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MFN 06-298
Supplement 3

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Subject: **Response to NRC Request for Additional Information Related to ESBWR Design Certification Application – Structural Analysis - RAI Numbers 3.8-5 S02 and 3.8-9 S02 – DCD Section 3.8 – Structural Analysis**

Enclosure 1 contains GE-Hitachi Nuclear Energy Americas LLC (GEH)'s response to the subject NRC RAIs 3.8-5, Supplement 2 and 3.8-9, Supplement 2, were transmitted via Reference 1.

If you have any questions or require additional information, please contact me.

Sincerely,

Kathy Sedney for

James C. Kinsey
Project Manager, ESBWR Licensing

D068
NRO

Reference:

1. Email to GEH from Chandu Patel (NRC) dated 05/24/07
2. MFN 06-298, Supplement 1, Response to Portion of NRC Request for Additional Information Letter No. 38 Related to ESBWR Design Certification Application – Structural Analysis - RAI Numbers 3.8-1 S01, 3.8-2 S01, 3.8-4 S01, 3.8-5 S01, 3.8-7 S01, 3.8-9 S01, 3.8-10 S01, 3.8-12 S01, 3.8-15 S01, 3.8- 29 S01, 3.8-30 S01, 3.8-31 S01, 3.8-42 S01, 3.8-52 S01, 3.8-53 S01, 3.8- 54 S01, 3.8-58 S01, 3.8-60 S01, 3.8-61 S01, 3.8-67 S01, 3.8-70 S01, 3.8- 71 S01, 3.8-72 S01, 3.8-74 S01 & 3.8-98 S01 - Supplement 1, January 29, 2007

Enclosure:

1. MFN 06-298, S03, RAI Response to RAIs 3.8-5 S02 and 3.8-9 S02

cc:	AE Cubbage	USNRC (with enclosures)
	RE Brown	GEH/Wilmington (with enclosures)
	GB Stramback	GEH/San Jose (with enclosures)

eDRF 0000-0068-8512

MFN 06-298, Supplement 3

Enclosure 1

RAI Response to RAIs 3.8-5 S02 and 3.8-9 S02

For historical purposes, the original text of RAI 3.8-5 and 3.8-9 and the GE responses are included. The attachments are not included from the original response to avoid confusion.

NRC RAI 3.8-5

a) DCD Section 3.8.1.2.2 and Table 3.8-9 indicate that ASME BPVC – 2004 is used for the design, fabrication, construction, testing, and in-service inspection of the concrete containment. The 2004 edition of the Code has not as yet been endorsed by the NRC; however, the 1989 edition was reviewed and accepted during the advanced boiling water reactor (ABWR) review process. Please provide a description of the differences between these two editions of the Code that are applicable to the design of the ESBWR containment (e.g., Subsections CC, NCA, and NE).

b) Assuming that the staff accepts the implementation of ASME Code 2004 edition for design of the ESBWR containment, the staff considers any deviation from the ASME Code 2004 edition for the design and construction of the containment would require NRC review and approval prior to implementation. This needs to be stated in Sections 3.8.1 and 3.8.2.

c) Since DCD Section 3.8.1.2.3 does not reference Regulatory Guide (RG) 1.94 (item 29 in Table 3.8-9), provide a discussion of how the provision of ANSI N45.2.5 and RG 1.94 are incorporated in the referenced codes and standards.

GE Response

a) The differences between 1989 edition and 2004 edition (including the addenda after 1989 edition) of the ASME Section III Code for Subsections CC, NCA, and NE are summarized in two tables. One table presents the reduction in requirements due to the change from 1989 edition to the editions after 1989, while the other table presents the increase in requirements due to the change. When the requirements are reduced, a column called "Comments" at the end of the table summarizes those changes accepted by the USNRC and those that have not been endorsed. When the requirements are increased, the design is more conservative and meets 1989 edition requirements.

The changes found in the table of reduction in requirements not endorsed by the USNRC, which are applicable to the ESBWR design, need NRC review and approval.

