GE Energy

David H. Hinds
Manager, ESBWR

PO Box 780 M/C L60
Wilmington, NC 28402-0780
USA

T 910 675 6363
F 910 362 6363
david.hinds@ge.com

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Subject: **Response to Portion of NRC Request for Additional Information Letter No. 58 – Engineered Safety Features – RAI Numbers 6.1-1 through 6.1-15**

Enclosure 1 contains GE's response to the subject NRC RAIs transmitted via the Reference 1 letter.

If you have any questions about the information provided here, please let me know.

Sincerely,

Kathy Sedney for

David H. Hinds
Manager, ESBWR

D068

Reference:

1. MFN 06-328, Letter from U.S. Nuclear Regulatory Commission to David Hinds, *Request for Additional Information Letter No. 58 Related to ESBWR Design Certification Application*, September 13, 2006

Enclosure:

1. MFN 06-365 – Response to Portion of NRC Request for Additional Information Letter No. 58 – Engineered Safety Features – RAI Numbers 6.1-1 through 6.1-15

cc: AE Cubbage USNRC (with enclosures)
GB Stramback GE/San Jose (with enclosures)
eDRF 0058-5457

ENCLOSURE 1

MFN 06-365

Response to Portion of NRC Request for

Additional Information Letter No. 58

Related to ESBWR Design Certification Application

Engineered Safety Features

RAI Numbers 6.1-1 through 6.1-15

NRC RAI 6.1-1

Provide verification that all engineered safety feature (ESF) materials meet the requirements of Appendix I to Section III, Division 1 of the ASME Code, and parts A, B and C of Section II of the ASME Code or Regulatory Guide (RG) 1.84. Also provide a description of the design, fabrication and testing requirements of ESF components and fracture toughness requirements for all ferritic ESF materials in the ESBWR design.

GE Response

Table 6.1-1 will be revised to show the ASME Section III Code Classes for each ESF system. Materials for these systems are required to comply with Section III, and as such will only be materials that appear in Appendix I (now Section II, Part D). All such materials are according to ASME Section II, Parts A, B, or C, or as allowed by Regulatory Guide 1.84. The design, fabrication and testing requirements of ESF components, and fracture toughness requirements for all ferritic ESF materials in the ESBWR design will comply with the appropriate Section III class shown in the table.

DCD Tier 2, Section 6.1, Table 6.1-1 will be revised as noted in the attached markup.

NRC RAI 6.1-2

6.1-2 Modify DCD Tier 2, Table 6.1-1 to include filler metal specifications that are be used to weld ESF systems to

GE Response

Filler metals will be added to Table 6.1-1, similar to revised Table 5.2-4 (RAI Response 5.2-36). Please see attached revised Table 6.1-1.

DCD Tier #2, Section 6.1, Table 6.1-1 will be revised as noted in the attached markup.

NRC RAI 6.1-3

Provide a description of the fabrication requirements for each ESF system including the applicable ASME Code or Industry Standard.

GE Response

Please see the response to RAI 6.1-1 above. Fabrication requirements for each system will comply with the corresponding Section III classification.

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

NRC RAI 6.1-4

Verify that minimum preheat requirements meet the recommendations of ASME Code, Section III, Appendix D, Article D-1000 and follow the guidelines of RG 1.50, "Control of Preheat Temperature for Welding Low-Alloy Steel." If RG 1.50 will not be followed, please provide a description of the portions of RG 1.50 that will not be followed and a description of the steps that will be taken to ensure delayed cracking of the weld metal or heat affected zone will not occur. Explain in detail, the process methods, temperature monitoring and post weld bake out to be performed.

GE Response

The only welded low alloy steel requiring post weld heat treatment in the ESF systems is the SLC accumulator tank. For this component the minimum preheat recommendations of ASME Section III, Appendix D, Article D-1000 will be applied. Regarding RG 1.50, please see response to RAI 5.2-44. For welding processes other than narrow gap gas shielded welding, including flux shielded welding, rigorous qualification of the effectiveness of post weld baking will be required prior to approval to apply post weld baking before drop of preheat.

