not considered an exception. If a licensee chooses to implement a "more stringent" requirement, the licensee should, however, document its basis for determining that the alternate requirement is "more stringent," in particular, with respect to not increasing susceptibility to inservice degradation and not decreasing structural margins.

In evaluating the desirability of exceptions to the material guidance, it should be noted that there are, and will always be, reference documents with more or less stringent requirements for almost every parameter. Exceptions need to be carefully evaluated for their suitability for a "life of plant" repair in the BWR ex-core environment. Not all of the reference documents available are focused on this application.

1.5 Previously Fabricated Contingency Repairs

Some BWRVIP member utilities have designed and fabricated repair and/or replacement hardware, as a contingency, that has not been installed.

For contingency repairs that were designed and fabricated in accordance with the material requirements contained in the BWRVIP Repair Design Criteria:

- No modification of the repair/replacement hardware is required by this document.
- The NRC submittal for those repairs should indicate that they were fabricated to the material requirements of the repair design criteria, prior to the issuance of this document.
- Any items that are not consistent with the guidance of this document should be specifically identified in the NRC submittal.

1.6 Implementation Requirements

In accordance with Nuclear Energy Institute (NEI) 03-08, "Guideline for the Management of Materials Issues" the requirements in this report are considered "needed" when performing a repair to BWR internals.

2
DEFINITIONS/ACRONYMS

ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
BWR	Boiling Water Reactor
BWRVIP	BWR Vessel and Internals Project
CFR	Code of Federal Regulations
CMTR	Certified Material Test Report
EDM	Electrical Discharge Machining
FN	Ferrite Number
FSAR	Final Safety Analysis Report
IGSCC	Inter-grannular Stress Corrosion Cracking
IASCC	Irradiation Assisted Stress Corrosion Cracking
NDE	Non-destructive Evaluation
NRC	Nuclear Regulatory Commission
NUREG	Nuclear Regulatory Guide
Repair	A broad term that applies to actions taken to design, analyze, fabricate and install hardware that ensures that the structural integrity of a degraded component will be maintained.

Permanent Repair	A repair designed for the remaining life of the plant (plus life-extension, if any).
Temporary Repair	A repair designed for a specific amount of time (e.g., months or years of operation). Temporary repairs may be installed, for example, to maintain plant operation while a permanent repair is being designed and hardware procured.
Replacement	Replacement constitutes removal of all or portions of a degraded component and installation of new components in their place.

3
DESIGN AND REGULATORY BASIS

3.1 Designs for plants with internals that were designed and constructed in accordance with ASME Section III must utilize materials and design stress intensity and allowable stress values that meet the requirements of the applicable Subsection of ASME Section III. Otherwise, if it is necessary to deviate from that requirement, relief to use an acceptable alternative pursuant to the provisions of 10 CFR 50.55(a)(3)(i) must be requested.

Note: for those components subject to the provisions of ASME Section XI, the plant repair and replacement program is also applicable.

3.2 Designs for plants with internals that were not designed and constructed in accordance with ASME Section III must meet the individual plant FSAR and other plant commitments for RPV internals mechanical design. In that instance, materials must meet the requirements of ASME Code Section II specifications, equivalent ASTM specifications, ASME Code Cases approved by the NRC in Regulatory Guide 1.147 ("Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1"), material specifications used during original fabrication, materials approved in Regulatory Guide 1.84 ("Design and Fabrication and Material Code case Acceptability, ASME Section III"), or other material specifications that have been previously accepted by the NRC. Otherwise, a material that is necessary for a design must be submitted on a case by case basis to the governing regulatory authority for approval, either on a plant specific basis, or through a mechanism such as a BWRVIP Repair Design Criteria topical report. Design stress intensity and allowable stress values shall be established for the limiting design conditions consistent with the methodology of ASME Section III Appendix III.

Note: for those components subject to the provisions of ASME Section XI, the plant repair and replacement program is also applicable.

ASME Section XI Components.

Materials used in the repair/replacement of components subject to the provisions of ASME Section XI (e.g., shroud, shroud support) must be selected in accordance with the provisions of the plant repair/replacement program. Additionally, materials that meet ASME Section II requirements, ASME equivalent ASTM materials, ASME Code Cases approved by the regulator, or other materials that are approved by the regulator may be used.

Non-ASME Section XI Components.

Materials used in the repair/replacement of the RVI components not subject to the provisions of ASME Section XI must meet the requirements of ASME Section II specifications, ASME Code Cases, ASTM specifications, or other material specifications that have been previously accepted by the regulatory authorities.

3.3 To the extent committed in the plant's current licensing basis, the use of unstabilized grades of austenitic stainless steel such as types 304 and 316 with very low carbon (a special requirement for 0.020% C maximum) shall meet the requirements of the governing regulatory guidance (e.g., Regulatory Guide 1.44, "Control of the Use of Sensitized Stainless Steel," and NUREG-0313 Rev. 2, "Technical Report on Material Selection and Processing Guidelines for BWR Coolant Pressure Boundary Piping."). It should be noted that type XM-19 is stabilized and does not fall into the class of material covered by Regulatory Guide 1.44.

3.4 To the extent committed in the plant's current licensing basis, welds in 300 Series and equivalent cast austenitic stainless steel components shall meet the requirements of the governing regulatory guidance (e.g., Regulatory Guide 1.31, "Control of Ferrite Content in Stainless Steel Weld Metal," Regulatory Guide 1.44, "Control of the Use of Sensitized Stainless Steel," and NUREG-0313 Rev. 2).

4
GENERAL MATERIAL GUIDELINES

4.1 The design shall use new or replacement materials that are demonstrated to be highly resistant to intergranular stress corrosion cracking (IGSCC) and irradiation assisted stress corrosion cracking (IASCC), and be suitable for BWR reactor environmental conditions. Previous regulatory staff positions on materials used in BWR reactor environments should be considered. The vendor is to provide appropriately documented data to justify the suitability of all materials used in a BWR corrosion and irradiation environment.

4.2 Austenitic stainless steels of the 300 Series and cast equivalent alloys, nickel alloy X-750, and type XM-19 austenitic stainless steel shall meet the following special requirements. Other alloys may be used in designs as justified on a case basis.

4.2.1 As a minimum, austenitic stainless steels of the 300 Series and equivalent cast alloys meet the requirements of Appendix A of this Materials Guideline, "Design, Procurement, Fabrication, and Installation of 300 Series and Cast Equivalent Austenitic Stainless Steel for Use in BWR Internals."

4.2.2 As a minimum, nickel alloy X-750 shall meet the requirements of Appendix B of this Materials Guideline, "Design, Procurement, Fabrication, and Installation of Alloy X-750 for Use in BWR Internals."

4.2.3 As a minimum, type XM-19 austenitic stainless steel shall meet the requirements of Appendix C of this Materials Guideline, "Design, Procurement, Fabrication, and Installation of Type XM-19 Austenitic Stainless Steel for Use in BWR Internals."