They are:
(1) Item III-1-A97 (96-250), Table NE-4622.7(b)-1, Exemption from PWHT
(2) Item III-1-A95 (94-316), NE-3221.1(c)(1), Stress Intensity Values
(3) Item III-2-A04, III-2 (BC03-472), CC-4331.2(b)(6) etc. (See Table), Cold Rolled Parallel Threaded Splices

(4) Item III-2-A02 (BC01-698), CC-4542.1 and CC-4542.2, Back-up Bars
(5) Item III-2-A01 (2001 Edition, BC00-182), CC-4333.2.3 Splicing of Reinforcing Bars-Performance Tests MFN 06-298, Supplement 1 Page 13 of 116 Enclosure 1
(6) Item III-2-A01 (2001 Edition, BC00-183), Table CC-4552-2 Postweld Heat Treatment Exemptions
(7) III-2-A01 (2001 Edition, BC00-357), CC-5531.2, Extent of Examination
(8) III-2-A95 (94-306), CC-4331.2(b)(5) etc. (See Table), Splicing of Reinforcing Bars
(9) III-2-A91 (91-212), CC-3421.4.1(c) etc. (See Table), Evaluation of Membrane Stress
(10) III-2-A91 (91-222), CC-4321.1(c), CC-4321.2, CC-4322(a), Bending of Reinforcing Bar
(11) III-2-A91, Table I-2.2, Material for Concrete Containment Vessel Liner - Remove limitations on the use of SA-738, Grade B
(12) III-2-A90 (89-332), CC-4321.2, Bending of Reinforcing Bar
(13) III-2-A90 (90-174), CC-4240(c), CC-4240(d), CC-4260, Cold Weather Concrete Placement

No DCD change was made in response to this item.
b) There are no deviations from ASME Code 2004 edition for the design and construction of the ESBWR containment; therefore, no revisions to the DCD were necessary in response to this item.

c) Markup of DCD Subsection 3.8.1.2.3 to include item 29 as well as 31 and 33 of DCD Table 3.8-9 was provided under MFN 06-298.

NRC RAI 3.8-5, Supplement 1

NRC Assessment Following the December 14, 2006 Audit
GE identified 13 items in their comparison table where the criteria in the 2004 edition of the Code is considered to be a relaxation of the 1989 Code. For each reduction in requirements tabulated in the table, GE needs to submit its technical basis for concluding that an equivalent level of safety will be achieved. Parts a), b) and c) are Acceptable. During the audit, GE provided an update to the Table which provides the explanation for these items. Some of the 13 items do not apply to ESBWR which is acceptable. GE indicated that for the remaining items, they will provide additional technical information to justify these items.

GE Response
The comparison table provided in the original response under MFN 06-298 where the criteria in the 2004 edition of the ASME Section III Code is considered to be a relaxation of the 1989 edition is updated as follows in Table 3.8-5 (1) R1.

Please note that none of the changes reduce the levels of previous conservatisms in the ASME Section III 1989 edition.

DCD Impact
No DCD change is required in response to this RAI Supplement.

NRC RAI 3.8-5, Supplement 2

NRC Assessment from Chandu Patel E-mail Dated May 24, 2007

The staff notes that Regulatory Guide (RG) 1.136, Revision 3, entitled "Design Limits, Loading Combinations, Materials, Construction, and Testing of Concrete Containments," was officially issued in March 2007. This regulatory guide endorses the 2001 Edition of the ASME Code, Section III, Division 2, through the 2003 addenda, subject to the exceptions cited in Section C, Regulatory Position, of the RG. Since the staff has officially accepted the Code, through the 2003 addenda, the applicant needs to identify any applicable relaxations between the 2004 Code referenced for the ESBWR design and RG 1.136, Rev. 3, including the regulatory positions. The deviations will require technical justification for acceptability. As an alternative, to facilitate resolution, the applicant may reference RG 1.136, Rev. 3 directly, and thereby revise the applicable code for the ESBWR design to the 2001 Edition of the ASME Code, Section III, Division 2, through the 2003 addenda. If the applicable code edition is revised, it needs to be documented in the DCD.

GEH Response
Regulatory Guide 1.136, Revision 3, which endorses the 2001 Edition of the ASME Code, Section III, Division 2, through the 2003 addenda, did not exist six months prior to the ESBWR design certification application. Consequently, Regulatory Guide 1.136, Revision 2 is applicable to the ESBWR.

