MITSUBISHI HEAVY INDUSTRIES, LTD.
16-5, KONAN 2-CHOME, MINATO-KU
TOKYO, JAPAN

May 13, 2009

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Attention: Mr. Jeffrey A. Ciocco

Docket No. 52-021
MHI Ref: UAP-HF-09236

Subject: MHI's Response to US-APWR DCD RAI No. 289-2217 REVISION 1

Reference: 1) "Request for Additional Information No. 289-2217 Revision 1, SRP Section: 05.02.03 - Reactor Coolant Pressure Boundary Materials, Application Section: DCD Tier 2, Section 5.2.3" dated March 25, 2009.

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") a document entitled "Response to Request for Additional Information No. 289-2217 Revision 1."

Enclosed is the response to the RAI contained within Reference 1.

In the responses to Question No. 05.02.03-4 and 05.02.03-9, the supplemental answers are provided in Enclosure 3. As indicated in Enclosure 3, this submittal contains information that MHI considers proprietary, and therefore should be withheld from public disclosure pursuant to 10 C.F.R. § 2.390 (a)(4) as trade secrets and commercial or financial information which is privileged or confidential. The proprietary information is bracketed by the designation "[ ]".

This letter includes a copy of the proprietary supplemental answers (Enclosure 3) and the Affidavit of Yoshiki Ogata (Enclosure 1) which identifies the reasons MHI respectfully requests that all materials designated as "Proprietary" in Enclosure 3 be withheld from public disclosure pursuant to 10 C.F.R. § 2.390 (a)(4).

Please contact Dr. C. Keith Paulson, Senior Technical Manager, Mitsubishi Nuclear Energy Systems, Inc. if the NRC has questions concerning any aspect of the submittals. His contact information is below.

Sincerely,

Y. Ogata

Yoshiki Ogata
General Manager- APWR Promoting Department
Mitsubishi Heavy Industries, LTD.

D081
NRO

Enclosures:

1. Affidavit of Yoshiki Ogata
2. Response to Request for Additional Information No. 289-2217 Revision 1
3. Supplemental Answers to RAI No.289-2217 Revision 1

CC: J. A. Ciocco
C. K. Paulson

Contact Information
C. Keith Paulson, Senior Technical Manager
Mitsubishi Nuclear Energy Systems, Inc.
300 Oxford Drive, Suite 301
Monroeville, PA 15146
E-mail: ck_paulson@mnes-us.com
Telephone: (412) 373-6466

ENCLOSURE 1

Docket No.52-021
MHI Ref: UAP-HF-09236

MITSUBISHI HEAVY INDUSTRIES, LTD.

AFFIDAVIT

I, Yoshiki Ogata, state as follows:

1. I am General Manager, APWR Promoting Department, of Mitsubishi Heavy Industries, LTD ("MHI"), and have been delegated the function of reviewing MHI's US-APWR documentation to determine whether it contains information that should be withheld from public disclosure pursuant to 10 C.F.R. § 2.390 (a)(4) as trade secrets and commercial or financial information which is privileged or confidential.

2. In accordance with my responsibilities, I have reviewed the enclosed document entitled "Supplemental Answers to RAI No.289-2217 Revision 1", and have determined that portions of the document contain proprietary information that should be withheld from public disclosure. Those pages containing proprietary information are identified with the label "Proprietary" on the top of the page and the proprietary information has been bracketed with an open and closed bracket as shown here "[ ]". The first page of the document indicates that all information identified as "Proprietary" should be withheld from public disclosure pursuant to 10 C.F.R. § 2.390 (a)(4).

3. The information identified as proprietary in the enclosed document has in the past been, and will continue to be, held in confidence by MHI and its disclosure outside the company is limited to regulatory bodies, customers and potential customers, and their agents, suppliers, and licensees, and others with a legitimate need for the information, and is always subject to suitable measures to protect it from unauthorized use or disclosure.

4. The basis for holding the referenced information confidential is that it describes the material procurement specifications developed by MHI for the Reactor Coolant Pressure Boundary of the US-APWR.

5. The referenced information is being furnished to the Nuclear Regulatory Commission ("NRC") in confidence and solely for the purpose of information to the NRC staff.

6. The referenced information is not available in public sources and could not be gathered readily from other publicly available information. Other than through the provisions in paragraph 3 above, MHI knows of no way the information could be lawfully acquired by organizations or individuals outside of MHI.