4.3 For new components, the susceptibility to intergranular stress corrosion cracking of each heat of material in its final condition of welding and heat treatment shall be demonstrated by appropriately documented test data.

4.4 The repair design shall be reviewed for crevices between components of the repair and between those repair components and the original structures to minimize the potential for crevice-induced intergranular stress corrosion cracking (IGSCC) that can occur under certain specific conditions. Criteria used for defining an acceptable crevice configuration shall be technically justified through appropriate analysis and/or testing. In the absence of plant-specific or vendor-specific crevice criteria, the criteria shown in Figure 4-1 may be used.

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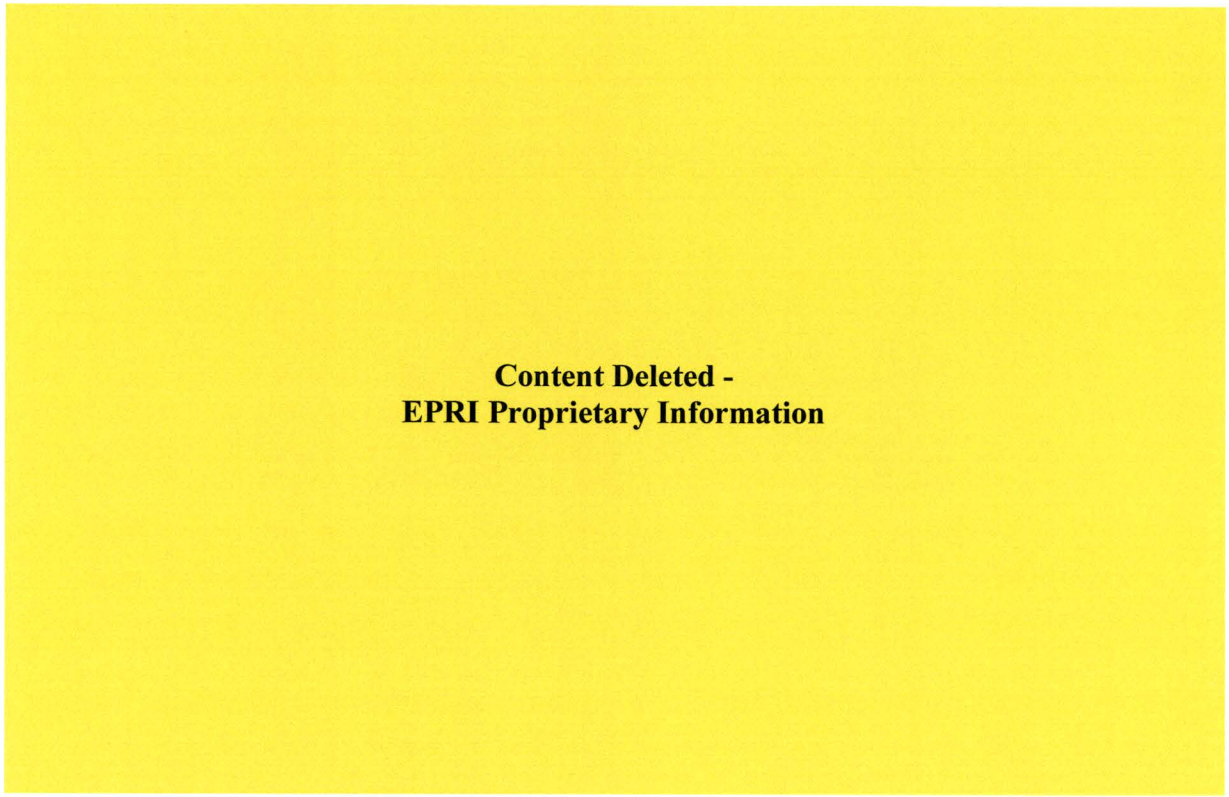

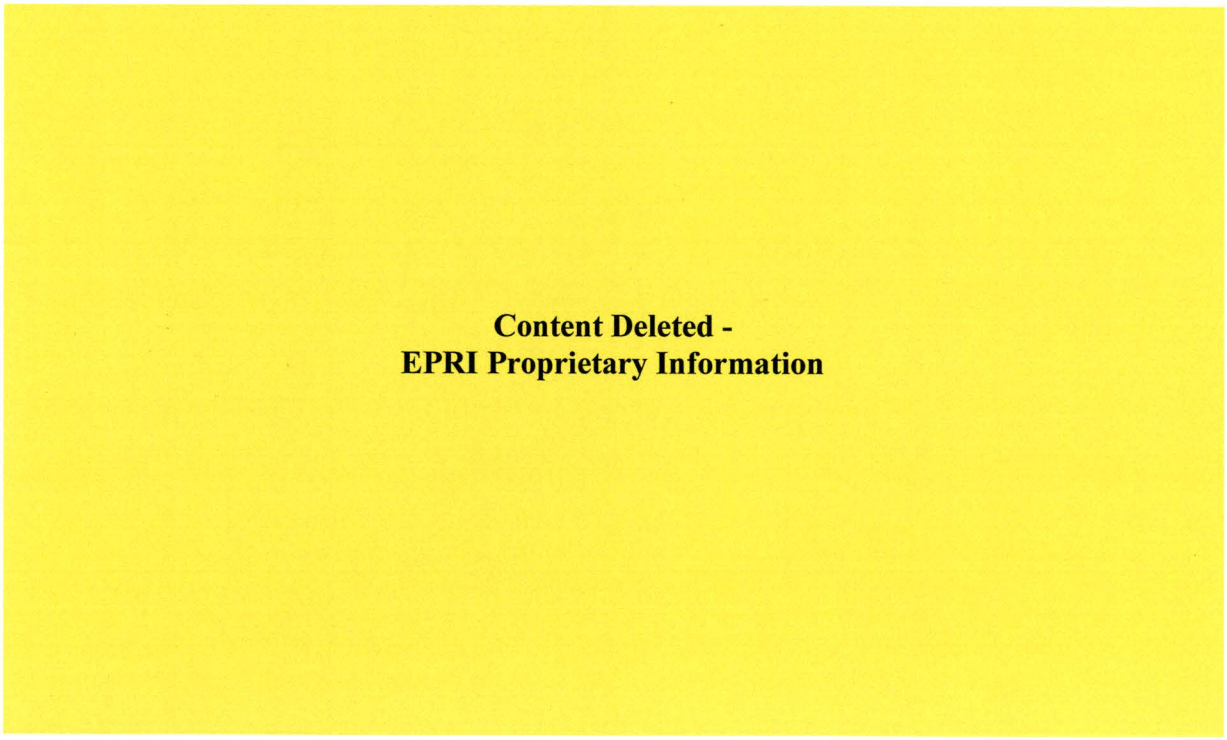

Figure 4-1
BWR crevice definition diagram

5
GENERAL WELDING AND FABRICATION GUIDELINES

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A

DESIGN, PROCUREMENT, FABRICATION, AND INSTALLATION OF 300 SERIES OR CAST EQUIVALENT AUSTENITIC STAINLESS STEEL FOR USE IN BWR INTERNALS

A.1 Scope

This Guideline provides minimum requirements for design, procurement, fabrication, and installation of 300 Series or cast equivalent austenitic stainless steel plate, forgings, bar, castings, pipe, and associated weld metal for BWR reactor internals applications. More stringent requirements may be imposed at the discretion of the utility. Material that meets this Guideline meets the criteria of NUREG-0313 Revision 2 for stress corrosion cracking resistant material.