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

NRC RAI 6.1-5

6.1-5 Provide a description of all dissimilar metal welds (DMWs) in the ESF systems and discuss the selection of filler metals, welding processes and process controls for DMWs. Provide a description of the fabrication requirements for each ESF system including the applicable ASME Code or Industry Standard.

GE Response

Dissimilar metal welds in the ESF will be performed with the same materials and process selections as for the RCPB. Please see response to RAI 5.2-40. Fabrication requirements are addressed in the response to RAI 6.1-1 and RAI 6.1-3.

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

NRC RAI 6.1-6

6.1-6 Verify that the fabrication of ESF system materials follow the guidance provided in RG 1.71. If the guidance provided in RG 1.71 is not followed, provide a description of an alternative and provide a basis for using the proposed alternative.

GE Response

Regulatory Guide 1.71 will be applied to ESF systems in the same manner as for RCPB systems. Please see response to RAI 5.2-45. The exclusion of two inch and smaller socket welds from restricted access qualification requirements is based on two main considerations. One is that socket welds are made as fillet welds, which are significantly easier to perform than groove welds, even under restricted access conditions. Secondly, a leak or failure of such a small line will not challenge the make-up water supply of the reactor system so safety is not affected. For ESBWR in particular, a survey of the current design shows only lines one inch and smaller are included in this category.

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

NRC RAI 6.1-7

6.1-7 Discuss the corrosion allowances and the method used to determine corrosion allowances for ferritic material in the ESF systems.

GE Response

The process for determining the corrosion allowance for ferritic materials is the same as that applied to reactor coolant pressure boundary ferritic materials (see RAI response 5.2-43). This process is summarized as follows: Corrosion allowances for ferritic materials are contained in an internal GE design guidance document. These allowances are based on underlying corrosion rate data generated by laboratory testing along with consideration of some available open literature. However, open literature on BWR specific water chemistry conditions was very limited at the time the corrosion allowances were set, so the bulk of the data was the result of GE internal testing. The allowances for 40 year life were based on extrapolation of rate data and set as a summation of an operating period (90% of the time) added to a shutdown allowance (10% of the time). The allowances consider fluid velocity, oxygen content, and temperature, and include a safety margin over the actual measured corrosion rates of approximately a factor of two. For the ESBWR 60 year life, the allowances were scaled up by an additional 50% of the 40 year allowances. The specific allowance applied to a ferritic component in the ESF systems depends on the local operating conditions projected over the life of the component (e.g. air or water, stagnant or flowing, velocity, temperature, oxygen concentration, etc.). This same method, with the corresponding allowances, has been applied to most operating BWRs (GE design), including the licensed ABWR design.

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

NRC RAI 6.1-8

6.1-8 DCD Tier 2, Section 6.1.1 discusses compatibility of materials with demineralized water, but some components not covered in Section 5.2.3,such as the isolation condenser tubing, may come into contact with reactor water. Identify any materials in the ESF system that come in contact with reactor water, but are not part of the reactor coolant pressure boundary (RCPB). Discuss the compatibility of these materials with reactor water.

GE Response

All materials in contact with reactor water in the ESF systems are the same selection as used for the RCPB, i.e. carbon steel, low alloy steel, austenitic stainless steel, and nickel alloy. The nickel alloy in particular is the same alloy used for the reactor vessel shroud support structure and bottom head stub tubes. As such, all of these materials have been qualified for BWR service and are fully demonstrated to be compatible with reactor water by many years of BWR operating experience.

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

NRC RAI 6.1-9

6.1-9 Provide values of the ESBWR design special control limits on hardness, bend radius and surface finish when using austenitic stainless steel.