7. Public disclosure of the referenced information would assist competitors of MHI in their design of new nuclear power plants without incurring the costs or risks associated with the design of the subject systems. Therefore, disclosure of the information contained in the referenced document would have the following negative impacts on the competitive position of MHI in the U.S. nuclear plant market::

   A. Loss of competitive advantage due to the costs associated with development of the material procurement specifications for the Reactor Coolant Pressure Boundary of the US-APWR. Providing public access to such information permits competitors to duplicate or mimic the methodology without incurring the associated costs.

B. Loss of competitive advantage of the US-APWR created by benefits of enhanced plant safety, and reduced operation and maintenance costs associated with the Reactor Coolant Pressure Boundary.

I declare under penalty of perjury that the foregoing affidavit and the matters stated therein are true and correct to the best of my knowledge, information and belief.

Executed on this 13th day of May, 2009.

Y. Ogata

Yoshiki Ogata,
General Manager- APWR Promoting Department
Mitsubishi Heavy Industries, LTD.

Enclosure 2

UAP-HF-09236
Docket Number 52-021

Response to Request for Additional Information No. 289-2217 Revision 1

May 2009

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

5/13/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.: **NO. 289-2217 REVISION 1**

SRP SECTION: **05.02.03 - REACTOR COOLANT PRESSURE BOUNDARY MATERIALS**

APPLICATION SECTION: **05.02.03**

DATE OF RAI ISSUE: **3/25/2009**

QUESTION NO. : 05.02.03-4

Based upon the staff's review of the information provided in FSAR Table 5.2.3-1, the staff has determined that additional information is needed to complete its review. The staff requests that the applicant address the following:

(a) FSAR Table 5.2.3-1 indicates that the applicant intends to use non-nuclear Code Case 2142-2. Given that ENiCrFe-7 (UNS N06052) and ENiCrFe-7A (UNS N06054) have been incorporated into ASME Code, Section IX, and assigned an F-No.43 designation, discuss why it is necessary to use Code Case 2142-2.

(b) Table 5.2.3-1 lists weld filler materials using the "G" classification. The staff notes that two filler materials with the same specification and "G" classification could be quite different in areas such as chemical composition. Filler materials with a "G" classification are purchased based on specific user requirements. The staff requests that the applicant modify FSAR Table 5.2.3-1 to list its weld filler metal requirements for weld filler metals using the "G" classification. In addition, the staff requests that the applicant provide a technical justification for why standard available non "G" classifications will not be used.

(c) Table 5.2.3-1 indicates that Type 308L/309L steel strip electrode will be used for cladding. In order for the staff to determine that the applicant's steel strip electrode meets ASME Code requirements, the staff requests that the applicant modify Table 5.2.3-1 to include the specification and classification for steel strip electrodes.

(d) FSAR Table 5.2.3-1 lists SA-213, SA-312 and SA-376 Type 316/316LN material. Material Type 316/316LN does not appear in SA-213, SA-312 or SA-376, although material Grades TP 316/TP 316LN are listed. The staff requests that the applicant modify Table 5.2.3-1 to list the appropriate material grades consistent with the applicable material specifications and ASME Code, Section II, Part D, Table 2A.

(e) FSAR Table 5.2.3-1 lists SB-637 UNS N07718 as a material that will be used to fabricate valve disks. ASME Code Section III, NB-2121 allows materials other than those specified in

ASME Code Section II, Subpart 1, Table 2B (nonferrous materials) as long as the use of the materials meets NB-2121(c). Given that SA-637 UNS N07718 does not appear in ASME Code Section II, Subpart 1, Table 2B, the staff requests that the applicant verify that its use of this material is allowed as specified in NB-2121(c).

(f) In order for the staff to be able to identify which materials are used to fabricate specific major components of the steam generator and pressurizer, the staff requests that the applicant identify, in Table 5.2.3-1, the materials that will be used to fabricate shells and heads for the steam generator and pressurizer and the steam generator tube sheet.

ANSWER:

(a) As NRC indicated in the RAI, Code Case 2142-2 has been incorporated into ASME Section IX. However, the material specification for this welding material is incorporated into the 2006 Edition of ASME Section II, Part C. The applicable Code Addenda of ASME Section II for the US-APWR RCS Class 1 components is specified as the 2001 Edition with 2003 Addenda, in accordance with 10 CFR 50.55(a) and as stated in the DCD Table 5.2.1-1, so we believe that it is necessary to list Code Case 2142-2. Therefore, we propose that no DCD change is necessary for this.

(b) Welding materials with "G" classification are developed based on the chemical compositions recommended by the welding material manufacturer considering the good weldability to low alloy steel. In the welding procedure qualification test, welding material with "G" classification is applied and all applicable Code requirements are satisfied. The specific chemical compositions can not be reflected in the DCD as such information is proprietary information of the welding material manufacturer.

