September 6, 2005

Bill Eaton, BWRVIP Chairman
Entergy Operations, Inc.
Echelon One
1340 Echelon Parkway
Jackson, MS 39213-8202

SUBJECT: NON-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"

Dear Mr. Eaton:

The Nuclear Regulatory Commission (NRC) staff has completed its review of the Electric Power Research Institute (EPRI) proprietary report, "BWR Vessel and Internals Project, Guidelines for Selection and Use of Materials for Repairs to BWR Internals, BWRVIP-84," dated October 2000. This report was submitted for NRC staff review and approval by letter dated November 6, 2000, and supplemented by letters dated March 26, 2002, March 24, 2004, and July 30, 2004. This report provides guidance for the selection and use of materials for repair/replacement of the specific Boiling Water Reactor (BWR) internal components, and is applicable to General Electric BWR/2-6's that are implementing repairs or replacements consistent with the Boiling Water Reactor Vessel and Internals Project (BWRVIP) Repair/Replacement Design Criteria (RDC) for components that are operated in compliance with the BWRVIP Water Chemistry Guidelines.

The NRC staff has reviewed your submittal and the staff's safety evaluation is attached. Please contact Meena Khanna of my staff at 301-415-2150 if you have any further questions regarding this subject.

Sincerely,

***/(RA by W. Bateman)/***

William H. Bateman, Chief
Materials and Chemical Engineering Branch
Division of Engineering
Office of Nuclear Reactor Regulation

Enclosure: As stated

cc: BWRVIP Service List

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U.S. NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
SAFETY EVALUATION OF THE "BWRVIP VESSEL AND INTERNALS PROJECT, GUIDELINES FOR SELECTION AND USE OF MATERIALS FOR REPAIRS TO BWR INTERNALS (BWRVIP-84)," EPRI REPORT 1000248

# 1.0 INTRODUCTION

## 1.1 Background

By letter dated November 6, 2000, as supplemented by letters dated March 26, 2002, March 24, 2004, and July 30, 2004, the Boiling Water Reactor Vessel and Internals Project (BWRVIP) submitted for staff review and approval the Electric Power Research Institute (EPRI) proprietary report 1000248, "BWR Vessel and Internals Project, Guidelines for Selection and Use of Materials for Repairs to BWR Internals (BWRVIP-84)," dated October 2000.
The BWRVIP-84 report was submitted as a means of exchanging information with the staff for the purpose of supporting generic regulatory improvements related to the repair of reactor vessel internals (RVI) components covered by existing and future BWRVIP repair/replacement design criteria (RDC) that have been reviewed and approved by the NRC staff.
The BWRVIP-84 report provides guidance on the selection and use of materials for the repair/replacement of RVI components. BWRVIP-84 is applicable to General Electric BWR/2-6's that are implementing RVI component repairs/replacements consistent with the BWRVIP RDC and which are operated in compliance with the BWRVIP Water Chemistry Guidelines.

## 1.2 Purpose

The staff reviewed the BWRVIP-84 report to determine whether it will provide an acceptable technical justification for the selection and use of materials for repair/replacement of the subject RVI components. The report assesses the design and regulatory basis for the selection of materials for the purpose of the repair/replacement of BWR RVI components. The report addresses general guidelines for materials selection, welding, and fabrication considering, in particular, concerns regarding susceptibility to intergranular stress corrosion cracking (IGSCC) and irradiation assisted stress corrosion cracking (IASCC). Finally, the report provides specific design, procurement, fabrication, and installation guidelines for 300 series or equivalent grade of cast austenitic stainless steel, Alloy X-750, and Type XM-19 austenitic stainless steel materials.

## 1.3 Organization of this Report

A brief summary of the contents of the subject report is given in Section 2 of this safety evaluation (SE), with the evaluation presented in Section 3. The conclusions are summarized in Section 4. The presentation of the evaluation is structured according to the organization of the BWRVIP-84 report.

ENCLOSURE

## 2.0 SUMMARY OF BWRVIP-84 REPORT

The BWRVIP-84 report addresses the following topics in the following order:

- Introduction - discusses the purpose of this document, guidelines for application of materials for the RVI components, scope and applicability of the RDC and exceptions to the design criteria.