GE Response

Hardness and cold work controls for austenitic stainless steels in the ESF systems that are exposed to high temperature primary system water are essentially the same as applied to reactor internals and RCPB piping. Please see RAI Response 4.5-31. The standard surface finish is 250 μinch or finer, but where grinding of weld heat affected zones is applied, polishing is required similar to reactor internals. Pipe counterbores for stainless steel piping likewise will be polished after machining to remove surface cold work

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

NRC RAI 6.1-10

DCD Tier 2, Table 6.1-1 indicates that Alloy 600 will be used in the isolation condenser. Given that Alloy 600 has a history of stress corrosion cracking under certain conditions, provide a description of the normal environment in the isolation condenser tubing. Also include material condition (i.e. mill annealed or thermally treated) as it relates to its susceptibility to stress corrosion cracking in reactor water and demineralized water.

GE Response

Note that there have been no reports of Alloy 600 cracking in BWRs in the absence of a welded crevice or a crack initiated in adjacent Alloy 182. These initiating features are absent from the ESBWR design. In addition, the material used for the isolation condenser is the same alloy as used for reactor shroud support and stub tubes (see RAI Response 4.5-18). This alloy is a significantly modified version of Alloy 600 wherein the carbon content is limited, niobium (columbium) is added as a stabilizer, and high temperature solution heat treatment is required instead of mill anneal. Stress corrosion resistance is very good. The components fabricated from this alloy are subject to in-service inspection. The alloy is recognized by the ASME Code (Code Case N-580-1) and has been deployed in several operating BWRs, including the Kashiwazaki-Kariwa 6/7 ABWRs. Several of these units have been operating for more than ten years.

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

NRC RAI 6.1-11

DCD Tier 2, Table 6.1-1 indicates that the containment vessel liner consist of carbon steel, stainless steel plate and stainless steel sheet. Provide a description of the construction methods/processes to join these materials.

GE Response

The liner materials in various regions of the containment are shown in DCD Figure 3G.1-48. Welding processes, including welds between dissimilar materials, follows ASME Section III requirements consistent with the response to RAI 6.1-5. Stainless steel clad carbon steel plates follow SA-264. The exact cladding method (roll bonding, welding, etc.) will be determined in the construction phase.

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

NRC RAI 6.1-12

Identify what, if any, portion of the stainless steel containment vessel liner is welded to A 709 Gr. HPS 70W material. Identify the welding process, filler metal, welding requirements and history of joining these two materials.

GE Response

The stainless steel liner will not be welded directly to A 709 Gr. HPS 70W. The structural joints will be between this alloy and plain carbon steel. Consequently, the weld will be performed using a carbon steel filler metal. This material combination is readily weldable.

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

NRC RAI 6.1-13

DCD Tier 2, Table 6.6-1 does not list material specification for automatic depressurization system (ADS) piping such as the piping from the relief valve to the suppression pool. Provide the appropriate specification and verify Table 6.6-1 is complete and includes the materials specifications for passive containment cooling system (PCCS), gravity driven cooling system (GDCS), ADS, isolation condenser system (ICS), standby liquid control (SLC), sealed emergency operating area (SEOA), and emergency breathing air system (EBAS) piping and components that are part of ESF systems but are not included in Section 5.2.3.

GE Response

It is assumed this RAI is in reference to DCD Table 6.1-1. Piping material for ADS Safety Relief Valve Discharge Lines and the missing information on materials for Control Room Habitability Area (CRHA) Emergency Breathing Air System (EBAS) will be added to Table 6.1-1 as shown in response to RAI 6.1-1. The revised Table 6.1-1 now includes all ESF systems.

DCD Tier #2, Section 6.1, Table 6.1-1 will be revised as noted in the attached markup.

Sealed Emergency Operating Area (SEOA) will be deleted from DCD Section 6.0 Item (3) a as shown below:

(3) Control Room Habitability Systems

a. Deleted

b. Emergency Breathing Air System (EBAS)

NRC RAI 6.1-14

DCD Tier 2, Table 6.6-1 indicates the SLC system accumulator is fabricated from low alloy steel with stainless steel cladding. Provide stainless steel cladding specification.

