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Attention: Meena Khanna

Subject: Project No. 704 – BWR Vessel and Internals Project, Guidelines for Selection and Use of Materials for Repairs to BWR Internal Components (BWRVIP-84NP)

Reference: Letter from Carl Terry (BWRVIP) to Document Control Desk (NRC), "Project 704 – BWR Vessel and Internals Project, Guidelines for Selection and Use of Materials for Repairs to BWR Internal Components (BWRVIP-84), EPRI Report 1000248, October 2000," dated November 6, 2000.

Enclosed are two (2) copies of the report "BWR Vessel and Internals Project, Guidelines for Selection and Use of Materials for Repairs to BWR Internal Components (BWRVIP-84NP)," EPRI Technical Report 1000248NP, January 2005. This is a non-proprietary version of the proprietary document submitted to the NRC by the letter referenced above.

If you have any questions on this subject please call Robin Dyle (Southern Nuclear, BWRVIP Integration Committee Technical Chairman) at 205.992.5885.

Sincerely,

William A Eaton

William A. Eaton
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BWR Vessel and Internals Project Guidelines for Selection and Use of Materials for Repairs to BWR Internal Components (BWRVIP-84NP)

Technical Report

BWR Vessel and Internals Project Guidelines for Selection and Use of Materials for Repairs to BWR Internal Components (BWRVIP-84NP)

1000248NP

Final Report, January 2005

EPRI Project Manager
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ORGANIZATION(S) THAT PREPARED THIS REPORT:

Guardian Metallurgy, Inc.
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The report is a corporate document that should be cited in the literature in the following manner:

BWR Vessel and Internals Project: Guidelines for Selection and Use of Materials for Repairs to BWR Internals (BWRVIP-84NP), EPRI, Palo Alto, CA and BWRVIP: 2000. 1000248NP.

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.

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 three specific material types most often used for in-vessel repairs—300 Series austenitic stainless steel, Alloy X-750, and Type XM-19 austenitic stainless steel. 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, 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
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BWR internals

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1
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.

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. Each exception must be specifically identified and justified, approved by the plant owner, and identified to the NRC as an exception in the submittal covering the repair.
- Material utilized for temporary repairs may deviate from these guidelines as long as the exceptions are identified, and repair life limitations consistent with the specific design and material utilized, are imposed.
- Establishment of more stringent (conservative) requirements by the plant owner is not considered an exception.

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.

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 Section II specifications, ASME Code Cases, ASTM specifications, or other material specifications that have been previously accepted by the regulatory authorities. 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.

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.

5
GENERAL WELDING AND FABRICATION GUIDELINES

5.1 The design shall minimize welding. If the design uses welded components, then configurations, materials, and techniques that specifically minimize the susceptibility of the weldments to IGSCC and IASCC shall be used.

5.2 Care shall be taken during fabrication to prevent carbon steel contamination of 300 Series and equivalent cast alloy and type XM-19 austenitic stainless steel and nickel alloys that will be wetted by reactor coolant.

5.3 Miscellaneous process materials shall be controlled to prevent contamination of new and existing components. Miscellaneous process materials include such items as machining lubricants, liquid penetrants, solvents, tapes, ultrasonic testing couplant, abrasive grit, packing materials, marking materials, weld spatter compounds, and other materials that will be in contact with new and existing components. The known contaminants of concern are chlorides, fluorides, bromides, sulfur, cadmium, zinc, lead, tin, mercury, bismuth and copper. In addition, when welding or heat treating is involved, all carbonaceous material and phosphates must be considered harmful.

5.4 Underwater groove and fillet welding shall be in accordance with Code Case N-516-1. Underwater tack welding applications shall be demonstrated with a mockup to be capable of withstanding the specified torque or load without breaking prior to use.

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

**Content Deleted -
EPRI Proprietary Information**

A.3.2 Bolting

**Content Deleted -
EPRI Proprietary Information**

A.3.3 Surface Roughness

**Content Deleted -
EPRI Proprietary Information**

A.4 Material Procurement

A.4.1 Material Specifications

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A.4.2 Chemical Requirements

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A.5 Solution Heat Treatment

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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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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

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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 Section IX

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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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

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B.4.2 Chemical Requirements

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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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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

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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 Bare Stainless Steel Welding Electrodes and Rod.

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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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

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Target:
Nuclear Power

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EPRI creates science and technology solutions for the global energy and energy services industry. U.S. electric utilities established the Electric Power Research Institute in 1973 as a nonprofit research consortium for the benefit of utility members, their customers, and society. Now known simply as EPRI, the company provides a wide range of innovative products and services to more than 1000 energy-related organizations in 40 countries. EPRI's multidisciplinary team of scientists and engineers draws on a worldwide network of technical and business expertise to help solve today's toughest energy and environmental problems.

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