- Design and Regulatory Basis - discusses the usage of American Society of Mechanical Engineers (ASME) construction code requirements, ASME Code Cases, American Society for Testing and Materials (ASTM) specifications, or other material specifications that have been previously accepted by the regulatory authorities in selecting materials to be utilized in repair/replacement activities. If the material has not been pre-approved, it is necessary for the proposed design to 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 RDC topical report.

- General Material Guidelines - requires that new or replacement materials be demonstrated to be highly resistant to IGSCC and IASCC, and be suitable for BWR reactor environmental conditions.

- General Welding and Fabrication Guidelines - discusses requirements to minimize the susceptibility of weldments to IGSCC and IASCC, and requires that underwater welding be performed in accordance with ASME Code Case N-516-1.

- Design, Procurement, Fabrication, and Installation of 300 Series or Cast Equivalent Austenitic Stainless Steel for Use in BWR Internals - provides minimum requirements for design, procurement, fabrication, and installation of 300 series or equivalent grade of cast austenitic stainless steel plate, forgings, bar, castings, pipe, and associated weld metal for BWR RVI components.

- Design, Procurement, Fabrication, and Installation of Alloy X-750 for Use in BWR Internals - provides minimum requirements for design, procurement, fabrication, and installation of Alloy X-750 forgings, bar, plate, strip, and sheet for BWR RVI components.

- Design, Procurement, Fabrication, and Installation of Type XM-19 Austenitic Stainless Steel for Use in BWR Internals - 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 RVI components.

## 3.0 STAFF EVALUATION

The BWRVIP-84 report proposes guidance for the selection and use of materials for repair/replacement of specific BWR RVI components that have associated staff-approved BWRVIP RDC. The guidance is intended to be consistent with the design objective of a permanent repair/replacement that requires minimum inspection for the life of the repair/replacement and to reflect good materials application practice that is independent of the RDC. Further, the materials guidance incorporates, either directly or by reference, industry guidance that was intended to cover a broad range of BWR materials applications enveloping, but not specific to, the ex-core (outside the core region) BWR environment. This guidance is intended to be incorporated by reference into individual RDC documents.

### 3.1 Introduction

This section addresses the scope and applicability of this document for the design, procurement, and installation requirements of materials for RVI components. Material selection is based on the requirements of the BWRVIP RDC for any given RVI components. This section also discusses the requirements for exceptions to the guidance of this document that are permitted under certain conditions. The staff, based on its review, finds that this section adequately addresses scope and applicability of this document for the design, procurement, and installation requirements of materials for the RVI components. However, the staff requires that the BWRVIP modify this section of the BWRVIP-84 report to include the following statements:

- Exceptions to this document are considered exceptions to the RDC, with each exception to be specifically identified and justified, approved by the plant owner, and submitted for NRC review and approval in the submittal covering the repair/replacement.

- Material utilized for temporary repair/replacements may deviate from these guidelines as long as a technical justification for the deviation is pre-approved by the staff. The technical justification shall demonstrate that the material complies with the design criteria and that it has adequate corrosion resistance in a BWR environment. In addition, the technical justification shall provide adequate assurance that the material used in RVI components shall maintain its integrity under service conditions and that the intended function of the RVI component shall be maintained during plant operation. Prior approval by the staff is required when a material that does not comply with the BWRVIP-84 guidelines is used for temporary repair/replacement of RVI components.

In addition, the staff recommends that the BWRVIP incorporate the following statements that would allow for exceptions or deviations to the guidance in this section of the BWRVIP-84 report:

- 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.

- No modification of existing repair/replacement hardware is required by this document. The staff finds this provision acceptable, with the following modification to the end of the item: “... unless there is an open item related to the materials requirements in the staff SE of a specific RDC.”

The staff requests that the BWRVIP revise the BWRVIP-84 report to include the aforementioned clarifications. With the above modifications, the staff finds this section acceptable.