GE Response

Application of stainless steel cladding will be very similar to that applied to the inside of the reactor pressure vessel, i.e. weld deposited cladding. Welding processes are mainly submerged arc welding or electroslag welding. However, shielded metal arc, gas tungsten arc, or gas metal arc welding may be used for local repair or coverage of plate or forging junctions. The cladding material will be either SFA-5.9 ER309L or a first layer of ER309L overlaid with ER308L. For single layer cladding, if used, the weld deposit is specially formulated to provide nominally an ER308L composition as deposited accounting for dilution.

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

NRC RAI 6.1-15

*DCD Tier 2, Table 6.6-1 indicates that some components are fabricated from cast austenitic stainless steel (CASS). Given that CASS components can be susceptible to thermal aging embrittlement, please discuss the following for any CASS component in a ESF system: (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 ESF components, (3) the need for inspections to detect this aging effect, and (4) verify that *-ferrite content is calculated using Hull's equivalent factors or a method producing an equivalent level of accuracy.*

GE Response

Ferrite and carbon content controls for ESF cast austenitic stainless steel exposed to elevated temperatures and pressure will be the same as for reactor internals and RCPB components. Please see GE responses to RAIs 4.5-3 and 5.2-38. GE prefers to use ASTM A 800 for ferrite determination because it is broadly recognized and readily available to any foundry worldwide. For low carbon castings operating at no more than 288°C, accuracy of the ferrite estimation method is not critical, especially for castings containing less than 25% ferrite. It can be seen from the data presented in NUREG/CR-4513 Rev. 1 that more than adequate toughness remains at 500,000 hours (~60 years) for castings under these conditions. It is agreed that the A 800 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.

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

Table 6.1-1 Engineered Safety Features Component Materials				
Component	**Applicable ASME Code Section III,**	**Form**	**Material**	**Specification (ASTM/ASME)**
Containment				
Containment Vessel Liner [1]	Div 2, Subsection CC	Plate ≤ 64 mm	Carbon Steel	SA-285 Gr ASA-516 Gr 60 or Gr 70
	Div 2, Subsection CC	Plate > 64 mm	Carbon Steel	SA-516 Gr 60 or Gr 70
	Div 2, Subsection CC	Plate	Stainless Steel	SA-240 Type 304L
Penetrations	Div 1, Subsection NE	Plate	Carbon Steel	SA-516 Gr 60 or Gr 70 SA-537 Class 1
	Div 1, Subsection NE	Pipe	Carbon Steel	SA-333 Gr 6
GDCS and Suppression Pool Liner	Div 2, Subsection CC	Sheet	Stainless Steel	A 240 Type 304L or A 167 Type 304L
Drywell Head, Personnel Lock, Equipment Hatch				
		Plate	Carbon Steel	SA-516 Gr 70 or SA-537 Class 1
Structural Steel	Div 1, Subsection NE	Shapes	Carbon Steel	A 36, A 572 Gr 50
Vent Pipe	Div 1, Subsection NE	Plate	Stainless Steel	SA-240 Gr 304L

Table 6.1-1 Engineered Safety Features Component Materials				
Component	**Applicable ASME Code Section III,**	**Form**	**Material**	**Specification (ASTM/ASME)**
PCCS				
Condenser	Div 1, Subsection NC	Forging	Stainless Steel	SA-182 Gr F304L
		Tube	Stainless Steel	SA-213 Gr TP304L
		Pipe	Stainless Steel	SA-312 Gr TP304L
Piping	Div 1, Subsection NC	Pipe	Stainless Steel	SA-312 Gr TP304L
Flanges	Div 1, Subsection NC	Forging	Stainless Steel	SA-182 Gr F304L
Nuts and Bolts	Div 1, Subsection NC	Bar	Stainless Steel	SA-194 Gr 8, SA-193 Gr B8
ADS				
DPV Body	See Table 5.2-4			