A.2 Applicable Documents

A.2.1 American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code

A.2.1.1 Section II Part A

SA-182 Specification for Forged or Rolled Alloy Steel Pipe Flanges, Forged Fittings and Valves and Parts for High Temperature Service.

SA-193 Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service.

SA-194 Specification for Carbon and Alloy-Steel Nuts for Bolts for High-Pressure and High-Temperature Service.

SA-240 Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels.

SA-312 Specification for Seamless and Welded Austenitic Stainless Steel Pipes.

SA-336 Specification for Alloy Steel Forgings for Pressure and High-Temperature Parts.

SA-351 Specification for Castings, Austenitic, Austenitic-Ferritic (Duplex), for Pressure-Containing Parts.

SA-358 Specification for Electric-Fusion-Welded Austenitic Chromium-Nickel Alloy Steel Pipe for High-Temperature Service.

SA-376 Specification for Seamless Austenitic Stainless Steel Pipe for High-Temperature Central Station Service.

SA-403 Specification for Wrought Austenitic Stainless Steel Piping Fittings.

SA-430 Specification for Austenitic Steel Forged and Bored Pipe for High-Temperature Service.

SA-479 Specification for Stainless and Heat-Resisting Steel Bars and Shapes for Use in Boilers and Other Pressure Vessels.

A.2.1.2 Section II Part C

SFA-5.4 Specification for Stainless Steel Electrodes for Shielded Metal Arc Welding.

SFA-5.9 Specification for Bare Stainless Steel Welding Electrodes and Rod.

SFA-5.22 Specification for Stainless Steel Electrodes for Flux Cored Arc Welding and Stainless Steel Flux Cored Rods for Gas Tungsten Arc Welding.

SFA-5.30 Specification for Consumable Inserts

A.2.1.3 Section III, Division 1

A.2.1.4 Section V

A.2.1.5 Section IX

A.2.1.6 Section XI

A.2.2 American Society for Testing and Materials (ASTM)

A 182 Specification for Forged or Rolled Alloy Steel Pipe Flanges, Forged Fittings and Valves and Parts for High Temperature Service.

A 193 Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service.

A 194 Specification for Carbon and Alloy-Steel Nuts for Bolts for High-Pressure and High-Temperature Service.

A 240 Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels.

A 262 Standard Practice for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels.

A 312 Specification for Seamless and Welded Austenitic Stainless Steel Pipes.

A 336 Specification for Alloy Steel Forgings for Pressure and High-Temperature Parts.

A 351 Specification for Castings, Austenitic, Austenitic-Ferritic (Duplex), for Pressure-Containing Parts.

A 358 Specification for Electric-Fusion-Welded Austenitic Chromium-Nickel Alloy Steel Pipe for High-Temperature Service.

A 376 Specification for Seamless Austenitic Stainless Steel Pipe for High-Temperature Central Station Service.

A 380 Recommended Practice for Cleaning and Descaling Stainless Steel Parts, Equipment, and Systems.

A 403 Specification for Wrought Austenitic Stainless Steel Piping Fittings.

A 430 Specification for Austenitic Steel Forged and Bored Pipe for High-Temperature Service.

A 479 Specification for Stainless and Heat-Resisting Steel Bars and Shapes for Use in Boilers and Other Pressure Vessels.

A 800 Standard Practice for Steel Casting, Austenitic Alloy, Estimating Ferrite Content Therof.

A.2.3 American National Standards Institute (ANSI)/American Society of Mechanical Engineers (ASME)

NQA-2-1989 Quality Assurance Requirements for Nuclear Facility Applications

A.2.4 Nuclear Regulatory Commission (NRC)

NUREG-0313 Rev. 2 Technical Report on Material Selection and Processing Guidelines for BWR Coolant Pressure Boundary Piping.

A.3 Design

A.3.1 Peak Stresses and Strains

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A.3.2 Bolting

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A.3.3 Surface Roughness

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A.4 Material Procurement

A.4.1 Material Specifications

Material shall be supplied in accordance with the specifications listed below, plus the additional special requirements described elsewhere in this section.

A.4.1.1 Types 304, 304L, 316, 316L, or Cast Equivalent

Plate:	SA-240/A 240
Forgings:	SA-182/A 182, SA-336/A 336
Pipe:	SA-312/A 312, SA-358/A 358, SA-376/A 376, SA-430/A 430
Fittings:	SA-182/A 182, SA-403/A 403
Bar:	SA-479/A 479
Bolting:	SA-193/A 193
Castings:	SA-351/A 351
Nuts	SA-194/A 194

A.4.1.2 Types E/ER308/308L/316/316L/308Mo/308LMo, IN308L/316L, E/ER209, E/ER309/309L

Covered Electrodes:	SFA-5.4
Bare Wire:	SFA-5.9
Flux Cored Electrodes:	SFA-5.22
Consumable Insert:	SFA-5.30

A.4.2 Chemical Requirements

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A.5 Solution Heat Treatment

Solution annealing temperature for all materials shall be 1900°F minimum, followed by rapid quenching, for material manufacture as well as subsequent solution annealing cycles during fabrication. Care must be taken to avoid excessive grain growth that may have an adverse effect on tensile properties. Quenching media shall be as specified in the applicable base material specification, with water quenching preferred. Quenching from the solution annealing temperature shall be sufficiently rapid to suppress carbide precipitation in the center of the material, as demonstrated by compliance with the testing required in A.8. Local solution annealing is only permitted on a case-by-case basis.

A.6 Mechanical Requirements

A.6.1 Hardness Properties

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A.6.2 Mechanical Properties

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A.7 Delta Ferrite

A.7.1 Time of Testing

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A.7.2 Delta Ferrite Level Requirements

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A.7.3 Delta Ferrite Determination Method

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A.8 IGSCC Susceptibility Testing

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A.9 Fabrication and Installation

A.9.1 Welding

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A.9.2 Cold Work

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A.9.3 Forming and Bending

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A.9.4 NDE Requirements

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A.9.5 Repairs to Material

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A.9.6 Cleanliness

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Table A-1
Demineralized water

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A.9.7 Finishing of Final Surfaces

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A.10 Material Traceability, Identification, and Marking

A.10.1 Marking

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A.10.2 Identification to Certified Material Test Report (CMTR)

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A.10.3 Welding Material

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A.11 Packaging, Shipping, and Storage

Packaging, shipping, and storage shall be in accordance with ASME NQA-2-1989, Part 2.2, Level B for welding filler materials, and Level C for all other materials.