3.2 Design and Regulatory Basis

This BWRVIP-84 report provides discussion of the material selection requirements for the design and construction of the RVI components. This section adequately addresses BWRVIP RDC for ASME Code Section XI and non-ASME Code repair/replacements of the RVI components, which are addressed in Section 3.2.1 of this SE. In this section the BWRVIP discusses the applicability of ASME Section II, “Material Specifications,” which is discussed further in Section 3.2.2 of this SE. In addition, it provides technical requirements for the selection of austenitic stainless steel components that can exhibit resistance to IGSCC in the reactor coolant system (RCS) water. Historically, stainless steel materials in the RVI components experience IGSCC in the sensitized heat affected zone (HAZ) near the weld region and in stainless steel weld metals with lower delta ferrite contents.

[ ]. The technical guidelines provided in this section of the BWRVIP-84 report address these issues and provide adequate guidance for the licensees in the selection of stainless materials that are more resistant to IGSCC. The BWRVIP-84 report also invokes the requirements of Regulatory Guide 1.44, “Control of the Use of Sensitized Stainless Steel,” and NUREG-0313, Revison 2, “Technical Report on Material Selection and Processing Guidelines for BWR Coolant Pressure Boundary Piping.” Regulatory Guide 1.44 provides extensive guidelines for minimizing the occurrence of sensitized microstructure in the HAZ of the stainless steel welds. NUREG-0313, Revision 2, provides adequate guidelines for the selection of corrosion resistant stainless steel materials that are exposed to BWR environment. The staff finds that this section adequately addresses the design and regulatory basis for the RVI components.

3.2.1 BWRVIP Repair/Replacement Design Criteria for ASME Section XI and Non-Code Repair/Replacements:

The staff finds that the RVI component materials that were designed and constructed in accordance with ASME Section III requirements and applicable provisions of ASME Section XI repair/replacement programs are acceptable. The report also indicates that the materials that

were not designed and constructed in accordance with ASME Section III requirements must meet the plant final safety analysis report (FSAR) and other plant commitments for the RVI’s design requirements.

3.2.2 Applicability of ASME Section II for the Reactor Vessel Internal Components:

In a supplementary request for additional information, dated June 21, 2004, the staff requested that the BWRVIP revise the report to indicate that the RVI must meet the requirements of ASME Code Section II specifications, ASME equivalent ASTM specifications, ASME Code Cases approved by the NRC staff in Regulatory Guide (RG) 1.147, “Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1," material specifications used during original fabrication, or other material specifications that have been previously accepted by the staff. In a response dated July 30, 2004, the BWRVIP stated that it will revise the report as suggested by the staff and plans to include materials approved in Regulatory Guide 1.84, “Design and Fabrication and Materials Code Case Acceptability, ASME Section III.” In addition, the BWRVIP proposed to add the following statements to the Section 3.2 of the BWRVIP-84 report to clarify the use of materials for repair/replacement of ASME Section XI and non-ASME Section XI components.

> 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.

The staff finds that this section, with the modifications above, is acceptable because all materials in RVI components will comply with the requirements of staff-approved specifications. The staff requests that the BWRVIP revise the BWRVIP-84 report to include the clarifications that are provided above. In addition, this section is consistent with, and incorporates comments made in previous staff SEs for several BWRVIP RDC (e.g., BWRVIP-56 and -57), and, as such, is acceptable.

3.3 General Material Guidelines

The selection of the materials is based on their mechanical properties, corrosion resistance characteristics, and suitability of application in the RCS environment. In addition, this section addresses technical guidelines for the selection of new materials for repair/replacement of the RVI components. These guidelines mandate the use of materials that are more resistant to IGSCC and IASCC in the BWR reactor environment. Compliance with the requirements specified in this section provides adequate assurance that these materials will perform satisfactorily when they are exposed to the BWR environment. Therefore, the staff finds that this section is acceptable, provided the following clarification is added to it in the BWRVIP-84 revised report:

> "If the material to be utilized is not resistant (i.e., non-L grade type 304/316 material) to IGSCC or IASCC, or is not suitable for BWR reactor environmental conditions, the licensee will evaluate and justify the usage of the material on a case-by-case basis and will submit the proposal for staff approval prior to initiation of the repair/replacement."

The staff believes that this clarification provides added assurance that regulatory approval is required when materials that do not have adequate resistance to IGSCC or IASCC are used for RVI components. With the above modification, the staff finds this section acceptable.