(c) Since type 308L/309L steel strip electrodes have been developed to improve the first layer's chemical composition, these welding materials are not mentioned in ASME Section II Part C. These welding materials are purchased following purchase specification and verified by welding procedure qualification testing in accordance with ASME Section III and IX. Therefore, these welding materials have no standard specification or classification Specific chemical compositions are considered proprietary information by the welding material manufacturer and can be provided in a proprietary supplement separate from this response.

(d) As indicated in the question, TP 316/TP 316LN are correct. The DCD Table 5.2.3-1 will be revised to incorporate TP 316/TP 316LN for SA-213, SA-312 or SA-376.

(e) The use of SB-637 UNS N07718 is limited to safety valve disks. ASME Section III NB-2121 (c) (1) accepts materials made to specifications other than those specified in Section II, Part D, Subpart 1, Tables 2A and 2B may be used for safety valve disks.

(f) The materials used for the heads and tubesheet of the steam generator and the head of the pressurizer are SA-508 Gr.3 forgings. Shells for the steam generator and pressurizer are designed as SA-508 Gr.3 forgings, or SA-533 Type B plate. The US-APWR standard design is based on the use of either of these materials considering the supplier's capability to supply these materials in the market place at the time of purchase. The mechanical properties of SA-

508 Gr.3 and SA-533 Type B are very similar and all pressure boundary parts are sized to accept either material.

Impact on DCD

DCD Table 5.2.3-1 will be changed to incorporate TP 316/TP 316LN in SA-213, SA-312 or SA-376.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

5/13/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.: NO. 289-2217 REVISION 1

SRP SECTION: 05.02.03 - REACTOR COOLANT PRESSURE BOUNDARY MATERIALS

APPLICATION SECTION: 05.02.03

DATE OF RAI ISSUE: 3/25/2009

QUESTION NO. : 05.02.03-5

The staffs expectation is that minimum preheat temperatures used for welding carbon steel and low alloy steel meet the minimum preheat temperatures listed in ASME Code Section III, Appendix D, Article D-1000. For low alloy steel, the recommendations of Appendix-D should be supplemented by RG 1.50. In order for the staff to continue its review of the applicant's welding of carbon steel and low alloy steel, the staff requests that the applicant address the following:

(a) FSAR Subsection 5.2.3.3.2 does not specify preheat and interpass temperatures for carbon steels. The staff requests that the applicant address minimum preheat and maximum interpass temperatures for carbon steels. Also, the staff requests that the applicant delete the word "proposed" from the second paragraph of Subsection 5.2.3.3.2.

(b) FSAR Subsection 5.2.3.3.2 states that the minimum Appendix D preheat temperature of 250° F may not be applied to P-3 materials on the first pass provided a welding procedure qualification demonstrates acceptable integrity and quality. Given that the welding procedure qualification does not necessarily represent some production welding conditions, such as the cooling rate due to the size of the heat sink in the production welding, provide the technical basis for using lower preheat temperatures and state what preheat temperatures will be used. In addition, the staff requests that this information be included in the FSAR.

(c) FSAR Subsection 5.2.3.3.2 does not reference RG 1.50. The staff requests that the applicant modify the FSAR Section 5.2.3.3.2 to reference RG 1.50 and provide a description of any alternatives to RG 1.50 including a technical basis for any alternatives. In addition, if an alternative to RG 1.50 is used, modify Table 1.9.2-5 under the line item for SRP 5.2.3 (page 1.9-92), to reflect the that the applicant does not conform to SRP 5.2.3 given that SRP 5.2.3 references the use of RG 1.50.

(d) FSAR Subsection 5.2.3.3.2 states that hydrogen is removed by either post heating [post-weld bake-out] at a time and temperature sufficient to preclude the effects of hydrogen assisted cracking or by maintaining preheat until post-weld heat treatment is performed. The guidance provided in RG 1.50 states that preheat should be maintained until post-weld heat treatment is performed. Although the staff is not opposed to using the post-weld bake-out technique in lieu of the recommendations listed in RG 1.50 that specify maintaining preheat until post-weld heat treatment is performed, the staff requests that the applicant discuss the post-weld backing temperatures and times that will be used and a technical basis to support the parameters selected. This information should be included in the FSAR.

ANSWER:

(a) Minimum preheat temperatures are maintained higher than those listed in Appendix D of ASME Section III, which is 250°F for P-No.3 material and 50°F for P-No.1 material. However, minimum preheat temperatures below this temperature may be applied to the first and second passes of P-No.3 material provided that the welding procedure specification demonstrates acceptable weld integrity and quality based on the welding procedure qualification test. Maximum interpass temperatures for production welding shall be those specified in the welding procedure specification. For low alloy steels and carbon steel, generally the maximum interpass temperature is 500°F for both materials. The third paragraph of the DCD Subsection 5.2.3.3.2 will be changed to incorporate the above sentences, and the word "proposed" will be deleted from the second paragraph of the DCD Subsection 5.2.3.3.2.