B

DESIGN, PROCUREMENT, FABRICATION, AND INSTALLATION OF ALLOY X 750 FOR USE IN BWR INTERNALS

B.1 Scope

This Guideline provides minimum requirements for design, procurement, fabrication, and installation of alloy X-750 forgings, bar, plate, strip, and sheet for BWR reactor internals applications. More stringent requirements may be imposed at the discretion of the utility. Caution: in order to avoid cracking in the BWR reactor internals environment, the use of alloy X-750 requires diligent control over composition, heat treatment, design, and operational stresses.

B.2 Applicable Documents

B.2.1 American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code

B.2.1.1 Section II Part B

SB-637 Specification for Precipitation-Hardening Nickel Alloy Bars, Forgings, and Forging Stock for High-Temperature Service.

B.2.1.3 Section III, Division 1

B.2.1.4 Section V

B.2.1.5 Deleted

B.2.1.6 Code Cases - Nuclear Components

N-60-5 Material for Core Support Structures, Section III Division 1

B.2.1.7 Section XI

B.2.2 American Society for Testing and Materials (ASTM) Standards

B 637 Specification for Precipitation-Hardening Nickel Alloy bars, Forgings, and Forging Stock for High-Temperature Service.

B.2.3 American National Standards Institute (ANSI)/American Society of Mechanical Engineers (ASME)

NQA-2-1989 Quality Assurance Requirements for Nuclear Facility Applications.

B.2.4 Society of Automotive Engineers (SAE) Aerospace Material Specification (AMS)

AMS 5542L — Nickel Alloy, Corrosion and Heat Resistant, Sheet, Strip, and Plate, 72Ni-15.5Cr-0.95Cb-2.5Ti-0.70Al-7.0Fe, Annealed, April 1994.

B.2.5 Military Specification (Unrestricted Distribution)

MIL-DTL-24114F(SH) — Detail Specification, Nickel-Chromium-Iron Age-Hardenable Alloy Bar, Rods, and Forgings.

B.3 Design

B.3.1 Peak Stresses and Strains

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Table B-1
Design stress ratio vs. design life

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B.3.2 Bolting

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B.3.3 Surface Roughness

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B.4 Material Procurement

B.4.1 Material Specifications

Material shall be supplied in accordance with the specifications listed below, plus the additional special requirements described elsewhere in this section.

Plate, Sheet, Strip:	AMS 5542L (except grain size requirements)
Forgings:	SB-637/B 637
Bar:	SB-637/B 637

B.4.2 Chemical Requirements

The chemical composition of all alloy X-750 material shall be in accordance with Table B-2. Product analysis tolerances for all alloy X-750 material shall be in accordance with SB-637/B 637 alloy UNS N07750.

Table B-2
Alloy X-750 chemical composition

Element	Percent
C	0.020-0.060
Mn	1.00 max.
Si	0.50 max.
S	0.01 max.
P	(Note 3)
Cr	14.00-17.00
Co	0.25 max. (Note 1)
Cb (Nb)	(Note 2)
Ta	(Note 2)
Cb (Nb) + Ta	0.70-1.20 (Note 2)
Ti	2.25-2.75
Al	0.40-1.00
Fe	5.00-9.00
Cu	0.50 max.
Zr	(Note 3)
B	(Note 3)
V	(Note 3)
Ni	70.00 min.

Note 1:The maximum cobalt content for all materials shall be 0.25%. Alternatively, if it is not practicable to procure the material for individual components to this requirement, a maximum allowable weighted average cobalt level of 0.25% is permissible. The weighted average must take into account the exposed surface area of all newly installed components wetted by reactor coolant. Higher cobalt levels may be justified on a case-by case basis in applications where erosion and/or corrosion will not occur.

Note 2:Cb (Nb) and Ta must be measured and reported separately for evaluation under the combined Cb (Nb) + Ta criteria.

Note 3:It is recommended that this element be analyzed and reported for the purpose of future evaluation.

B.5 Solution and Precipitation Hardening Heat Treatments

B.5.1 Fuel Composition

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B.5.2 Time, Temperature, Quenching

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B.5.3 Heat Treatment/Machining Sequence

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B.6 Mechanical Requirements

B.6.1 Hardness Properties

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B.6.2 Mechanical Properties

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B.7 Rising Load Testing

B.7.1 Required Tests

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B.7.2 Rising Load Test Acceptance Criteria

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B.8 Fabrication and Installation

B.8.1 Prefilming for Enhanced General Corrosion Resistance

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B.8.2 Welding

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B.8.3 Bending and Cold Straightening

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B.8.4 Machining

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B.8.5 Shot Peening

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B.8.6 NDE Requirements

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B.8.7 Repairs

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B.8.8 Cleanliness

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**Table B-3
Demineralized water**

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B.8.9 Finishing of Final Surfaces

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B.9 Material Traceability, Identification, and Marking

B.9.1 Marking

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B.10 Packaging, Shipping, and Storage

Packaging, shipping, and storage shall be in accordance with ASME NQA-2-1989, Level C.

C

DESIGN, PROCUREMENT, FABRICATION, AND INSTALLATION OF TYPE XM-19 AUSTENITIC STAINLESS STEEL FOR USE IN BWR INTERNALS

C.1 Scope

This Guideline provides minimum requirements for design, procurement, fabrication, and installation of solution annealed and high-strength hot rolled type XM-19 (Nitronic 50) austenitic stainless steel plate, forgings, bar, pipe, and associated weld metal for BWR reactor internals applications. More stringent requirements may be imposed at the discretion of the utility.

C.2 Applicable Documents

C.2.1 American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code

C.2.1.1 Section II Part A

SA-182 Specification for Forged or Rolled Alloy Steel Pipe Flanges, Forged Fittings and Valves and Parts for High Temperature Service.

SA-240 Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels.

SA-312 Specification for Seamless and Welded Austenitic Stainless Steel Pipes.

SA-358 Specification for Electric-Fusion-Welded Austenitic Chromium-Nickel Alloy Steel Pipe for High-Temperature Service.

SA-403 Specification for Wrought Austenitic Stainless Steel Piping Fittings.

SA-479 Specification for Stainless and Heat-Resisting Steel Bars and Shapes for Use in Boilers and Other Pressure Vessels.

C.2.1.2 Section II Part C

SFA-5.4 Specification for Stainless Steel Electrodes for Shielded Metal Arc Welding.

