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MFN 06-260
Supplement 3

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Subject: **Response to Portion of NRC Request for Additional Information Letter Nos. 41 and 109 Related to ESBWR Design Certification Application – Reactor Vessel and Reactor Coolant Pressure Boundary - RAI Numbers 5.2-38 S02 and 5.2-38 S03**

Enclosure 1 contains GEH's response to the subject NRC RAIs transmitted, respectively, via e-mail on August 7, 2007 and via the Reference 1 letter. Previous responses were provided in the Reference 2 and 3 letters.

If you have any questions or require additional information regarding the information provided here, please contact me.

Sincerely,

Kathy Sedney for

James C. Kinsey
Vice President, ESBWR Licensing

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NRO

References:

1. MFN 07-555, Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, *Request for Additional Information Letter No. 109 Related to ESBWR Design Certification Application*, dated October 12, 2007
2. MFN 06-260, Letter from David Hinds to U.S. Nuclear Regulatory Commission, *Response to Portion of NRC Request for Additional Information Letter No. 41 Related to ESBWR Design Certification Application – Reactor Coolant Pressure Boundary Materials – RAI Numbers 5.2-36 through 5.2-49*, dated August 7, 2006
3. MFN 06-260, Supplement 2, Letter from James C. Kinsey to U.S. Nuclear Regulatory Commission, *Response to Portion of NRC Request for Additional Information Letter No. 41 - Reactor Pressure Vessel and Nuclear Boiler System - RAI Number 5.2-38 S01*, dated June 6, 2007

Enclosure:

1. MFN 06-260, Supplement 3 - Response to Portion of NRC Request for Additional Information Letter Nos. 41 and 109 Related to ESBWR Design Certification Application – Reactor Vessel and Reactor Coolant Pressure Boundary - RAI Numbers 5.2-38 S02 and 5.2-38 S03

cc:	AE Cubbage	USNRC (with enclosure)
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	RE Brown	GEH/Wilmington (with enclosure)
	DH Hinds	GEH/Wilmington (with enclosure)
	eDRF	0000-0076-8136

Enclosure 1

MFN 06-260, Supplement 3

Response to Portion of NRC Request for

Additional Information Letter Nos. 41 and 109

Related to ESBWR Design Certification Application

Reactor Vessel and Reactor Coolant Pressure Boundary

RAI Numbers 5.2-38 S02 and 5.2-38 S03

NRC RAI 5.2-38

Given that cast austenitic stainless steel (CASS) can be susceptible to thermal aging embrittlement, please discuss the following for any CASS component that acts as a RCPB: (1) the impact of this aging effect on the integrity of the components, (2) the consideration of the thermal embrittlement mechanism in the design and material selection for RCPB components, (3) the need for inspections to detect this aging effect, and (4) verify that ä-ferrite content is calculated using Hull's equivalent factors or a method producing an equivalent level of accuracy.

GE Response:

See GE response to RAI 4.5-3 with respect to performance of cast stainless steel in the BWR environment and control of ferrite and carbon content as a means to control thermal embrittlement of cast austenitic stainless steel. (1) As described in RAI Response 4.5-3, there is virtually no thermal aging of cast stainless steel at BWR operating temperatures (288°C maximum) for Grades CF3/CF3A when ferrite content is limited to 20% maximum. (2) and (3) Consideration of these items is not necessary based on Item (1) response. (4) Delta ferrite will be determined in accordance with ASTM A800, which is considered to have adequate accuracy.

NRC RAI 5.2-38 S01:

In GE's response to RAI 5.2-38 (MFN 06-260), GE indicated that it will use ASTM A800 in lieu of Hull's equivalent factors. The staff's position is that percent ferrite is calculated using Hull's equivalent factors as indicated in NUREG/CR-4513, Rev.1 (May 1994). NUREG/CR-4513, Rev.1, states that ASTM A800 may produce lower ferrite numbers than Hull's equivalent factors for materials with greater than 12% ferrite. In response to RAI 6.1-15 (MFN 06-365) GE stated that, It is agreed that the A800 method tends to predict somewhat lower values at higher ferrite levels than the Hull's equivalent method. However, when the two methods are compared to the corresponding measured values reported in the NUREG using rigorous statistical analysis, it can be demonstrated the two methods are equally accurate. Provide the rigorous statistical analysis that shows that the method to calculate ferrite in ASTM A800 and Hull's equivalent factors are equally accurate.

GE Response:

The statistical equivalency of the accuracy of the two methods is demonstrated in Enclosure 2, "MFN 06-260 Supplement 1 - RAI Number 5.2-38 S01 - Evaluation of Statistical Equivalency Between ASTM A800 and Hull Methods."

DCD Impact:

No DCD changes will be made in response to this RAI.

NRC RAI 5.2-38 S02

Based on the teleconference held with the NRC Staff on July 19, 2007, GEH was requested to reconsider the use of ASTM A800 in lieu of Hull's equivalent factors. The staff's position is that percent ferrite is calculated using Hull's equivalent factors as indicated in NUREG/CR-4513, Rev.1 (May 1994), and that this response needs to apply to not only cast austenitic stainless steel reactor coolant pressure boundary components but also any cast austenitic stainless steel reactor vessel internal components.

GEH Response

GEH agrees to use the Hull's equivalent factors method as recommended by the staff.

DCD Impact

DCD Tier 2, Subsection 5.2.3.4, will be revised as noted in the attached markup.