(b) Taking into consideration the weldability and quality of the product, preheating above 122°F (50°C) is applied to the first and second passes of circumferential joint welding. Preheating above 250°F (121°C) is applied to subsequent passes in accordance with Appendix D (Nonmandatory). MHI will apply and verify these preheating temperatures in the welding procedure qualification tests. Subsection 5.2.3.3.3 of the DCD will be revised to refer to the above temperatures and the technical basis in a proprietary supplement.

(c) The third paragraph of the DCD subsection 5.2.3.3.2 will be changed to add "In accordance with Regulatory Guide 1.50 'Control of Preheat Temperature for Welding Low Alloy Steel' (Ref.5.3-13)," at the beginning of the first sentence. No change is needed to the DCD Table 1.9.2-5.

(d) Post heating [post-weld bake-out] is maintained at a temperature of 450-550°F for a period of 4 hours minimum based on the ASME Section III NB-4622.9 (Temper Bead Weld Repair), item 7. This information will be added after the first sentence of the fourth paragraph of Subsection 5.2.3.3.2 of the DCD.

Impact on DCD

- The word "proposed" will be deleted from the second paragraph of the DCD Subsection 5.2.3.3.2.

- The third paragraph of the DCD Subsection 5.2.3.3.2 will be revised as follows:

  <u>In accordance with Regulatory Guide 1.50 "Control of Preheat Temperature for Welding Low Alloy Steel" (Ref.5.3-13), m</u>inimum preheat temperatures are generally kept higher than

those listed in Appendix D of ASME Section III, which is 250°F for P-No.3 material and 50°F for P-No.1 material. However, minimum preheat temperatures below this temperature may be applied to the first passes of P-No.3 material provided a welding procedure qualification demonstrates acceptable weld integrity and quality. Taking into consideration the weldability and quality of the product, preheating above 122°F (50°C) is applied to the first and second passes of circumferential joint welding. Preheating for more than 250°F is applied to subsequent passes in accordance with Appendix D. Maximum interpass temperatures for production welding shall be those specified in welding procedure qualification. For low alloy steels and carbon steel, generally the maximum interpass temperature is 500°F for both materials.

- The first sentence of the forth paragraph of the DCD Subsection 5.2.3.3.2 will be revised as follows:

  Hydrogen is removed by either postheating at a temperature and time sufficient to preclude the effects of hydrogen assisted cracking, or by maintaining preheat until post-weld heat treatment is performed. Post-weld baking is maintained at a temperature of 450-550°F for a period of 4 hours minimum, based on the ASME Section III NB-4622.9 (Temper Bead Weld Repair), item 7.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

5/13/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.: NO. 289-2217 REVISION 1

SRP SECTION: 05.02.03 - REACTOR COOLANT PRESSURE BOUNDARY MATERIALS

APPLICATION SECTION: 05.02.03

DATE OF RAI ISSUE: 3/25/2009

QUESTION NO. : 05.02.03-6

FSAR Table 1.9.1-1 indicates that RG 1.71 will be followed without exception for welding RCPB components. FSAR Subsections 5.2.3.3.2 and 5.2.3.4.4 also indicate that RG 1.71 does not apply to shop welds. If the conditions stated in RG 1.71 Regulatory Position C.(1) do not exist in shop welds, the staff requests that the applicant modify the FSAR accordingly. If these conditions do exist in shop welds, the staff requests that the applicant provide a basis for excluding the use of RG 1.71 for shop welds that have conditions described in Regulatory Position C.(1) and modify FSAR 5.2.3.3.2 , 5.2.3.4.4 and Table 1.9.1-1 to reflect exceptions to RG 1.71 in the US-APWR design for RCPB components.

ANSWER:

In Table 1.9.1-1, the DCD indicates that the status of US-APWR conformance with RG 1.71, Welder Qualification for Areas of Limited Accessibility (Rev. 1, March 2007) is "Conformance with no exceptions identified." Where there are areas of limited accessibility, e.g., field welding applications, the US-APWR meets RG 1.71 guidance without exception. The conditions stated in RG 1.71, Regulatory Position C.1 do not apply to shop welding for the US-APWR. Unless the question is intended to cause a change to the status of conformance with RG 1.71 in Table 1.9.1-1, e.g., "Not applicable to shop welds," the DCD locations mentioned above do not require revision.