SFA-5.9 Specification for Bare Stainless Steel Welding Electrodes and Rod.

C.2.1.3 Section III, Division 1

C.2.1.4 Section V

C.2.1.5 Section IX

C.2.1.6 Section XI

C.2.2 American Society for Testing and Materials (ASTM)

A 182	Specification for Forged or Rolled Alloy Steel Pipe Flanges, Forged Fittings and Valves and Parts for High Temperature Service.
A 240	Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels.
A 262	Standard Practice for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels.
A 312	Specification for Seamless and Welded Austenitic Stainless Steel Pipes.
A 358	Specification for Electric-Fusion-Welded Austenitic Chromium-Nickel Alloy Steel Pipe for High-Temperature Service.
A 380	Recommended Practice for Cleaning and Descaling Stainless Steel Parts, Equipment, and Systems.
A 403	Specification for Wrought Austenitic Stainless Steel Piping Fittings.
A 479	Specification for Stainless and Heat-Resisting Steel Bars and Shapes for Use in Boilers and Other Pressure Vessels.

C.2.3 American National Standards Institute (ANSI)/American Society of Mechanical Engineers (ASME)

NQA-2-1989	Quality Assurance Requirements for Nuclear Facility Applications

C.3 Design

C.3.1 Peak Stresses and Strains

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C.3.2 Bolting

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C.3.3 Surface Roughness

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C.4 Material Procurement

C.4.1 Material Specifications

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C.4.2 Chemical Requirements

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C.5 Solution Heat Treatment

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C.6 Mechanical Requirements

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C.7 Delta Ferrite

C.7.1 Time of Testing

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C.7.2 Delta Ferrite Level Requirements

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C.7.3 Delta Ferrite Determination Method

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C.8 IGSCC Susceptibility Testing

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C.9 Fabrication and Installation

C.9.1 Welding

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C.9.2 Forming and Bending

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C.9.3 NDE Requirements

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C.9.4 Repairs to Material

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C.9.5 Cleanliness

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**Table C-1
Demineralized water**

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C.9.6 Finishing of Final Surfaces

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C.10 Material Traceability, Identification, and Marking

C.10.1 Marking

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C.10.2 Identification to Certified Material Test Report (CMTR)

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C.10.3 Welding Material

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C.11 Packaging, Shipping, and Storage

Packaging, shipping, and storage shall be in accordance with ASME NQA-2-1989, Part 2.2, Level B for welding filler materials, and Level C for all other materials.

D

DESIGN, PROCUREMENT, FABRICATION, AND INSTALLATION OF ALLOY 718 FOR USE IN BWR INTERNALS

D.1 Scope

This Guideline provides minimum requirements for design, procurement, fabrication, and installation of alloy 718 forgings and bar for BWR reactor internals applications. More stringent requirements may be imposed at the discretion of the utility. Caution: in order to avoid cracking in the BWR reactor internals environment, the use of alloy 718 requires diligent control over composition, heat treatment, design, and operational stresses.

D.2 Applicable Documents

D.2.1 American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code

D.2.1.1 Section II Part B

SB-637 Specification for Precipitation-Hardening Nickel Alloy Bars, Forgings, and Forging Stock for High-Temperature Service.

D.2.1.2 Section III, Division 1

D.2.1.3 Section V

D.2.1.4 Code Cases - Nuclear Components

N-60-6 Material for Core Support Structures, Section III Division 1

D.2.1.5 Section XI

D.2.2 American Society for Testing and Materials (ASTM) Standards

B 637 Specification for Precipitation-Hardening Nickel Alloy bars, Forgings, and Forging Stock for High-Temperature Service.

D.2.3 American National Standards Institute (ANSI)/American Society of Mechanical Engineers (ASME)

NQA-1-2008/2009a Quality Assurance Requirements for Nuclear Facility Applications.

D.3 Design

D.3.1 Peak Stresses and Strains

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Table D-1
Design stress ratio vs. design life

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D.3.2 Bolting

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D.3.3 Surface Roughness

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D.4 Material Procurement

D.4.1 Material Specifications

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D.4.2 Chemical Requirements

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Table D-2
Alloy 718 chemical composition

Element	Percent
C	0.08 max.
Mn	0.35 max.
Si	0.35 max.
S	0.015 max.
P	0.015 max.
Cr	17.0 – 21.0
Co	0.25 max. (Note 3)
Cb (Nb)	(Note 1)
Ta	(Note 1)
Cb (Nb) + Ta	4.75 – 5.50 (Note 1)
Ti	0.65 – 1.15
Al	0.20 – 0.80
Fe	Remainder
Cu	0.30 max.
Zr	(Note 2)
B	0.006 max.
V	(Note 2)
Ni	50.0 – 55.0
Mo	2.80 – 3.30

Note 1: Cb (Nb) and Ta must be measured and reported separately for evaluation under the combined Cb (Nb)+Ta criteria. In case of only Cb (Nb) addition, content of Ta combined with Cb (Nb) is very slight (0.05% max. by AMS 5662) and Cb (Nb) and Ta are not necessary to be measured and reported separately.

Note 2: It is recommended that this element will be analyzed and reported for the purpose of future evaluation.

Note 3: The maximum cobalt content for all materials shall be 0.25%. Alternatively, if it is not practicable to procure the material for individual components to this requirement, a maximum allowable weighted average cobalt level of 0.25% is permissible. The weighted average must take into account the exposed surface area of all newly installed components wetted by reactor coolant. Higher cobalt levels may be justified on a case-by case basis in applications where erosion and/or corrosion will not occur.

D.5 Solution and Precipitation Hardening Heat Treatments

D.5.1 Fuel Composition

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D.5.2 Time, Temperature, Quenching

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D.5.3 Heat Treatment/Machining Sequence

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D.5.4 Examination of Microstructure

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D.6 Mechanical Requirements

D.6.1 Hardness Properties

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D.6.2 Mechanical Properties

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D.7 Fabrication and Installation

D.7.1 Prefilming for Enhanced General Corrosion Resistance

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D.7.2 Welding

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D.7.3 Bending and Cold Straightening

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D.7.4 Machining

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D.7.5 NDE Requirements

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D.7.6 Repairs

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D.7.7 Cleanliness

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**Table D-3
Demineralized water**

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D.7.8 Finishing of Final Surfaces

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D.8 Material Traceability, Identification, and Marking

D.8.1 Marking

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D.8.2 Identification to Certified Material Test Report (CMTR)

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D.9 Packaging, Shipping, and Storage

Packaging, shipping, and storage shall be in accordance with ASME NQA-1-2008/2009a, SUBPART 2.2, Level C.