3.4 General Welding and Fabrication Guidelines

This section provides general guidelines for welding and fabrication of stainless steel and nickel-alloy RVI components. [ ]. This section also addresses the use of ASME Section XI Code Case N-516-1, "Underwater Welding," for underwater welding of the RVI components. This code case provides requirements for the underwater welding process qualifications and weld inspections. With the exception of the conditions noted below, compliance with the requirements that are provided in Code Case N-516-1 will ensure adequate quality of welds fabricated under water.

Previous research work on underwater welding of stainless steel materials that are exposed to high levels of radiation indicated that these welds are prone to cracking and that the severity of cracking depends on the original boron concentration of the stainless steel materials. In a letter dated September 16, 2003, the staff requested the BWRVIP to address the underwater welding of irradiated materials using ASME Section XI, Code Case N-516-1. In a response dated March 24, 2004, the BWRVIP addressed this issue by proposing to add the following paragraph to Section 5 of the BWRVIP-84 report:

> Paragraph 5.5: Weld repair/replacement of irradiated materials requires special considerations. The guidance contained in BWRVIP-97, "BWR Vessel and Internals Project, Guidelines for Performing Weld Repair Replacements to Irradiated BWR Internals", which is currently under review by the NRC, shall be implemented in conjunction with welded repair/replacements.

The staff finds that this response is acceptable because the BWRVIP's proposal adequately addresses the difficulties associated with underwater welding of irradiated stainless steel. The staff requires that the BWRVIP revise the BWRVIP-84 report to include the aforementioned clarifications. The staff further requires that the BWRVIP revise this section of the BWRVIP-84 report to include a reference to the BWRVIP-44 report, "BWR Vessel and Internals Project, Underwater Weld Repair of Nickel Alloy Reactor Vessel Internals," and the ASME Section XI Code Case N-516-2 which was approved by the staff in Regulatory Guide 1.147, Revision 13, with a limitation requiring the staff's prior approval of its use for underwater weld repairs/replacements of irradiated materials. With the above modifications, the staff finds this section acceptable.

3.5 Design, Procurement, Fabrication, and Installation of 300 Series or Cast Equivalent Austenitic Stainless Steel for Use in BWR Internals

This section covers the selection, fabrication, procurement, and installation of 300 series austenitic stainless steel materials for repair/replacement of the RVI components. This section

mandates that the stainless steel materials be procured in accordance with approved ASME materials specifications. Approved ASME materials not only meet the design criteria but also comply with stringent testing requirements commensurate with the ASME Code. Compliance with these requirements provides adequate assurance that the selected materials will meet the necessary design criteria of the RVI components. In addition, compliance with these requirements provides reasonable assurance that the materials will maintain good corrosion resistance so that the occurrence of IGSCC is minimized when they are exposed to the BWR environment. The requirements specified in this section also comply with the NUREG-0313, Revision 2 criteria. Therefore, the staff finds that this section adequately addresses the selection, fabrication, procurement, and installation requirements for austenitic stainless steel materials that are used for the RVI components. The staff finds this section acceptable provided some clarifications related to the following issues are addressed in the BWRVIP-84 revised report.

3.5.1- Use of cast austenitic stainless steel materials for the jet pump assemblies:

The BWRVIP-84 report does not discuss, in detail, inspections of cast austenitic stainless steel (CASS) components. The staff requires that the BWRVIP modify the BWRVIP-84 report to reference the BWRVIP-41 report, "BWR Jet Pump Assembly Inspection and Flaw Evaluation Guidelines," which discusses the susceptibility of CASS components to IGSCC and neutron and/or thermal embrittlement effects and provides specific inspection and evaluation guidelines.

3.5.2- Surface preparation of the cold worked austenitic stainless steel materials:

In a letter dated September 16, 2003, the staff requested that the BWRVIP address the proper mitigation techniques that can be implemented on cold-worked stainless steel materials that are not solution annealed. In a response dated March 24, 2004, the BWRVIP addressed this issue by proposing to add the following paragraph to Section A.9.2 of the BWRVIP-84 report which addresses cold work criteria for the stainless steel components:

[ ]

The staff believes that the application of the aforementioned surface preparation techniques on the cold worked stainless steel materials will remove the cold worked surface condition, which in turn reduces the susceptibility to stress corrosion cracking and fatigue cracking. Therefore, the staff recommends that the additional requirements that are stipulated in Section A.9.7 of the BWRVIP-84 report shall apply for the subsequent surface preparation of the cold worked stainless steel materials.