NRC RAI 5.2-38 S03

Discuss aging effects, thermal embrittlement, inspection needs, and ferrite content calculation of the cast Austenitic Stainless Steel.

The NRC position regarding the use of Hull's factor was established during license renewal documented in Grimes letter of May 19, 2000. Ensuring ferrite content does not exceed 20 percent was a determining factor in whether an applicant for license renewal needed a long-term aging management program to address embrittlement of cast stainless steel with > 20 percent ferrite content in high temperature applications. Based on NUREG/CR-4513, Rev. 1, staff believes that above approximately 12 percent ferrite content that there is no equivalency between ASTM A800 and Hull's factors. Based on the above, the staff requests that the applicant consider:

1) using Hull's factors for determining ferrite, or;

2) propose a compensating factor to be applied to their alternate approach (ASTM A800) that ensures that 20 percent ferrite is not exceeded.

In addition, the applicant should ensure that the approach used applies to both cast austenitic stainless steel reactor coolant pressure boundary components and cast austenitic stainless steel reactor vessel internal components.

GE Response

As noted above in response to Supplement 02 of this RAI, GEH agrees to use the recommended Hull method.

DCD Impact

No additional DCD changes will be made in response to this RAI.

5.2.3.4 Fabrication and Processing of Austenitic Stainless Steels

Austenitic stainless steels in a variety of product forms are used for construction of a limited number of pressure-retaining components in the reactor coolant pressure boundary. Process controls are exercised during various stages of component manufacturing and reactor construction to avoid severe sensitization of the material and to minimize exposure of the stainless steel to contaminants that could lead to stress corrosion cracking.

The ESBWR design complies with Regulatory Guide 1.44 and with the guidelines of Generic Letter 88-01 and NUREG-0313 Revision 2, to avoid sensitization through the use of reduced carbon content and process controls. In general, weld filler material used for austenitic stainless steel base metals is Type 308L/316L/309L/309MoL with an average ferrite content not less than 8 FN (ferrite number). For cast austenitic stainless steel (CASS) material used as part of the RCPB or reactor vessel internals component fabrications, the percent ferrite is calculated using Hull's equivalent factors as indicated in NUREG/CR-4513, Rev.1 (May 1994).

5.2.3.4.1 Avoidance of Stress/Corrosion Cracking

Avoidance of Significant Sensitization

When austenitic stainless steels are heated in the temperature range 427°C – 982°C (801°F – 1800°F), they are considered to become "sensitized" or susceptible to intergranular corrosion. ~~The ESBWR design complies with Regulatory Guide 1.44 and with the guidelines of Generic Letter 88-01 and NUREG-0313 Revision 2, to avoid sensitization through the use of reduced carbon content and process controls.~~

All austenitic stainless steels are supplied in the solution heat treated condition and special sensitization tests are applied to confirm and assure proper heat treatment. For applications where stainless steel surfaces are exposed to reactor water at temperatures above 93°C (199°F) in welded applications where solution heat treatment is not performed, nuclear grade materials (carbon content ¡Ü 0.02%) are used.

During fabrication, any heating operation (except welding) above 427°C (801°F) is avoided, unless followed by solution heat treatment. During welding, heat input is controlled. The interpass temperature is also controlled. Where practical, shop welds are solution heat treated. ~~In general, weld filler material used for austenitic stainless steel base metals is Type 308L/316L/309L/309MoL with an average ferrite content not less than 8 FN (ferrite number).~~

Process Controls to Minimize Exposure to Contaminants

Process controls are exercised during all stages of component manufacturing and construction to minimize contaminants. Cleanliness controls are applied prior to any elevated temperature treatment. Exposure to contaminants capable of causing stress/corrosion cracking of austenitic stainless steel components are avoided by carefully controlling all cleaning and processing materials which contact the stainless steel during manufacture, construction, and installation.

Special care is exercised to insure removal of surface contaminants prior to any heating operations. Water quality for cleaning, rinsing, flushing, and testing is controlled and monitored. Suitable protective packaging is provided for components to maintain cleanliness during shipping and storage. The degree of surface cleanliness obtained by these procedures meets the requirements of Regulatory Guides 1.37 and 1.44.

Cold-Worked Austenitic Stainless Steels

Cold worked austenitic stainless steels are not used for RCPB components. Cold work controls are applied for components made of austenitic stainless steel. During fabrication, cold work is controlled by applying limits in hardness, bend radii and surface finish on ground surfaces.

5.2.3.4.2 Control of Welding

Avoidance of Hot Cracking

Regulatory Guide 1.31 describes the acceptable method of implementing requirements with regard to the control of welding when fabricating and joining austenitic stainless steel components and systems.

Written welding procedures that are approved by GEH are required for all primary pressure boundary welds performed for material fabrication and plant construction. These procedures shall comply with the requirements of Sections III and IX of the ASME Code and applicable NRC Regulatory Guides.

All austenitic stainless steel weld filler materials are required by specification to have a minimum delta ferrite content of 8 FN (ferrite number) and a maximum of 20 FN determined on undiluted weld pads by magnetic measuring instruments calibrated in accordance with AWS Specification A4.2.

5.3.1.4 Special Controls for Ferritic and Austenitic Stainless Steels

Regulatory Guide 1.31: Control of Stainless Steel Welding

Controls on stainless steel welding are discussed in Subsection 5.2.3.4.2. Consistent with Generic Letter 88-01 and NUREG-0313 Revision 2, control of weld filler metal ferrite content is described in Subsection 5.2.3.4.~~1.~~