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U.S. Nuclear Regulatory Commission
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Subject: **Revised Response to a Portion of NRC RAI Letter No. 368 Related to ESBWR Design Certification Application – Piping Design; RAI Number 3.12-3 S05**

The purpose of this letter is to submit the GE Hitachi Nuclear Energy (GEH) revised response to a portion of the U.S. Nuclear Regulatory Commission (NRC) Request for Additional Information (RAI) letter number 368 sent by NRC letter dated September 10, 2009 (Reference 1). Reference 2 transmitted GEH's original response to RAI Number 3.12-3 S05. As a result of susequent interactions with the staff, a revsion to Reference 2 is required to address the staff's concerns. GEHs revised response to RAI 3.12-3 S05 is addressed in Enclosure 1.

Enclosure 2 contains the revised DCD changes to address the staff's concerns. Verified DCD changes associated with this RAI response are identified in the enclosed DCD markups by enclosing the text within a black box.

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

Sincerely,

Richard E. Kingston

Richard E. Kingston
Vice President, ESBWR Licensing

References:

1. MFN 09-598 Letter from U.S. Nuclear Regulatory Commission to J. G. Head, GEH, *Request For Additional Information Letter No. 368 Related to ESBWR Design Certification* dated September 10, 2009
2. MFN 09-670 Letter from R. E. Kingston to the U.S. Nuclear Regulatory Commission, *Response to a Portion of NRC RAI Letter No. 368 Related to ESBWR Design Certification Application – Piping Design; RAI Number 3.12-3 S05* dated October 28, 2009

Enclosures:

1. Revised Response to Portion of NRC RAI Letter No. 368 Related to ESBWR Design Certification Application - Piping Design; RAI Number 3.12-3 S05 Revision 1
2. Revised Response to Portion of NRC RAI Letter No. 368 Related to ESBWR Design Certification Application – Revised DCD Markups for RAI Number 3.12-3 S05 Revision 1

cc:	AE Cubbage	USNRC (with enclosures)
	JG Head	GEH/Wilmington (with enclosures)
	DH Hinds	GEH/Wilmington (with enclosures)
	HA Upton	GEH/San Jose (with enclosures)
	eDRF Section	0000-0101-5570 R3 (RAI 3.12-3 S05)

Enclosure 1

MFN 09-670, Supplement 1

Revised Response to Portion of NRC Request for

Additional Information Letter No. 368

Related to ESBWR Design Certification Application

- Piping Design

RAI Number 3.12-3 S05[1]
Revision 1

[1]GEH Response to Supplement 3 and Supplement 4 R1, previously submitted under MFNs 06-119 Supplement 5 and 09-319 Revision 1, respectively, are included to provide historical continuity during the review.

NRC RAI 3.12-3 S03

NRC Summary:

GEH's use of SRSS of group responses in the application of Independent Support Motion (ISM) response spectrum analysis does not meet the current staff position.

NRC Full Text:

GEH uses SRSS of group responses in its application of Independent Support Motion (ISM) response spectrum analysis. The staff position in NUREG-1061, Volume 4 specifies absolute sum. GEH provided the results of a study performed to justify its use of SRSS for group responses in its September 13, 2007, letter. The study compares the results from a sample of two piping runs analyzed using multi-support time history (a method acceptable to the staff) with the proposed GEH

use of ISM with SRSS of group responses. The study indicated that multi-support time history responses exceeded the ISM responses at several locations in the feedwater system, the maximum being 8%. As a consequence, the staff recommends that GEH increase the piping stresses and loads by 10% when using the ISM SRSS method. Alternatively, GEH should follow the staff position in NUREG-1061, Volume 4.

GEH Response

GEH accepted the NRC's recommendation and agreed to increase the piping stresses and loads by 10% when using the ISM SRSS method. The following paragraph was added to the DCD Tier 2, Subsection 3.7.3.9.

'To use the SRSS method for independent support response spectrum (ISM) analysis it is required to include 10 percent margin in the design requirements for piping stress and piping support loads to address the uncertainties that may exist from the use of the SRSS method rather than the absolute sum method (ABS) for the group combination method when performing an ISM analysis'.

Based on this response, DCD Tier 2 Subsections 3.7.3.9 and 3.7.3.12 were revised.

DCD Impact

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

NRC RAI 3.12-3 S04

Provide justification to demonstrate that the selected piping system for ESBWR inside containment could be considered as representative for the ESBWR Class 1, 2, and 3 piping for all building. Clarification on the SRSS method.