In a letter dated September 16, 2003, the staff requested that the BWRVIP address the surface finish criteria for components that are prone to fatigue and IGSCC failures. In a response dated March 24, 2004, the BWRVIP addressed this issue by proposing to add the following paragraph to section A.3.3 of the BWRVIP-84 report, which addresses the effect of surface roughness on IGSCC and fatigue cracking in austenitic stainless steel materials.

"The surface finishing techniques described in Section A.9.2 may be considered for these applications. When surface finishing is performed per the guidance of Section A.9.2, the additional requirements of Section A.9.7 shall also be applied."

Section A.9.2. addresses surface preparation techniques that are to be implemented on the cold worked stainless steel materials. The staff believes that the surface finishing techniques that are stipulated in Section A.9.2 is essential in achieving quality surface finish which is essential in reducing cracking susceptibility due to IGSCC or fatigue. Therefore, the staff requests that the BWRVIP revise the aforementioned BWRVIP proposal (first sentence) dated March 24, 2004, to read as follows:

"The surface finishing techniques described in Section A.9.2 shall be implemented, as necessary, to minimize material susceptibility to IGSCC and fatigue cracking."

The staff finds this response, with the above modifications (including staff's recommendation), acceptable because it provides guidance for maintaining a good surface finish which is essential in minimizing the potential for cracking due to IGSCC and fatigue. The staff requests that the BWRVIP include its response dated March 24, 2004, in Section A of the BWRVIP-84 report.

3.5.3 - Incorporation of the previous EPRI guidelines for the stainless steel materials into the BWRVIP-84 report:

By letter dated June 21, 2004, the staff requested that the BWRVIP reference EPRI #84-MG-18, "Nuclear Grade Stainless Steel Procurement, Manufacturing and Fabrication Guidelines," in the BWRVIP-84 report. In its response dated July 30, 2004, the BWRVIP stated that EPRI #84-MG-18 was developed prior to the BWRVIP-84 report and that the relevant aspects of this document are included in the current version of the BWRVIP-84 report. Consequently, EPRI #84-MG-18 is not referenced in the BWRVIP-84 report. The staff has concluded that the BWRVIP-84 report provides extensive guidelines for the selection of corrosion resistant stainless steel materials, stainless steel weld materials (with a minimum delta ferrite requirement), and fabrication of these materials for RVI components. The staff has concluded that compliance of these guidelines will ensure adequate performance of the RVI components during their service in the BWR environment. The staff finds this section acceptable.

## 3.6 Design, Procurement, Fabrication, and Installation of Alloy X-750 for Use in BWR Internals

This section covers the selection, fabrication, procurement, and installation of Alloy X-750 components for repair/replacement of the RVI components. This section mandates that Alloy X-750 materials be procured in accordance with approved ASME materials specifications. Approved ASME materials not only meet the design criteria but also comply with stringent testing requirements commensurate with the ASME Code. Compliance with these requirements provides adequate assurance that the selected materials will meet the necessary

design criteria of RVI components. In addition, this section mandates requirements related to the enhancement of corrosion resistance for the Alloy X-750 material in the RVI components. Compliance with these requirements provides reasonable assurance that the materials will have good corrosion resistance so that the occurrence of IGSCC is minimized when they are exposed to the BWR environment. In addition, Alloy X-750 materials that comply with these requirements possess sound mechanical properties which in turn enhances their performance during the service in the BWR environment. Therefore, the staff finds that this section adequately addresses the design, procurement, fabrication, and installation requirements for Alloy X-750 materials that are used for the RVI components. The staff finds this section acceptable provided some clarifications related to the following issues are addressed in the BWRVIP-84 revised report.