In response to the original NRC RAI 3.8-5, the differences between ASME Section III, Division 2, 1989 Edition and the 2004 Edition (including all intermediate editions and addenda) were summarized in tabular form. This information had been previously reviewed and accepted by the NRC during the Advanced Boiling Water Reactor (ABWR) review process. In this table (revised in the Supplement 1 RAI response), the differences between the 2004 Edition and the 2001 Edition through the 2003 Addenda were included. As stated in the response to NRC RAI 3.8-5S1, none of the changes in the 2004 Edition reduces the levels of previous conservatisms in the Code since the 1989 Edition.

DCD Impact
No DCD change is required in response to this RAI Supplement.

NRC RAI 3.8-9
Provide a description of the different subcategories for SRV discharge (e.g., single valve, two valve, automatic depressurization system (ADS), and all valves) and for LOCA (large, intermediate, and small) if applicable, and how they are treated in the load combinations described in DCD Section 3.8.1.3. Also, provide a description and the basis for the method used to combine all of the dynamic loads.

In addition, (1) identify the applicable detailed report/calculation (number, title, revision and date, and brief description of content) that will be available for audit by the staff, and (2) reference this report/calculation in the DCD.

GE Response
LOCA (large, intermediate, and small break) and SRV discharges (single valve first actuation, single valve subsequent actuation, and multiple valves) are discussed the in Containment Load Definition (CLD) - NEDE-33261P. The bounding pressure and temperature values are used respectively as accident pressure P_a and LOCA temperature T_a in load combinations for design. The bounding pressure values are used as SRV loads for design. The SRV pressure values for these three limiting conditions (single valve first actuation, single valve subsequent actuation, and multiple valves) are furnished in Table 6 of NEDE-33261P. The multiple valve case bounds ADS. The SRV pressure values for these three limiting conditions cover the different subcategories of SRV discharge (e.g., single valve, two valve, ADS, and all valves). The bounding values of these three limiting conditions are shown in DCD Figure 3B-1 and are considered as SRV loads in DCD Subsections 3.8.1.3 and in the load combination DCD Tables 3.8-2, 3.8-4 and 3.8-7. Depending on the distribution of SRV loads in the suppression pool, they are further classified as axisymmetrical loads, or non-axisymmetrical loads. The SRV pressure loads are applied throughout the entire suppression pool as axisymmetrical SRV (DCD Subsection 3.8.1.4.1.1.2), which represents all of the (or multiple) valve cases. The SRV pressure loads are applied on half of the entire suppression pool as non-axisymmetrical SRV (DCD Subsection 3.8.1.4.1.1.1), which represents the single valve or two-valve case. Because the total load for the axisymmetrical SRV load case is greater than those for the non-axisymmetrical cases, only the former is considered in the RCCV and vent wall design. The design evaluation of the affected structures for SRV loads is performed using equivalent static pressure

input equal to a dynamic load factor (DLF) of 2 times the peak dynamic pressure (i.e., the bounding values). The resulting forces or stresses were combined with those due to other loads in the most conservative manner by systematically varying the signs associated with dynamic (including seismic) loads. (See also response to RAI 3.8-48).
The SRV pressure time history and other related information is presented in DCD Appendix 3B. The SRV forcing function as defined in DCD Appendix 3B and the CLD (NEDE-33261P) has a range between 5 to 15 Hz. To perform dynamic analyses to generate response spectra, a finite number of cases using various forcing function frequencies are selected to match with the natural frequencies of the structure to maximize the responses and is described in DCD Appendix 3F as follows: Axisymmetrical SRV (all) response analysis is covered by n=0 harmonic. Nonaxisymmetrical of SRV actuation is covered by n=1 harmonic that corresponds to the effect of the overturning moment.