Impact on DCD

There is no impact on the DCD.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

5/13/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.: NO. 289-2217 REVISION 1

SRP SECTION: 05.02.03 - REACTOR COOLANT PRESSURE BOUNDARY MATERIALS

APPLICATION SECTION: 05.02.03

DATE OF RAI ISSUE: 3/25/2009

QUESTION NO. : 05.02.03-7

RG 1.43 provides guidance acceptable to the staff for the control of underclad cracking in stainless-steel, corrosion-resistant, weld-overlay cladding of low-alloy steel components. The applicant has indicated, in Subsection 5.2.3.3.2, that the US-APWR Class 1 components, that will be clad, are made from SA-508 Grade 3 Class 1 or 2 and SA-533 type B Class 1 or 2. Subsection 5.3.1.2 states that reactor vessel forgings are required to have a fine grain size of 5 or finer. If the applicant's fine grain size requirement, of 5 or finer, applies to all low-alloy steels listed in Table 5.2.3-1 that will be clad, the staff requests that the applicant modify Subsection 5.2.3.3.2 accordingly.

ANSWER:

The pressure retaining low-alloy steel materials of the US-APWR Class 1 components, that will be clad, are constructed of pressure forgings (SA-508 Grade 3) or pressure plates (SA-533 Type B). These materials are heat treated by quenching and tempering, and fine grain size of five (5) or finer is required. The DCD Subsection 5.2.3.3.2 will be modified to incorporate the grain size requirements.

Impact on DCD

- The third sentence of the fifth paragraph of the DCD Subsection 5.2.3.3.2 will be changed to add the following:

The US-APWR Class 1 components use SA-508 Grade 3 Class 1 or 2 and SA-533 Type B Class 1 or 2 of ASME Code Section II (2001 edition). These materials are heat treated by quenching and tempering, and fine grain size of five (5) or finer is required.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

5/13/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.: NO. 289-2217 REVISION 1

SRP SECTION: 05.02.03 - REACTOR COOLANT PRESSURE BOUNDARY MATERIALS

APPLICATION SECTION: 05.02.03

DATE OF RAI ISSUE: 3/25/2009

QUESTION NO. : 05.02.03-8

The applicant stated, in FSAR Subsection 5.2.3.3.2, that electroslag welding, as mentioned in RG 1.34, is not applied to longitudinal joints in SA-508 Class 1 and 2 components in the US-APWR design. The staff notes that RG 1.34 applies to core support structures and Class 1 and 2 vessels and components. Therefore, the staff requests that the applicant identify any core support structures, Class 1 or Class 2 vessels or components that are fabricated using the electroslag welding process and discuss the level of compliance with the guidelines in RG 1.34. In addition, the staff requests that the applicant modify the FSAR accordingly.

ANSWER:

In Table 1.9.1-1, the DCD indicates that the status of US-APWR conformance with RG 1.34, Control of Electroslag Weld Properties (Rev. 0, December 1972) is "Not applicable." In US-APWR, Electroslag welding is not employed in structural welds of low alloy steel. Electroslag welding is only applied for cladding."

RG 1.34 does not specifically provide guidance for cladding.

Impact on DCD

There is no impact on the DCD.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

5/13/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.: **NO. 289-2217 REVISION 1**

SRP SECTION: **05.02.03 - REACTOR COOLANT PRESSURE BOUNDARY MATERIALS**

APPLICATION SECTION: **05.02.03**

DATE OF RAI ISSUE: **3/25/2009**

QUESTION NO. : 05.02.03-9

FSAR Table 5.2.3-1 indicates that some reactor coolant piping components will be fabricated from SA-182 or SA-336 Grade F316 or F316LN forged austenitic stainless steel material. These specifications do not contain limitations on grain size. Given that grain size can affect the material properties of a component and the ability to perform ultrasonic examination, the staff requests that the applicant modify FSAR Section 5.2.3 to include the maximum grain size for forged stainless steel components within the entire RCPB and a basis for the grain size specified. In addition, provide a basis for the grain size selected based on the ability to perform UT examinations.

ANSWER:

Specifications for limitations on grain size and their bases for forged austenitic stainless steel materials in US-APWR are required to implement ASME Section II requirements. Maximum grain size limitations are specified to the manufacturer. Grainsize specifications are considered proprietary information to be protected, and this specification has proven to be sufficient for inspection purposes because forged austenitic stainless steel materials in MHI operating plants are manufactured by the same specification, and UT inspection results for these parts have been satisfactory.