Table 6.1-1 Engineered Safety Features Component Materials				
Component	**Applicable ASME Code Section III,**	**Form**	**Material**	**Specification (ASTM/ASME)**
SRV Body	See Table 5.2-4			
SRV Discharge Piping Outside Suppression Pool	Div 1, Subsection ND	Pipe	Carbon Steel	SA-106 Gr B
SRV Discharge Piping Inside Suppression Pool	Div 1, Subsection ND	Pipe	Stainless Steel	SA-312 Gr TP316L[2]
GDCS				
Piping-downstream of check valve	Div 1, Subsection NB	Pipe	Stainless Steel	SA-376 Gr TP304L or TP316L [2] SA-312 Gr TP304L or TP316L [2] SA-358 Gr TP304L or TP316L [2]
Piping-upstream of check valve	Div 1, Subsection NC			
Fittings	Same as mating pipe	Forging	Stainless Steel	SA-182 Gr F304L or F316L [2] SA-403 WP 304L or WP 316L [2]
Flanges	Same as mating pipe	Forging	Stainless Steel	SA-182 Gr F304L or F316L [2]
Valves (Gate, Squib, Check)				
Body	Div 1, Subsection NB	Forging	Stainless Steel	SA-182 Gr F304L or F316L [2]
		Casting	Stainless Steel	SA-351 Gr CF3 or CF3M
Bolts	Div 1, Subsection NB	Bar	Low Alloy Steel	SA-193 Gr B7 or B7M
Nuts	Div 1, Subsection NB	Bar	Low Alloy Steel	SA-194 Gr 7 or 7M
ICS				

Table 6.1-1 Engineered Safety Features Component Materials				
Component	**Applicable ASME Code Section III,**	**Form**	**Material**	**Specification (ASTM/ASME)**
Condenser	Div 1, Subsection NC	Tube	Alloy Steel	SB-163 (Inconel 600)
		Header	Alloy Steel	SB-564 (Inconel 600)
Steam Piping	Div 1, Subsection NB	Pipe	Carbon Steel	SA-333 Gr 6
Condensate Piping	Div 1, Subsection NB	Pipe	Stainless Steel	SA-376 Gr TP304L/316L [2] SA-312 Gr TP304L/316L [2] SA-358 Gr TP304L/316L [2]
SLC				
Accumulator	Div 1, Subsection NC	Plate Forging	Low Alloy Steel with Stainless Steel Cladding	SA-533 Gr B Cl 2 SA-508 Gr 3 Cl 1
Piping-downstream of injection valve	Div 1, Subsection NB	Pipe	Stainless Steel	SA-312 Gr TP316L [2]
Piping-upstream of injection valve	Div 1, Subsection NC	Pipe	Stainless Steel	SA-312 Gr TP316L [2]
EBAS				
Tanks	Div 1, Subsection ND	Pipe	Carbon Steel	SA-333 Gr 8
Piping (high pressure)	Div 1, Subsection ND	Pipe	Carbon Steel	SA-333 Gr 6 or 8

Table 6.1-1 Engineered Safety Features Component Materials				
Component	**Applicable ASME Code Section III,**	**Form**	**Material**	**Specification (ASTM/ASME)**
Piping (low pressure)	Div 1, Subsection ND	Pipe	Carbon Steel	SA-106 Gr B
Weld Filler Metals				
Carbon Steel Filler	Same as the for the component being welded	Covered Electrode or Filler Wire	Carbon Steel	SFA-5.1 SFA-5.17 or SFA-5.18
Low Alloy Steel Filler	Same as the for the component being welded	Covered Electrode or Filler Wire	Low Alloy Steel	SFA-5.5 SFA-5.23 or SFA-5.28
Stainless Steel Filler	Same as the for the component being welded	Covered Electrode or Filler Wire	Stainless Steel	SFA-5.4, Grades E308L/E316L or E309L SFA-5.9, Grades ER308L/ER316L or ER309L
Nickel Alloy Filler	Same as the for the component being welded	Filler Wire	Nickel Alloy	SFA-5.14, Grade ERNiCr-3

1. All carbon plate is Gr 60 or Gr 70 regardless of thickness.
2. Carbon content not to exceed 0.020% for components exposed to reactor water that exceeds 93°C (200°F) during normal plant operation.