Frequency range of SRV Loads: $f_1 < f < f_2$ ($f_1 = 5$ Hz, $f_2 = 12$ Hz)

For vertical structural frequencies $(fs)_v$ (n=0):

a. If $(fs)_v > f_2$ then use f_2
b. If $f_1 < (fs)_v < f_2$ then use $(fs)_v$
c. If $f_1 > (fs)_v$ then use f_1

For horizontal structural frequencies $(fs)_h$ (n=1):

a. If $(fs)_h > f_2$ then use f_2
b. If $f_1 < (fs)_h < f_2$ then use $(fs)_h$
c. If $f_1 > (fs)_h$ then use f_1

In an axisymmetrical load case, three vertical frequencies of 5 Hz, 6.06 Hz and 12 Hz are selected. In a non-axisymmetrical load case, 3 horizontal frequencies of 5 Hz, 8.83 Hz and 12 Hz, of the structure satisfying the above selection are adopted as SRV forcing function frequencies.

The bounding response spectra of these cases are documented in DCD Appendix 3F. They are to be used with the response spectra due to seismic and other hydrodynamic loads for the design of safety-related structures, systems, and components inside of containment using the SRSS method of combination.

(1) The applicable detailed report/calculation that will be available for the NRC audit is:

NEDE-33261P, *Containment Load Definition, Revision 1*, May 2006, containing the description of the hydrodynamic loads.

(2) Since this information exists as part of GE's internal tracking system, it is not necessary to add it to the DCD submittal to the NRC.

Markup of DCD Section 3.7 was provided under MFN 06-298.

NRC RAI 3.8-9, Supplement 1

NRC Assessment Following the December 14, 2006 Audit

a) If NEDE-33261P indicates that SRV has a range of 5 to 15 Hz, why does the analysis only consider a range of 5 to 12 Hz.

b) Are the values 6.06 and 8.83 the fundamental natural frequencies of the structure in the vertical and horizontal direction respectively?

c) Provide a comparable description for selecting the appropriate forcing functions for the different LOCA loads (chugging, CO, pool swell, AP, vent clearing, etc.)

d) Since this is done for generation of floor response spectra throughout the building (not just local containment response), aren't there other structural natural frequencies that should be considered?

e) GE provided a markup to 3.7 (first paragraph) where it states that the method for combining seismic and RBV loads for reinforced concrete structures varies the sign (+ or -), equivalent to ABS. This is acceptable for reinforced concrete structures. However, it also states that the method used (presumably for all other SSCs) is the SRSS in accordance with NUREG-0484., Rev. 1. This is acceptable for seismic plus LOCA; however, the criteria for combining other dynamic loads (e.g., SRV and individual LOCA loads (AP, PS, CO, CH, LCO, HVL, etc) are not clearly defined. According to NUREG-0484, the use of SRSS for the other loads would require demonstrating a non-exceedance probability (NEP) of 84 percent or higher is achieved. Some of this information may be implied and buried within various scattered sections of the DCD (e.g., response spectra for some of the loads in App. 3F; however, the criteria should be clearly specified in one location. e) If time permits during the audit, the referenced NEDE report should be looked at, not for development of the loads (not within BNL's scope) but for proper application of the defined loads to the plant structures. Note: This is also identified as an RAI (RAI-3.12-17) during the piping review of DCD Section 3.9.

During the audit, GE provided a draft supple mental response to this RAI. The staff needs to review this information. The response for items a, b, c, and d are acceptable. For item e, GE needs to provide documentation which describes the use of the SRSS method based on demonstrating that the NEP criteria was met.

GE Response

a) Frequency range of 5 to 15 Hz, as stated in the original response, was a typographical error. NEDE-33261P, page 6-5 specifies the bubble frequency range to be 5 to 12 Hz.

b) Yes, 6.06 and 8.83 Hz are the fundamental frequencies of the structure in the vertical and horizontal directions respectively.

c) Sixteen chugging and five CO cases, as described in DCD Tier 2 Subsection 3F.2.3 (4), cover the entire range of forcing functions, and there is no need to select specific structural frequencies.

d) The dynamic analysis model includes all structures in the reactor building. The resulting natural frequencies of 6.06 and 8.83 Hz are the only structural frequencies within the SRV forcing frequency range of 5 to 12 Hz.

e) ESBWR hydrodynamic loads are the same as the ABWR. The ABWR loads satisfy the 84-percentile non-exceedance (NEP) requirement of NUREG-0484, Rev. 1 as shown in the following memorandum that documents the applicability of the SRSS method for hydrodynamic loads.