Impact on DCD

There is no impact on the DCD because maximum grain size requirements include vender know-how information.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

5/13/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.: **NO. 289-2217 REVISION 1**

SRP SECTION: **05.02.03 - REACTOR COOLANT PRESSURE BOUNDARY MATERIALS**

APPLICATION SECTION: **05.02.03**

DATE OF RAI ISSUE: **3/25/2009**

QUESTION NO. : 05.02.03-10

FSAR Table 5.2.3-1 indicates that SA-351 Grades CF3, CF3M, CF8 and CF8M cast austenitic stainless steels (CASS) will be used to fabricate RCPB components. Table 4.5.2 indicates that SA-351 Grade CF8 will be used for the guide funnel of the CRDM thermal sleeve. CASS components used in light-water reactors (LWRs) can be susceptible to thermal aging embrittlement. The NRC staff position regarding thermal aging embrittlement of CASS materials is documented in a letter from Christopher I. Grimes of the NRC to Douglas J. Walters of the Nuclear Energy Institute, dated May 19, 2000 (Agencywide Documents Access and Management System (ADAMS) Accession No.: ML003717179. In order to determine that applicant has addressed the potential for thermal aging embrittlement of CASS materials used in the RCPB, the staff requests the following information.

(1) Discuss the consideration of the thermal embrittlement mechanism in the design and material selection for RCPB components and reactor vessel internal components.

(2) Discuss the need for inspections to detect this aging effect

(3) Verify that δ-ferrite content is calculated using Hull's equivalent factors or a method producing an equivalent level of accuracy.

(4) Modify the FSAR to address the above.

ANSWER:

(1) The formation of Cr-rich α' phase by spinodal decomposition of the ferrite phase is the primary mechanism for thermal embrittlement of austenitic stainless steel castings (cast duplex stainless steel). Thermal aging of cast duplex stainless steel has little effect on the austenite phase. MHI controls thermal embrittlement by specifying the range of ferrite content in duplex stainless steel

(2) Cast austenitic stainless steels that are selected for use in US-APWR RCPB components are categorized based on Table 2, "CASS Thermal Aging Susceptibility Screening Criteria," of the NRC staff position in ML003717179, and are inspected and examined based on Table 3, ,Examination Requirements for CASS Components" of the document.

(3) MHI calculates ferrite content of austenitic stainless steel casting (cast duplex stainless steel) by use of the Schoefer Diagram in ASTM A800 "Standard Practice for Steel Casting, Austenitic Alloy, Estimating Ferrite Content Thereof." MHI specifies ASTM A800 to the supplier to calculate ferrite content when purchasing cast duplex stainless steel. The method employed by the Schoefer Diagram is to convert the composition ratio of "chromium equivalent" to "nickel equivalent," which is essentially the same as Hull's equivalent factor method.

(4) The DCD Subsection 5.2.3.4 will be revised to incorporate the above explanations.

Impact on DCD

- The DCD Subsection 5.2.3.4 will be modified to add a new paragraph at the end of the subsection as follows:

  Cast austenitic stainless steel components used in light-water reactors can be susceptible to thermal aging embrittlement due to the formation of a Cr-rich phase from the decomposition of the ferrite phase by exposing the material to elevated temperatures. Cast austenitic stainless steels that are used in US-APWR RCPB components are categorized based on molybdenum content, casting method, and δ-ferrite level and examined based on ASME Section XI requirements. Hull's equivalent factor method or Schoefer Diagram in ASTM A800 "Standard Practice for Steel Casting, Austenitic Alloy, Estimating Ferrite Content Thereof" is used to calculate δ-ferrite level. Reference License Renewal Issue No. 98-0030, Thermal Aging Embrittlement of Cast Austenitic Stainless Steel Components, dated May 19, 2000.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

5/13/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.: **NO. 289-2217 REVISION 1**

SRP SECTION: **05.02.03 - REACTOR COOLANT PRESSURE BOUNDARY MATERIALS**

APPLICATION SECTION: **05.02.03**

DATE OF RAI ISSUE: **3/25/2009**

QUESTION NO. : 05.02.03-11

FSAR Subsections 5.2.3.4.1 and 5.2.3.4.2 address RG 1.44 and present the methods and controls used by the applicant to avoid sensitization and to prevent intergranular attack of austenitic stainless steels. Based on the information included in the aforementioned FSAR Subsections and the exclusion of any reference in the line item for RG 1.44 in Table 1.9.1-1 regarding Subsection 5.2.3, the staff requests that the applicant modify FSAR Subsection 5.2.3 and Table 1.9.1-1 to make it clear that the applicant follows the guidance provided in RG 1.44 for all stainless steel piping and components in the RCPB.

ANSWER:

The line item for RG 1.44 of DCD Table 1.9.1-1 will be changed to incorporate Subsection 5.2.3.