3.6.1-Incorporation of the previous EPRI guidelines for the Alloy X-750 materials into the BWRVIP-84 report:

By letter dated June 21, 2004, the staff requested that the BWRVIP reference EPRI-7032, "Material Specification for Alloy X-750 for use in LWR Internal Components, Revision 1" in the BWRVIP-84 report. In its response dated July 30, 2004, the BWRVIP stated that the EPRI-7032 report was developed prior to the BWRVIP-84 report, and the relevant aspects of EPRI-7032 are included in the current version of the BWRVIP-84 report. Consequently, EPRI-7032 report is not referenced in the BWRVIP-84 report.

The staff believes that the BWRVIP-84 report provides extensive guidelines for the selection of corrosion resistant Alloy X-750 materials and fabrication of these materials for the RVI components. The staff believes that compliance of these guidelines ensures adequate performance of the Alloy X-750 in the RVI components during the service in the BWR environment. The staff finds this section acceptable.

3.6.2-Surface preparation of the cold worked Alloy X-750 materials:

In a letter dated September 16, 2003, the staff requested that the BWRVIP address the surface finish criteria for components that are prone to fatigue and IGSCC failures. In its response dated March 24, 2004, the BWRVIP addressed this issue, by proposing to add the following paragraph to section B.3.3 which addresses effect of surface roughness on IGSCC and fatigue cracking in Alloy X-750 material:

> "The surface finishing techniques described in Section B.8.9 may be considered for these applications. When surface finishing is performed per the guidance of Section B.8.9, the shot peening requirements of Section B.8.5 may also be applied".

Section B.8.9 addresses surface preparation techniques that are to be implemented on cold worked Alloy X-750 material. The staff believes that the surface finishing techniques that are stipulated in Section B.8.9 are essential in achieving quality surface finish which reduces cracking susceptibility due to IGSCC or fatigue. Therefore, the staff requests that the BWRVIP revise the aforementioned BWRVIP proposal (first sentence) dated March 24, 2004, to read as follows:

"The surface finishing techniques described in Section B.8.9 shall be implemented, as necessary, to minimize material susceptibility to IGSCC and fatigue cracking."

Compliance with the additional requirements that are stipulated in Section B.8.9 provides additional assurance in obtaining an acceptable surface finish so that the susceptibility of Alloy X-750 material to stress corrosion and fatigue cracking is minimized. The staff finds this response, as modified above (including staff's recommendation), acceptable because it provides guidance for maintaining a good surface finish which is essential in resisting cracking due to IGSCC and fatigue. The staff requests that the BWRVIP include its response dated March 24, 2004, in Section B of the BWRVIP-84 report.

3.6.3-Electrical Discharge Machining (EDM) of Alloy X-750 Materials:

In accordance with the supplemental BWRVIP letter dated March 26, 2002, Section B.8.9.4 of the BWRVIP-84 report is revised to read as follows:

[ ]

With the above modification, the staff finds this section acceptable.

## 3.7 Design, Procurement, Fabrication, and Installation of Type XM-19 Austenitic Stainless Steel for Use in BWR Internals

This section covers the selection, fabrication, procurement, and installation of Type XM-19 austenitic stainless steel components for repair/replacement of the RVI components. This section mandates that XM-19 material be procured in accordance with approved ASME materials specifications. Approved ASME materials not only meet the design criteria but also comply with stringent testing requirements commensurate with the ASME Code. Compliance with these requirements provides adequate assurance that the selected materials will meet the necessary design criteria of RVI components. In addition, this section mandates requirements related to the enhancement of corrosion resistance for the stainless steel RVI components. Compliance with these requirements provides reasonable assurance that the materials will have good corrosion resistance and sound mechanical properties so that their performance during service is adequately maintained in the BWR environment. Therefore, the staff finds that this section adequately addresses the design, procurement, fabrication, and installation requirements for XM-19 materials that are used for the RVI components. The staff finds this section acceptable provided some clarifications related to the following issues are addressed in the BWRVIP-84 revised report.

3.7.1-Surface preparation of the cold worked austenitic stainless steel Type XM-19 materials:

Section 3.5.2 of this SE addresses the surface finishing techniques that are to be implemented to minimize the susceptibility of cold worked austenitic stainless steel materials to IGSCC and fatigue cracking. The staff recommends that all the requirements in Section 3.5.2 of this SE will apply for Type XM-19 austenitic stainless steel components.