E
NRC REQUEST FOR ADDITIONAL INFORMATION

Dennis Madison
Southern Nuclear
Chairman, BWR Vessel and Internals Project
3420 Hillview Avenue
Palo Alto, CA 94304

SUBJECT: REQUEST FOR THE REVIEW OF ELECTRIC POWER RESEARCH INSTITUTE REPORT, "BWRVIP [BOILING WATER REACTOR VESSEL AND INTERNALS PROJECT]-84, REVISION 2: BWR VESSEL AND INTERNALS PROJECT, GUIDELINES FOR SELECTION AND USE OF MATERIALS FOR REPAIRS TO BWR INTERNAL COMPONENTS" (TAC NO. MF2154)

Dear Mr. Madison:

By letter dated March 13, 2013 (Agencywide Documents Access and Management System Accession No. ML13105A024), the Electric Power Research Institute (EPRI) submitted for U.S. Nuclear Regulatory Commission (NRC) staff review Topical Report (TR), BWRVIP-84, Revision 2: "BWR Vessel And Internals Project, Guidelines For Selection And Use Of Materials For Repairs To BWR Internal Components." Upon review of the information provided, the NRC staff has determined that additional information is needed to complete the review.

By Email dated February 13, 2014, Mr. Chuck Wirtz, representing EPRI, and I agreed that EPRI will complete its response to the enclosed Request for Additional Information (RAI) questions by June 30, 2014.

If you have any questions regarding the enclosed RAI questions, please contact me at (301) 415-7297.

Sincerely,

/RA/

Joseph J. Holonich, Senior Project Manager
Licensing Processes Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Project No. 704

Enclosure:
RAI question

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ADAMS Accession No.: ML14037A313 **NRR-106**

OFFICE	PLPB/PM	PLPB/LA	DE/EVIB/BC	PLPB/BC
NAME	JHolonich	DBaxley	SRosenberg	AMendiola
DATE	02/05/2014	02/26/2014	03/06/2014	03/10/2014

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REQUEST FOR ADDITIONAL INFORMATION ON BWRVIP-84, REVISION 2: "BWR VESSEL AND INTERNALS PROJECT, GUIDELINES FOR SELECTION AND USE OF MATERIALS FOR REPAIRS TO BWR INTERNAL COMPONENTS"

By letter dated March 13, 2013 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML13105A024), the Electric Power Research Institute (EPRI) submitted for U.S. Nuclear Regulatory Commission (NRC) staff review Topical Report (TR), BWRVIP [Boiling Water Reactor Vessel And Internals Project]-84, Revision 2: "BWR Vessel And Internals Project, Guidelines For Selection And Use Of Materials For Repairs To BWR Internal Components." Upon review of the information provided, the NRC staff has determined that additional information is needed to complete the review.

RAI 1

Background: The safety evaluation (SE) for the license amendment request (LAR) approving the use of Alloy 718 Modified (ADAMS Accession No. ML120940373) includes the following statements regarding the fabricability of Alloy 718 for use in BWR internals.

> Fabricability
>
> The NRC staff considers the main fabricability issue to consider for this LAR is the heat treatment given to the Modified Alloy 718 component, which is the last major step in the fabrication process. Enclosure 4, Section 2.6 of the licensee's December 30, 2011, submittal describes the heat treatment as follows:
>
> > Solution heat treatment (SHT) for modified alloy 718 shall be 1850°F-1922°F (1010°C-1050°C), target temperature of 1886°F (1030°C), for 1 to 2 hours, followed by rapid quenching in oil or water. SHT for modified alloy 718 shall be followed by precipitation hardening heat treatment at 1300°F+15°F (704°C+8°C) for 6 hours, +1/-0 hours, followed by air cooling. Solution and precipitation hardening heat treatment conditions were determined from the T-T-P (time-temperature-precipitation) curve (Reference 3 and Figure 2-3) and isothermal aging curves for yield strength and elongation of alloy 718 (Figure 2-4). In order to improve SCC resistance and ductility, SHT temperature 1010-1050°C was selected for complete solution and the precipitation hardening heat treatment condition *704°C/6* hours was selected to avoid the precipitation of δ-phase ...
>
> Microstructure has been shown to play a determinant role in the SCC behavior of high-strength Ni-based alloys [Reference 1]. The two most important microstructural characteristics of alloy Modified Alloy 718 are grain structure (size and distribution) and δ-phase structure. After the recommended solution heat treatment for this alloy (1850°F-1922°F for 1 to 2 hours), the grain structure should be relatively uniform (an average grain size of ASTM No.2 to No.6 is considered optimum for Alloy X-750 and would be similar for the Modified Alloy 718) while the δ phase is completely dissolved in the matrix. The grain boundaries should be free of precipitates. The final, low-temperature, aging step (1300°F+15°F for 6 hours) is sufficient to increase the YS to the desired range through intragranular precipitation of γ' and avoid any grain-boundary precipitation.

ENCLOSURE

The March 30, 2012, submittal for Modified Alloy 718 and other related sources of information [Reference 1 and 2] include extensive microstrucural characterization for the different versions of Alloy 718. With the microstructural characterization available for the Modified Alloy 718 components to be installed at Nine Mile Point, Unit 2, the staff is satisfied that the resistance to SCC will be similar to that which has been demonstrated in the December 30, 2011 submittal.

Issue: In approving the LAR for the Alloy 718 material, the staff indicated that the microstructure was a key part of SCC resistance, and assurance through microstructural characterization of a relatively uniform microstructure (an average grain size of ASTM No. 2 to No. 6) allowed approval of the amendment.

Request: Provide a technical justification why a microstructural characterization is not included as a quality control check on each lot of heat treated components.

REFERENCES

1. T. Yonezawa, N. Yamaguchi, Y. Okada, and M. Igarashi, "Effects of Chemical Compositions and Heat Treatment on the Stress Corrosion Cracking Resistance of Precipitation Hardened Nickel Base Alloys in High Temperature Water," J. Japan Inst. Metals, Vol. 51, No.4, 1987, pp. 309-318.

2. Y. Katayama, M. Tsubota, Y. Saito, N. Tanaka, and S. Tanaka, "SCC Properties of Modified Alloy 718 in BWR Plant." 15th International Conference on Environmental Degradation Edited by J.T. Busby, G. Hevbare, and P.L. Andresen, TMS (The Minerals, Metals, and materials Society) 2011.

3. W. J. Mills and L. D. Blackburn, "Variations in Fracture Toughness for Alloy 718 Given a Modified Heat Treatment," J. Eng. Mater. Technol., January 1990, Volume 112, Issue 1, pp. 116-124.

F

BWRVIP RESPONSE TO NRC REQUEST FOR ADDITIONAL INFORMATION

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

2015-015 BWR Vessel & Internals Project (BWRVIP)

February 17, 2015

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

Attention: Joseph Holonich

Subject: Project No. 704 – BWRVIP Response to NRC Request for Additional Information on BWRVIP-84, Revision 2

Reference: Letter from Joseph J. Holonich (NRC) to Dennis Madison (BWRVIP Chairman), Request for Additional Information on BWRVIP [Boiling Water Reactor Vessel Internals Project]-84 Revision 2: "BWR Vessel and Internals Project, Guidelines for Selection and Use of Materials for Repairs to BWR Internal Components" (TAC NO. MF2154)," dated March 10, 2014.

