HITACHI

GE Hitachi Nuclear Energy

James C. Kinsey
Vice President, ESBWR Licensing

PO Box 780 M/C A-55
Wilmington, NC 28402-0780
USA

T 910 675 5057
F 910 362 5057
jim.kinsey@ge.com

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Subject: **Response to Portion of NRC Request for Additional Information Letter No. 176 Related to ESBWR Design Certification Application - Design of Structures, Components, Equipment, and Systems - RAI Number 3.9-148 S01**

The purpose of this letter is to submit the GE Hitachi Nuclear Energy (GEH) response to a portion of the U.S. Nuclear Regulatory Commission Request for Additional Information (RAI) sent by NRC Letter 176, dated April 10, 2008 (Reference 1). The GEH response to RAI Number 3.9-148 S01 is addressed in Enclosure 1.

The GEH response to RAI 3.9-148 was submitted via Reference 2 in response to Reference 3.

Should you have any questions about the information provided here, please contact me.

Sincerely,

James C. Kinsey

James C. Kinsey
Vice President, ESBWR Licensing

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NRO

References:

1. MFN 08-375, Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, *Request for Additional Information Letter No. 176 Related to the ESBWR Design Certification Application,* dated April 10, 2008

2. MFN 07-652, Reponses to Portions of NRC Requests for Additional Information Letter 67 *Related To ESBWR Design Certification Application - DCD Chapter 3 - Design of Structures, Components, Systems, and Equipment - RAI 3.9-148 and RAI 3.9-149 S01*, dated December 14, 2007

3. MFN 06-378, Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, *Request for Additional Information Letter No. 67 Related to the ESBWR Design Certification Application,* dated October 10, 2006

Enclosure:

1. Response to Portion of NRC Request for Additional Information Letter No. 176 Related to ESBWR Design Certification Application – Design of Structures, Components, Equipment, and Systems - RAI Number 3.9-148 S01

cc:	AE Cubbage	USNRC (with enclosure)
	RE Brown	GEH/Wilmington (with enclosure)
	DH Hinds	GEH/Wilmington (with enclosure)
	GB Stramback	GEH/San Jose (with enclosure)
	eDRF	0000-0076-4271, Revision 1

Enclosure 1

MFN 08-479

Response to Portion of NRC Request for

Additional Information Letter No. 176

Related to ESBWR Design Certification Application

Design of Structures, Components, Equipment, and Systems

RAI Number 3.9-148 S01

For historical purposes, the original text of RAI 3.9-148 and the GEH response are included.

NRC RAI 3.9-148

As indicated in DCD Tier 2, Section 3.9.5.4, GE stated that the design and construction of the core support structures are in accordance with the ASME Code, Subsection NG. GE is requested to identify the specific paragraphs of Subsection NG that are followed for the design and construction of the core support structures. In addition, in Tables 3.9-4 through 3.9-7 of DCD Tier 2, GE provides the stress, deformation, and fatigue criteria for safety-related reactor internals (except core support structures), which are based on the criteria established in applicable codes and standards for similar equipment, by manufacturers' standards, or by empirical methods based on field experience and testing. GE is requested to: (1) identify which specific paragraphs of Subsection NG from which these criteria are derived, or (2) if other than the ASME Code is used, identify and justify the other criteria (based on manufacturers' standards or empirical methods) that are used as the basis to develop the stress, deformation, and fatigue criteria for safety-related reactor internals.

GEH Response

Core support structures are designed and built to ASME, Section III, Subsection NG. The stress analysis being used is an elastic analysis method that is most commonly performed on the reactor core support structures in accordance with ASME Section III, Subsection NG, Sub-article NG-3200 for Service Conditions A&B, C, and D; and Section III, Appendix F as applicable for Service Level D condition. An inelastic analysis method is also used for a postulated blowout of a CRD Housing caused by a weld failure as discussed in Section 3.9.1.4.