In a letter dated September 16, 2003, the staff requested that the BWRVIP address the surface finish criteria for components that are prone to fatigue and IGSCC failures. In a response dated March 24, 2004, the BWRVIP addressed this issue by proposing to add the following paragraph to section C.3.3 which addresses effect of surface roughness on IGSCC and fatigue cracking in XM-19 material:

[ ]

The staff believes that the surface finishing techniques that are stipulated in BWRVIP proposal are essential in achieving quality surface finish which reduces cracking susceptibility due to IGSCC or fatigue. Therefore, the staff requests that the BWRVIP revise the aforementioned BWRVIP proposal (first sentence) dated March 24, 2004, to read as follows:

[ ]

Compliance with the additional requirements that are stipulated in Section C.9.6 provides adequate assurance in obtaining acceptable surface finish so that the susceptibility of stainless steel materials to IGSCC and fatigue cracking is minimized. The staff finds this response, as modified above (including staff's recommendation), acceptable because it provides guidance for maintaining a good surface finish which is essential in minimizing the potential for cracking due to IGSCC and fatigue. The staff requests that the BWRVIP include its response dated March 24, 2004, in Section C of the BWRVIP-84 report. With the above modification, the staff finds this section acceptable.

3.8 Presence of Crevice in the Reactor Pressure Vessel Internal Components

By letter dated September 16, 2003, the staff requested that the BWRVIP address the issue related to the presence of crevices that are inherently present in RVI components. Previous experience indicates that the presence of crevices in the RVI components can cause stress corrosion cracking in austenitic stainless steel and high-nickel alloy materials when exposed to an oxygenated RCS water environment. The BWRVIP in its response dated March 24, 2004, provided criteria for crevice geometry that can be used by the licensees in their RDC. According to the BWRVIP, the crucial variables that effect the design of the crevice include implementation of mitigation techniques such as hydrogen water chemistry, location in the RVI components, and local RCS water flow rate. The BWRVIP stated that the licensees can use these variables in developing a plant-specific crevice design. The BWRVIP also stated that by using an appropriate analysis an acceptable plant-specific crevice geometry can be designed. The BWRVIP recommended that in the absence of a plant-specific or vendor-specific crevice criteria, the criteria shown in Figure 1 of the BWRVIP's March 24, 2004 response may be used. The crevice geometry shown in the Figure 1 of the response provides general guidelines in selecting the optimum crevice design criteria for the RVI components under normal water conditions (NWC). The staff believes that this response provides acceptance criteria for the geometric configuration of the crevices that are inherently present in RVI components, and implementation of appropriate crevice design facilitates a condition that will reduce the potential for crevice-induced SCC in RVI components. Therefore, the staff finds the response acceptable because these guidelines provide extensive guidance for the development of an acceptable plant-specific crevice design for the RVI components.

The staff requests that the BWRVIP include its March 24, 2004, response regarding this issue (including Figure 1) in the BWRVIP-84 report. With the above modification, the staff finds this section acceptable.

3.9 Non-Destructive Examination (NDE)

The BWRVIP-84 report does not discuss in detail NDE requirements for the various materials to be used in repair/replacements. The staff requests that the report be modified to more fully address generic inspection guidance and methodology that should be utilized in the repair/replacements. This can be accomplished by reference to an appropriate revision of the "BWR Vessel and Internals Project, Reactor Pressure Vessel and Internals Examination Guidelines (BWRVIP-03)." The recommendations specified in either the appropriate revision of the BWRVIP-03 or BWRVIP-84 reports should be implemented and cited, wherever appropriate, to ensure consistency with prior NRC-approved inspection guidelines pertaining to BWR internal components.

4.0 CONCLUSIONS

The NRC staff has reviewed the BWRVIP-84 report and the supplemental information that was transmitted by letters dated March 26, 2002, March 24, 2004, and July 30, 2004, and found that the report, as modified and clarified to incorporate the staff's recommendations and deviations, provides an acceptable technical justification for the selection and use of materials for repair/replacement of the RVI components. The supplemental information that was provided in response to the staff's RAIs should be incorporated in a revision or the -A version of the BWRVIP-84 report. In addition, the modifications addressed below should be incorporated in a revision or the -A version of the BWRVIP-84 report. The BWRVIP-84 report is considered by the staff to be acceptable for licensee usage, as modified by the staff requirements and recommendations given below, at any time during either a facility's current operating term or extended license period.