Enclosed are five (5) copies of the BWRVIP proprietary response to the NRC Request for Additional Information (RAI) on the BWRVIP report entitled "BWRVIP-84, Revision 2: BWR Vessel and Internals Project, Guidelines for Selection and Use of Materials for Repairs to BWR Internal Components." The RAI was transmitted to the BWRVIP by the NRC letter referenced above.

Please note that the enclosed response contains proprietary information. A letter requesting that the response be withheld from public disclosure and an affidavit describing the basis for withholding this information are provided as Attachment 1. The response includes yellow shading and brackets to indicate the proprietary information. The proprietary information is also marked with the letters "TS" in the margin indicating the information is considered trade secrets in accordance with 10CFR2.390.

Two (2) copies of a non-proprietary version of the BWRVIP response to the RAI are also enclosed. This non-proprietary response is identical to the enclosed proprietary response except that the proprietary information has been deleted.

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BWRVIP 2015-015

If you have any questions on this subject please call Ron DiSabatino (Exelon, BWRVIP Assessment Committee Technical Chairman) at 717-456-3685.

Sincerely,

A. O. McGehee Tim Hanley

Andrew McGehee, EPRI, BWRVIP Program Manager
Tim Hanley, Exelon Corporation, BWRVIP Chairman

EPRI Proprietary Licensed Materials

Response to NRC Request for Additional Information (RAI) on
BWRVIP-84, Revision 2: BWR Vessel and Internals Project, Guidelines for Selection and Use of Materials for Repairs to BWR Internal Components

Proprietary Version

ENCLOSURE

EPRI Proprietary Information

BWRVIP Response to NRC Request for Additional Information (RAI) on BWRVIP-84, Revision 2

RAI:

Issue: In approving the LAR for the Alloy 718 material, the staff indicated that the microstructure was a key part of SCC resistance, and assurance through microstructural characterization of a relatively uniform microstructure (an average grain size of ASTM No. 2 to No. 6) allowed approval of the amendment.

Request: Provide a technical justification why a microstructural characterization is not included as a quality control check on each lot of heat treated components.

BWRVIP Response to RAI:

The BWRVIP agrees that a microstructural characterization of the material is appropriate. Consequently, it is proposed that the following paragraph be added to the Alloy 718 Appendix in BWRVIP-84, Revision 2:

D.5.4 Examination of Microstructure

Content Deleted -
EPRI Proprietary Information

G
RECORD OF REVISIONS – REVISION 1

BWRVIP-84-Revision 1	Information from the following documents was used in preparing the changes included in this revision of the report: 1. "BWR Vessel and Internals Project, Guidelines for Selection and Use of Material for Repairs to BWR Internal Components (BWRVIP-784)," EPRI Report 1000248, October 2000. 2. Letter from Carl Terry (BWRVIP Chairman) to C.E. Carpenter (NRC), "Project No. 704 – Revision to BWRVIP-84," March 26, 2002 (BWRVIP Correspondence File Number 2002-081) 3. Letter from Meena Khanna (NRC) to Carl Terry (BWRVIP Chairman), "Proprietary Request for Additional Information – Review of BWR Vessel and Internals Project Report, BWRVIP-84, Guidelines for Selection and Use of Methodology (sic) for Repairs" TAC No. MB9014, September 16, 2003 (BWRVIP Correspondence File Number 2003-331B). 4. Letter from William Eaton (BWRVIP Chairman) to Meena Khanna (NRC), "BWRVIP Response to NRC Request for Additional Information on BWRVIP-84," March 24, 2004 (BWRVIP Correspondence File Number 2004-101) 5. Letter from Matthew Mitchell (NRC) to Bill Eaton (BWRVIP Chairman), "Supplemental Request for Additional Information – Review of BWR Vessel and Internals Project Report, BWRVIP-84, Guidelines for Selection and Use of Material for Repairs," June 21, 2004 (BWRVIP Correspondence File Number 2004-283) 6. Letter from William Eaton (BWRVIP Chairman) to Meena Khanna (NRC), "Project NO. 704 – BWRVIP Response to NRC Supplementary Request for Additional Information on BWRVIP-84," July 30, 2004 (BWRVIP Correspondence File Number 2004-288). 7. Letter from William Bateman (NRC) to William Eaton (BWRVIP Chairman), "Proprietary Safety Evaluation of EPRI Proprietary Report "BWR Vessel and Internals Project, Guidelines for Selection and Use of Materials for Repairs to BWR Internals (BWRVIP-84), EPRI Report 1000248, October 2000," September 9, 2005 (BWRVIP Correspondence File Number 2005-390). 8. Letter from William Eaton (BWRVIP Chairman) to Matthew Mitchell (NRC), "Project 704 – BWRVIP Response to NRC Safety Evaluation of BWRVIP-84," December 5, 2006 (BWRVIP Correspondence File Number 2006-500). 9. Letter from Richard Libra (BWRVIP Chairman) to John Honcharik (NRC), "Project No. 704 – Revision to BWRVIP-84," August 27, 2007 (BWRVIP Correspondence File Number 2007-245) 10. Letter from Thomas Blount (NRC) to Rick Libra (BWRVIP Chairman), "Supplemental Safety Evaluation for Electric Power Research Institute Boiling Water Reactor (BWR) Vessel and Internals Project (BWRVIP) Topical Report (TR) "BWR Vessel and Internals Project, Guidelines for Selection and Use of Materials for Repairs to BWR Internals (BWRVIP-84," TAC No. MD3762," September 23, 2008 (BWRVIP Correspondence File Number 2008-276). Details of the revisions can be found in Table G-1.
END	