Impact on DCD

The line item for RG 1.44 of DCD Table 1.9.1-1 will be changed to incorporate Subsection 5.2.3.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

5/13/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.: **NO. 289-2217 REVISION 1**

SRP SECTION: **05.02.03 - REACTOR COOLANT PRESSURE BOUNDARY MATERIALS**

APPLICATION SECTION: **05.02.03**

DATE OF RAI ISSUE: **3/25/2009**

QUESTION NO. : 05.02.03-12

The applicant has listed standard grades of stainless steels (non-low carbon) in Table 5.2.3-1. The staff requests that the applicant specify its maximum carbon content for all austenitic stainless steels, other than cast materials, used in the RCPB. If the maximum carbon content is greater that 0.03%, provide a justification for the use of these materials given that such materials may be susceptible to stress corrosion cracking. The maximum carbon content should be included in Table 5.2.3-1.

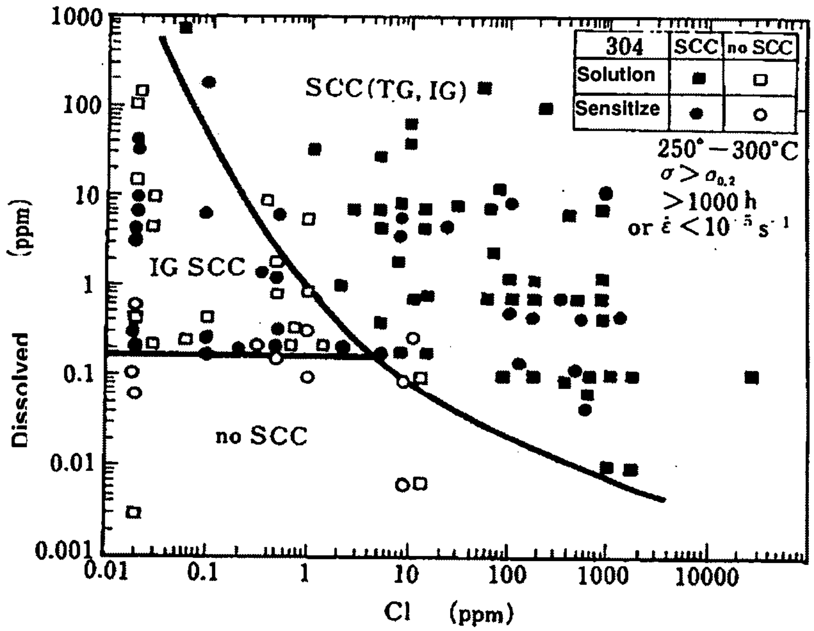
ANSWER:

MHI understands that low-carbon austenitic stainless steel is a better choice of material because of its higher resistance to stress corrosion cracking even in the PWR environment. On the other hand, strength properties of low-carbon austenitic stainless steel are lower than that of the standard grade stainless steel. LN grade stainless steels contain low-carbon content, but have the equivalent strength of standard grade 304/316 materials by adding Nitrogen. The basic policy for austenitic stainless steels in reactor coolant pressure boundary of US-APWR is to select LN grade materials permitting market conditions and availability at the time of procurement.

Material procurement for the forging F316LN austenitic stainless steel is available and F316LN pressure forging materials will be used in RCPB components. Regarding other materials such as piping and tubing materials, LN grade materials are not yet available because of difficulties in manufacturing. Therefore, standard 304/316 grade materials are selected, instead of low-carbon (and standard Nitrogen content) stainless steel, because the loss of strength properties is not preferable. If the LN grade materials become available, MHI will select LN grade austenitic stainless steel piping or tubing materials.

The NRC position in the RG 1.44 is based on the BWR environment condition.
Dissolved oxygen in the primary water is controlled under 0.1ppm. The standard value of the dissolved oxygen is 0.05ppm, as discussed in the DCD Table-5.2.3-2. This dissolved oxygen area is under the limit of SCC environment condition. The following figure shows the relationship between SCC potential and chemical condition of dissolved oxygen and chloride ion by M. O. Speidel, which was presented at the 1st U.S. – Japan Joint Symposium on Light Water Reactors, Fuji, Japan (1978). The chemical conditions of the US-APWR primary water is in the no SCC area – below the curve.
In existing PWR plants, pressure boundary piping is made from Type 316 stainless steel, and reactor internal structures are made from Type 304 stainless steel. These materials do not experience SCC phenomenon, which supports the following data.

Therefore it is MHI's position that low carbon stainless steel is not necessary in the primary water of the PWR.