The staff requires that the BWRVIP modify Section 3.1 of the BWRVIP-84 report to include the following statements:

> Exceptions to this document are considered exceptions to the RDC, with each exception to be specifically identified and justified, approved by the plant owner, and submitted for NRC review and approval in the submittal covering the repair/replacement.
>
> Material utilized for temporary repair/replacements may deviate from these guidelines as long as a technical justification for the deviation is pre-approved by the staff. The technical justification shall demonstrate that the material complies with the design criteria and that it has adequate corrosion resistance in a BWR environment. In addition, the technical justification shall provide adequate assurance that the material used in RVI components shall maintain its integrity under service conditions and that the intended function of the RVI component shall be maintained during plant operation.
>
> Prior approval by the staff is required when a material that does not comply with the BWRVIP-84 guidelines is used for temporary repair/replacement of RVI components.

The staff requires that the BWRVIP modify Section 3.3 of the BWRVIP-84 report to add a clarification to indicate the following:

> "If the material to be utilized is not resistant (i.e., non-L grade type 304/316 material) to IGSCC or IASCC, or is not suitable for BWR reactor environmental conditions, the licensee will evaluate and justify the usage of the material on a case-by-case basis and will submit the proposal for staff approval prior to initiation of the repair/replacement."

The staff requires that the BWRVIP modify Section 3.4 of the BWRVIP-84 report to include a reference to the BWRVIP-44 report, "BWR Vessel and Internals Project, Underwater Weld Repair of Nickel Alloy Reactor Vessel Internals," and the ASME Section XI Code Case N-516-2, which was approved by the staff in Regulatory Guide 1.147, Revision 13, with a limitation requiring the staff's prior approval if its use for underwater weld repairs/replacements of irradiated materials.

In addition, the staff requires that the BWRVIP modify Section 3.5.1 of the BWRVIP-84 report to reference the BWRVIP-41 report, "BWR Jet Pump Assembly Inspection ad Flaw Evaluation Guidelines," which discusses the susceptibility of CASS components to IGSCC and neutron and/or thermal embrittlement effects and provides specific inspection and evaluation guidelines.

In addition, the staff recommends that the BWRVIP incorporate the following statements that would allow for exceptions or deviations to the guidance in Section 3.1 of the BWRVIP-84 report:

> 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.
>
> No modification of existing repair/replacement hardware is required by this document. The staff finds this provision acceptable, with the following modification to the end of the item: "... unless there is an open item related to the materials requirements in the staff SE of a specific RDC."

The staff recommends that, with respect to Section 3.5.2 of the BWRVIP-84 report, that the BWRVIP revise its proposal as stated in its March 24, 2004 letter, to read as follows:

> "The surface finishing techniques described in Section A.9.2 shall be implemented, as necessary, to minimize material susceptibility to IGSCC and fatigue cracking."

The staff recommends that, with respect to Section 3.6.2 of the BWRVIP-84 report, that the BWRVIP revise its proposal as stated in its March 24, 2004 letter, to read as follows:

> "The surface finishing techniques described in Section B.8.9 shall be implemented, as necessary, to minimize material susceptibility to IGSCC and fatigue cracking."

The staff recommends that, with respect to Section 3.7.1 of the BWRVIP-84 report, that the BWRVIP revise its proposal as stated in its March 24, 2004 letter, to read as follows:

"Surface finishing techniques involving the use of flappers, controlled machining in accordance with demonstrated procedures, mechanical polishing or electropolishing, among others shall be implemented, as necessary, to minimize material susceptibility to IGSCC and fatigue cracking."

Lastly, the staff recommends that the BWRVIP modify Section 3.9 of the BWRVIP-84 report to more fully address generic inspection guidance and methodology that should be utilized in the repair/replacement. This can be accomplished by reference to an appropriate revision of the BWRVIP-03 report. The recommendations specified in either the appropriate revision of the BWRVIP-03 or BWRVIP-84 reports should be implemented and cited, wherever appropriate, to ensure consistency with prior NRC-approved inspection guidelines pertaining to BWR internal components.