The ASME Code, Section III does not set specific stress limits for Reactor Internal Structures. Per NG-1122(c) "The Certificate Holder shall certify that the construction of all internal structures is such as not to affect adversely the integrity of the core support structure." To ensure that the internal structures meet this requirement, the Safety Factors for Level A Level B, Level C and Level D as shown in DCD 3.9.5.are selected so that the calculated stress levels will meet the stress limits for Core Support Structures given in Article NG-3200. For example, in Table 3.9-5 of the DCD, Tier 2, the ratios between the elastic evaluated primary stresses, PE, and the permissible primary stresses, PN shall be :

$$PE/PN \leq 2.25/SFmin$$

Applying a Safety Factor of 2.25 to Levels A and B makes PE/PN ≤ 1 or PE ≤ 1 PN. Where PE is the elastic primary stress and PN equals the Code limit of 1 S_m for Level A and B. The limit given in Fig. NG-3221-1 is met.

Similarly for Level C, SF_{min} = 1.5. Hence, PE/PN ≤ 2.25/1.5 or PE ≤ 1.5 PN, which meets the requirements of Fig. NG-3224-1

For Level D, SF_{min} = 1.125. Hence, PE/PN ≤ 2.25/1.125 or PE ≤ 2.0 PN which is more conservative than the 2.4 S_m limit set by Appendix F of the ASME Code, Section III.

Similarly, when using the largest lower bound limit load, CL, the Permissible load LP :

LP/CL ≤ 1.5/SF_{min} . When SF_{min} = 2.25, LP = 0.667 CL, which is consistent with NG-3228.2 and Fig. NG-3221-1.

When using the conventional ultimate strength at temperature, US, as a limit, the elastic evaluated primary stress, PE : PE/US ≤ 0.75/SF_{min} . When SF_{min} = 2.25,

PE ≤ 0.33 US, that meets the stress intensity criterion of ASME Section II, Part D, Appendix 2 110*(b).*

Moreover, the criterion shown in Tables 3.9-4 through 3.9-7 is developed from Subsection NG of the ASME Code. Per NG-3224.6 the deformation limit can be derived from the ultimate load determined by testing. The elastic limit therefore can be determined as a specified fraction of this load. Per NG-3228.4, NG-3224.1 (e), and NG-3225, this fraction is .44, .6 and .88 for service levels A or B, C and D respectively.

Note: In Table 3.9-4 entitled, Deformation Limit for Safety Class Reactor Internal Structures Only, the footnote (**) to equation b of Table 3.9-4 shall be changed to read: "Equation b will not be used unless supporting data are provided to the NRC." DCD impact has been addressed in GE's Response to RAI 3.9-149 S01.

DCD Impact

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

NRC RAI 3.9-148 S01

Summary:

Provide additional information related to the primary stress limit for safety class reactor internal structures.

Full Text:

The staff finds that the GEH's response to RAI 3.9-148, dated December 14, 2007, is partially complete. The staff needs the following additional information related to DCD Tier 2, Table 3.9-5:

(1) Identify the specific paragraphs of Subsection NG for Requirement (d) as applied to Service Condition Levels A and B.

(2) For Service Condition Level C, Requirement (d) provides General Limit of 0.6 ultimate strength (US), whereas Fig. NG-3224-1 provides a smaller limit of 0.5 US. Please explain this difference.

(3) The footnote (*) to equations e, f, g needs to be changed to read:

"Equations e, f, g will not be used unless supporting data are provided to

the NRC for review and approval."

GEH Response

(1) There is no paragraph in Subsection NG that specifically refers to requirement (d) for Service Level A and B Loads applicable to core support structures, and consequently for reactor internal structures. However, for Level A and B Service Limits, Figure NG-3221-1 requires the primary stresses to be less than 0.44 L_u. This requirement is considered in Table 3.9-5 (d) where L_u, defined in NG-3228.4, is the equivalent of US. For Service Level A and B primary stresses in Table 3.9-5 (d):

$EP/US \leq 0.9/SFmin$, and with $SFmin = 2.25$

$EP \leq 0.4\ US$

which is comparable to the Code limit of 0.44 L_u by test.

(2) For Service Level C Limits, Figure NG-3224-1 requires primary stresses to be less than 0.6 L_e by test. This requirement is considered in Table 3.9-5 (d) where L_e, defined in NG-3224.1(*e*), is the equivalent of US. For Service Level C primary stresses in Table 3.9-5 (d):

EP/US ≤ 0.9/SFmin , and with SFmin = 1.5

EP ≤ 0.6 US

which is comparable to the Code limit of 0.6 L_e by test. This limit is appropriate for reactor internal structures, using the core support structure Code requirements as guidance. Reactor internal structures are not required by Code to satisfy the stress limits of Article NG-3200 (i.e., EP ≤ 0.5 US for elastic-plastic stress limits). The above methodology applies Code proven limits to Service Level C reactor internal structures to satisfy the NG-1122(c) requirement to not adversely affect the integrity of core support structures.