Impact on DCD

There is no impact on the DCD because of the above reason.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

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QUESTION NO. : 05.02.03-13

FSAR Section 5.2.3 states that Alloy 690 is thermally treated to prevent PWSCC. The staff requests that the applicant discuss its thermal treatment requirements for Alloy 690 components listed in Table 5.2.3-1and a basis for why its thermal treatment is optimal to prevent stress corrosion cracking. This information should be included in the FSAR.

ANSWER:

MHI has carried out extensive R&D on Alloy 600/690 materials and their resistance to PWSCC. Current MHI requirements for thermal treatment are based on the results of these R&D efforts, where all results have shown that thermally treated Alloy 690 material shows excellent resistance against PWSCC. As stated in Section 5.2.3.5 of the DCD, details and results concerning MHI's R&D efforts are provided in reference documents 5.2-32 and 5.2-33.

Impact on DCD

There is no impact on the DCD.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

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QUESTION NO. : 05.02.03-14

Cold work and residual stress imparted on components fabricated from austenitic stainless steels and nickel based alloys has contributed to stress corrosion cracking in operating PWRs and BWRs. The staff requests that the applicant describe the fabrication process requirements employed to limit the effects of cold work and residual stress, caused by grinding/repair or other fabrication processes on surfaces that come into contact with RCS fluids.

ANSWER:

Components fabricated from austenitic stainless steel and nickel-based alloys are designed so that residual stress and cold worked effects are minimized as much as possible. Austenitic stainless steel large diameter piping is bent during hot conditions, and small diameter piping is bent by low residual stress processes such as the plug-less bending process, or heat treatment is applied after bending. Regarding dissimilar welds with nickel-based alloy welding material, alloy 690 filler materials are used to avoid stress corrosion cracking.

Impact on DCD

There is no impact on the DCD.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

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QUESTION NO. : 05.02.03-15

FSAR Table 5.2.3-1 indicates that Alloy 690 CRDM RPV upper head penetration nozzles are welded to the RPV head using Alloy 52/52M/152. The partial penetration jgroove joint design can be difficult to weld given the highly restrained nature of the joint design and the limited accessibility for the welder. The staff notes that recently fabricated RPV replacement heads have required extensive welding repairs during fabrication. In addition, large numbers of welding flaws have been identified during baseline UT examination of CRDM nozzles. Given the susceptibility of Alloys 52, 52M and 152 to ductility dip cracking and other types of welding flaws, the staff requests that the applicant discuss its welding process controls to minimize welding flaws in CRDM RPV upper head penetration nozzles welds and any other partial penetration welds that involve dissimilar materials within the RCPB. In addition, the staff requests that the applicant discuss welding process controls employed to reduce weld metal dilution in order to retain the maximum percentage of Chromium possible in order to decrease the susceptibility of components to stress corrosion cracking for the life of the plant.

ANSWER:

J-groove welding is performed by the Gas Tungsten Arc Welding (GTAW) method, which has less possibility of weld flaws and the heat input is controlled in order to prevent hot cracks. Interpass treatment is also performed to minimize the number of weld flaws in the J-groove weld region.

For dissimilar material weld area between the Alloy 52 buttering and stainless steel cladding, small amounts of chromium dilution may occur. However, heat input is controlled in accordance with welding qualification procedures, and therefore, chromium dilution is minimized and controlled so that the dilution does not reach the first layer of the stainless steel cladding. Even in the case when some dilution occurs, Post Weld Heat Treatment (PWHT) is applied to the dissimilar weld area which will minimize residual stress. Therefore, the possibility of PWSCC is decreased.

Impact on DCD

There is no impact on the DCD.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

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QUESTION NO. : 05.02.03-16

FSAR Section 5.2.3 indicates that austenitic stainless steel and Ni-Cr-Fe alloy weld filler metal will be used for dissimilar metal welds (DMWs) in the RCPB. The staff notes that several operating experience issues have arisen related to the fabrication quality and inservice performance of DMWs in LWRs. The staff requests that the applicant provide a description of DMWs in the RCPB and discuss the selection of filler metals and welding processes and process controls. In addition, discuss welding process controls employed to reduce weld metal dilution in order to retain the maximum percentage of chromium possible in order to decrease the susceptibility of components to stress corrosion cracking for the life of the plant.

ANSWER:

The dissimilar metal weld between austenitic stainless steel and Ni-Cr-Fe alloy (Alloy 52) are performed by GTAW with Ni-Cr-Fe alloy (Alloy 152) weld filler material, which has less possibility of weld flaws. The heat inputs are controlled to prevent hot cracking and minimize weld metal dilution. Interpass treatment is also performed to minimize the number of weld flaws.

Impact on DCD

There is no impact on the DCD.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.