(e.d. Note: Memo not included. See Supplement 1 response.)

DCD Impact

No DCD change is required in response to this RAI Supplement.

NRC RAI 3.8-9, Supplement 2

NRC Assessment from Chandu Patel E-mail Dated May 24, 2007
In response to item (e), the applicant stated that ESBWR hydrodynamic loads are the same as the ABWR. The ABWR loads satisfy the 84-percentile non-exceedance (NEP) criteria of NUREG 0484, Rev. 1, as shown in the memorandum attached to the response that documents the applicability of the square root of sum of squares (SRSS) method for hydrodynamic loads. The staff could not confirm that the ESBWR hydrodynamic loads are the same as the ABWR. In addition, the memorandum attached to the response does not clearly establish that the NEP criteria was satisfied for ABWR. Therefore, the staff requests the applicant to provide additional information demonstrating that the ESBWR hydrodynamic loads satisfy the 84 percentile NEP criteria of NUREG 0484, Rev. 1.

GEH Response

The ESBWR hydrodynamic load definitions and bases are described in the ESBWR containment loads report NEDE-33261P (Reference 1). These include the SRV loads, the LOCA CO loads and the LOCA chugging loads. As described in Reference 1 the ESBWR load definitions are developed based on the corresponding ABWR loads.

SRV Loads

The ESBWR plant uses X-Quencher devices based on the design used in Mark II and Mark III plants and also in the ABWR. The ESBWR SRV induced pool boundary bubble pressure loads are defined using the GE X-Quencher SRV load methodology which is described in Appendix 3B, Attachment A of GESSAR II (Reference 2). The GE X-Quencher load methodology was approved for BWR plants with X-Quenchers in Mark II and Mark III plants in NUREG-0802 (Reference 3). The GE X-Quencher load methodology was also used to define the ABWR X-Quencher SRV loads. The GE X-Quencher SRV load methodology employs empirically derived correlations, developed from partial and full scale tests, to generate a load definition with a statistical 95%/95% confidence level. This means that there is 95% confidence that the defined load will bound 95% of all future occurrences. This statistical confidence level bounds 84% non-exceedance probability (NEP) required by NUREG-0484.

LOCA CO and Chugging Loads

The ESBWR LOCA CO and chugging load definition consists of wall pressure time histories, which were originally defined for the ABWR. Justification for application of the ABWR CO and chugging wall pressure histories to the ESBWR containment is provided in NEDE-33261P (Reference 1).

The basis for the ABWR CO and chugging loads are described in Appendix 3B of the ABWR SSAR and is also included in the ESBWR containment loads report (Reference 1). A source load approach was used to define both the ABWR CO load and the ABWR chugging loads. With this approach, a test source load is initially developed with an acceptance criterion that the source load, when applied to the analytical model of the test facility, produces wall pressure histories, which match the test data. This test source, with appropriate adjustments is then applied to the full-scale ABWR containment to generate the ABWR wall pressure loads.

The sources loads for CO and chugging were developed from a comprehensive database (Reference 4) developed to envelope the range of expected conditions during CO and chugging in an ABWR plant. A set of sources for CO and chugging were developed with the criteria that when the sources are applied to an analytical model of the test facility, the Power Spectral Densities (PSD) of the resultant pressure histories envelope the PSDs for the measured CO and chugging test data.

Since the CO and chugging source loads, used to generate the load definition, were developed to envelope all available test data, the associated non-exceedance probability is considered to be near 100%. Therefore the ABWR CO and chugging load definitions, which have been applied to the ESBWR, meet the 84% NEP criteria required by NUREG-0484.

REFERENCES:

1. NEDE-33261P, "Licensing Topical Report, ESBWR Containment Load Definition," May 2006.
2. GESSAR II, 238 Nuclear Island, General Electric Company, Docket No. STN 50- 447, Amendments 1 through 21, Appendix 3B (Attachment A).
3. NUREG-0802, "Safety/Relief Valve Quencher Loads: Evaluation for BWR Mark II and III Containment," Oct. 1982.
4. NEDC-31393, "ABWR Containment Horizontal Vent Confirmatory Test, Part I," March 1987.

DCD Impact

No DCD change is required in response to this RAI Supplement.