(3) The footnote (*) to equations e, f and g will be revised to read: " Equations e, f, or g will not be used unless supporting data are provided to the NRC for review and approval."

DCD Impact

DCD Tier 2, Table 3.9-5 footnote (*) will be revised in Revision 5 as noted in the attached markup.

Table 3.9-5

Primary Stress Limit for Safety Class Reactor Internal Structures Only

	Any One of (No More than One Required)	General Limit	
a.	Elastic evaluated primary stresses, PE / Permissible primary stresses, PN	≤	2.25 / SF_{min}
b.	Permissible load, LP / Largest lower bound limit load, CL	≤	1.5 / SF_{min}
c.	Elastic evaluated primary stress, PE / Conventional ultimate strength at temperature, US	≤	0.75 / SF_{min}
d.	Elastic-plastic evaluated nominal primary stress, EP / Conventional ultimate strength at temperature, US	≤	0.9 / SF_{min}
e.	Permissible load, LP* / Plastic instability load, PL	≤	0.9 / SF_{min}
f.	Permissible load, LP* / Ultimate load from fracture analysis, UF	≤	0.9 / SF_{min}
g.	Permissible load, LP* / Ultimate load or loss of function load from test, LE	≤	1.0 / SF_{min}

where:

PE = Primary stresses evaluated on an elastic basis. The effective membrane stresses are to be averaged through the load carrying section of interest. The simplest average bending, shear or torsion stress distribution, which supports the external loading, is added to the membrane stresses at the section of interest.

PN = Permissible primary stress levels under service level A or B (normal or upset) conditions under ASME B&PV Code, Section III.

LP = Permissible load under stated conditions of service level A, B, C or D (normal, upset, emergency or faulted).

CL = Lower bound limit load with yield point equal to 1.5 Sm where Sm is the tabulated value of allowable stress at temperature of the ASME III code or its equivalent. The "lower bound limit load" is here defined as that produced from the analysis of an ideally plastic (non-strain hardening) material where deformations increase with no further increase in applied load. The lower bound load is one in which the material everywhere satisfies equilibrium and nowhere exceeds the defined material yield strength using either a shear theory or a strain energy of distortion theory to relate multiaxial yield to the uniaxial case.

US = Conventional ultimate strength at temperature or loading which would cause a system malfunction, whichever is more limiting.

EP = Elastic plastic evaluated nominal primary stress. Strain hardening of the material may be used for the actual monotonic stress strain curve at the temperature of loading or any approximation to the actual stress curve which everywhere has a lower stress for the same strain as the actual monotonic curve may be used. Either the shear or strain energy of distortion flow rule may be used.

PL = Plastic instability loads. The "Plastic Instability Load" is defined here as the load at which any load bearing section begins to diminish its cross-sectional area at a faster rate than the strain hardening can accommodate the loss in area. This type analysis requires a true-stress/true-strain curve or a close approximation based on monotonic loading at the temperature of loading.

UF = Ultimate load from fracture analyses. For components, which involve sharp discontinuities (local theoretical stress concentration), the use of a "Fracture Mechanics" analysis where applicable utilizing measurements of plane strain fracture toughness may be applied to compute fracture loads. Correction for finite plastic zones and thickness effects as well as gross yielding may be necessary. The methods of linear elastic stress analysis may be used in the fracture analysis where its use is clearly conservative or supported by experimental evidence. Examples where "Fracture Mechanics" may be applied are for fillet welds or end of fatigue life crack propagation.

LE = Ultimate load or loss of function load as determined from experiment. In using this method, account is taken of the dimensional tolerances, which may exist between the actual part and the tested part or parts as well as differences, which may exist in the ultimate tensile strength of the actual part and the tested parts. The guide to be used in each of these areas is that the experimentally determined load is adjusted to account for material property and dimension variations, each of which has no greater probability than 0.1 of being exceeded in the actual part.

SF_{min} =Minimum safety factor (Subsection 3.9.5.4).

Notes:

* Equations e, f, or g ~~are~~ will not be used unless supporting data are provided to the NRC for review and approval.