Table G-1
Revision details

Required Revision	Source of Requirement for Revision	Description of Revision Implementation
	Editorial	Section 1.1 revised to describe content of Revision 1
Add NRC correspondence	NRC Request	NRC correspondence added as Appendices D through I.
Revise Section B.8.9.4	NRC SE (2005-390) Item 3.6.3	EDM requirements revised in Section B.8.9.4 per letter 2002-081.
Revise Section A.9.3.1	BWRVIP letter to NRC (2007-245)	Section A.9.3.1 revised to allow crimping to secure bolted connections
Include guidance for design of creviced joints	NRC SE (2005-390) Item 3.8 and RAI Response (2004-101) Item 84-3	Section 4.4 added.
Include guidance for weld repair of irradiated material	NRC SE (2005-390) Item 3.4	Section 5.5 added.
Clarify general material requirements in Section 3	NRC SE (2005-390) Item 3.2.2 and RAI Response (2004-288) Item 84-1.	Section 3.2 revised.
Revise Section 1.4	NRC SE (2008-276) item OI 3.1(a).	"Exceptions" defined.
Revise section 1.4	NRC SE (2008-276) item OI 3.1(b)	Technical justification for deviation from guidelines clarified by BWRVIP in response to NRC RAI (BWRVIP letter 2006-500). In subsequent discussions with the NRC, the BWRVIP agreed to delete the discussion of temporary repairs in Section 1.4.
Revise Section 1.4	NRC SE (2008-276) item OI 3.1(c)	Documentation for use of "more stringent" material requirements clarified.
Add NEI-03-08 Implementation requirements	BWRVIP-94, Revision 1	Section 1.6 added.
Revise Section 5.4	NRC SE (2008-276) item OI 3.4	Paragraph revised to clarify use of Code Case N-516.
Revise Section A.9.2	NRC SE (2006-500 and 2008-276) item OI 3.5.2(a)	Section A.9.2 revised to clarify requirements for surface treatment.
Revise Section A.3.3	NRC SE (2008-276) item OI 3.5.2(b)	Section A.3.3 revised to clarify requirements for surface treatment.

Table G-1
Revision details (continued)

Required Revision	Source of Requirement for Revision	Description of Revision Implementation
Revise Section B.3.3	NRC SE (2008-276) item OI 3.6.2	Section B.3.3 revised to clarify requirements for surface treatment.
Revise Section C.3.3	NRC SE (2006-500 and 2008-276) item OI 3.7.1	Section C.3.3 revised to clarify requirements for surface treatment.
Revise allowable stress ratio for X-750 components for consistency with current BWRVIP position	BWRVIP letter 2010-279	Section B.3.1 revised.
Repair typo in section numbering in B.9.2.2	Editorial	Section number B.9.2.2 changed to B.9.1.2.
Include metric units	Editorial	Metric units included at multiple locations (changes not tracked)
Section C.2.1.2: Typo. Revise description of SFA-5.4	Editorial	Description of SFA-5.4 revised to indicate applicability to shielded metal arc welding
Section B.2.1: Delete B.2.1.5 "Section IX". Section IX is welding qualification. Welding is prohibited per Section B.8.2	Editorial	Section B.2.1.5 marked "Deleted"
Section A.4.1.2: Delete "308MoL. Not a recognized classification	Editorial	"308MoL" deleted.
END		

H
RECORD OF REVISIONS – REVISION 2

BWRVIP-84-Revision 2	Information from the following documents was used in preparing the changes included in this revision of the report: *BWRVIP-84, Revision 1: BWR Vessel and Internals Project: Guidelines for Selection and Use of Materials for Repairs to BWR Internal Components.* EPRI, Palo Alto, CA: 2011. 1022836. Details of the revisions can be found in Table H-1.
END	

Table H-1
Revision details

Required Revision	Source of Requirement for Revision	Description of Revision Implementation
	Editorial	Section 1.1 revised to describe content of Revision 2
Add E/ER309 filler metal	BWRVIP comment	Section A.4.1, A.4.2, and A.7.2: E/ER309 added as acceptable filler metal. "308MoL" deleted (typo).
Update Table A-1 (water quality requirements)	BWRVIP comment	Table A-1 updated for consistency with NQA-1 and to require that conductivity and pH be determined at 77-degrees F.
Revise X-750 bolt head forming specification	BWRVIP comment	Section B.3.2.2 revised to require full anneal prior to precipitation hardening
Correct typo in Table B-2: Cobalt maximum should be 0.25% consistent with footnote and NRC SE.	BWRVIP comment	Table B-2 revised
Update Table B-3 (water quality requirements)	BWRVIP comment	Table B-3 updated for consistency with NQA-1 and to require that conductivity and pH be determined at 77-degrees F.
Revise Section C.9.1.1 to allow tack welding with filler metal other than E/ER209.	BWRVIP comment	Section C.9.1.1 revised.
Update Table C-1 (water quality requirements)	BWRVIP comment	Table C-1 updated for consistency with NQA-1 and to require that conductivity and pH be determined at 77-degrees F.
Add requirements for Alloy 718	BWRVIP comment	Appendix D inserted: "Design, Procurement, Fabrication and Installation of Alloy 718 for Use in BWR Internals". Existing Appendices D through K renumbered.
END		

I

RECORD OF REVISIONS – REVISION 2-A

BWRVIP-84-Revision 2-A	Information from the following documents was used in preparing the changes included in this revision of the report: 1. *BWRVIP-84, Revision 2: BWR Vessel and Internals Project: Guidelines for Selection and Use of Materials for Repairs to BWR Internal Components*. EPRI, Palo Alto, CA: 2012. 1026603. 2. Letter from Joseph Holonich (NRC) to Dennis Madison (BWRVIP Chairman), *Request for the Review of Electric Power Research Institute Report, "BWRVIP [Boiling Water Reactor Vessel and Internals Project]-84, Revision 2: BWR Vessel and Internals Project, Guidelines for Selection and Use of Materials for Repairs to BWR Internal Components" (TAC NO. MF2154)*, March 10, 2014 (BWRVIP Correspondence File Number 2014-051). 3. Letter from Andrew McGehee (BWRVIP Program Manager) and Tim Hanley (BWRVIP Chairman) to Joseph Holonich (NRC), *Project No. 704 – BWRVIP Response to NRC Request for Additional Information on BWRVIP-84, Revision 2*, February 17, 2015 (BWRVIP Correspondence File Number 2015-019). 4. Letter from Mirela Gavrilas (NRC) to Tim Hanley (BWRVIP Chairman), *Safety Evaluation of "BWRVIP-84, Revision 2: BWR Vessel and Internals Project, Guidelines for Selection and Use of Materials for Repairs to BWR Internals" (EPRI Report 1026603 Ferurary 2013 (TAC NO. MF1456)*, August 24, 2015 (BWRVIP Correspondence File Number 2015-119). Details of the revisions can be found in Table I-1.
END	

Table I-1
Revision details

Required Revision	Source of Requirement for Revision	Description of Revision Implementation
Include NRC Safety Evaluation (SE), NRC Request for Additional Information (RAI) and BWRVIP Response to RAI	NRC request	SE added after Title Page; RAI and RAI Response added as Appendices E and F. Prior Appendices E through K deleted. Remaining Appendices relabeled.
Revise report history discussion at end of Section 1.1.		Text in Section 1.1 revised to include discussion of this latest revision and updated references to the modified Appendices.
Added Section D.5.4	BWRVIP RAI Response and NRC Safety Evaluation	Text provided in RAI response incorporated as new Section D.5.4.
Add Record of Revisions for BWRVIP-84-Rev.2-A	BWRVIP Protocol	Record of Revisions added as Appendix I. Note also added to "Record of Revisions" table in frontmatter.
END		

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