Section 3.7.3.9 of ESBWR DCD stated that the independent support motion (ISM) response spectrum method of analysis combines responses of different support groups by the SRSS procedure for component and equipment and additional 10 percent margin for piping stress and piping support loads. Section II.9 of SRP 3.7.3 states that if the ISM method is utilized, all of the criteria presented in NUREG-1061 related to the ISM method must be followed. NUREG-1061 states that group responses for each direction should be combined by the absolute sum method. NUREG-1061 also states that unless the groups are from different structures or if from the same structure, they can be shown to be phase uncorrelated, then SRSS should be used. In RAI 3.12-3 S02, the staff requested the applicant to demonstrate that time histories from different support groups can be shown to be phase uncorrelated, and therefore, SRSS combination can be used. The applicant provided an alternative by performing a dynamic analysis for SSE earthquakes by two different procedures for two typical piping systems for ESBWR inside containment. The staff is requesting the applicant to provide justification to demonstrate that the selected piping system for ESBWR inside containment could be considered as representative for the ESBWR Class 1, 2, ad 3 piping for all building.

The staff also notes that Figure B-3-5 of the GEH study report, MFN 06-119, Supplement 2, (ML072680480) showed phase correlation in the vertical direction. How does this justify the use of the SRSS method?

GEH Response

It is GEH experience that using ABS group responses for ISM will result in very conservative results; and as such, it is not likely that GEH will use ISM when the ABS combination is required. For ESBWR the ISM method using the SRSS combination will be used under the following conditions:

1. For piping within the RCCV (see bases provided in the remainder of the RAI response).
2. For piping outside the RCCV, the SRSS method will be used if it is established. That the support motions are reasonably phase uncorrelated; otherwise, the absolute sum procedure is required if ISM is used as the analysis method.

The use of this criteria is supported by the Consultant Position Paper by R. P. Kennedy in NUREG-1061. In section 2.1.1 on page B-51, it states that: “Only if one can demonstrate that the responses are reasonably phase uncorrelated should group responses be combined SRSS. Reasonable phase uncorrelation is likely between different structures." Reinforcement of this statement is then reflected in Table 3 on page B-79 where the following revision for combining responses using the ISM response spectrum analysis method was suggested:

"A. Inertial or Dynamic Components (primary)

1. For each mode and for each input motion direction:
   Combine group response; by absolute sum (ABS) or preferably, by actual relative phasing if structural phasing information is retained. If it can be shown that group responses are reasonably phase uncorrelated (such as responses between different structures). then an SRSS combination may be used.
2. For each response quantity and each input motion direction:
   Combine modal responses by the Double Sum (DSC) or CQC method with provisions for high frequency modes.
3. For each response quantity:
   Combine input motion direction on responses by SRSS or Equivalent method."

The justification for using the SRSS procedure in conjunction with the ISM method by demonstrating that it is phase uncorrelated for piping inside the RCCV is shown as follows:

The selections of piping systems for the response spectrum analysis, the time history analysis and the comparisons have been performed according to the agreement reached between NRC, BNL and GE during the January 2007 audit meeting. The selected piping systems are representative for ESBWR piping inside the containment.

The NRC, in response to RAI 3.12-3 S03, has reviewed the detailed piping analysis results for the analyzed representative piping systems. The analysis results have demonstrated that SRSS combination of group responses yields conservative results for all the components in the main steam piping system and feedwater piping system, except for the six (6) node point locations in the feedwater piping analysis The maximum ratio for these 6 locations is 1.08. All these 6 locations are the low stress node points and they do not control the design. The maximum stress for the feedwater system is at the sweepolet node point 973. For this point the ratio is only 0.79. The table of the stress comparisons is attached with this response (Excerpted from report).

Additional time histories plots for the RPV nozzle and vent wall in the horizontal directions, North-South (N-S) and East-West (E-W), are plotted to demonstrate that there will be no correlation in the horizontal direction when the piping is not supported by the same structure. These plots are presented with this RAI response: It is noted that the time period selected for the plots is between 7.5 sec. to 8.0 sec. This is because during this period, the accelerations are the maximum in the 20 second of the seismic time history.

Figure B-3-5 (a) - Acceleration Time Histories for Vent Wall 701, and RPV Nozzle in N-S Direction from Time 7.5 sec. to 8.0 sec. (Not Correlated)

Figure B-3-5 (b) - Acceleration Time Histories for Vent Wall 701, and RPV Nozzle in E-W Direction from Time 7.5 sec. to 8.0 sec. (Not Correlated)

Figure B-3-2 (a) - Acceleration Time Histories for Containment Node 206 and RPV Nozzle in N-S direction, from time 7.5 sec. to 8.0 sec.(Not Correlated)

Figure B-3-2 (b) - Acceleration Time Histories for Containment Node 206 and RPV Nozzle in E-W direction, from time 7.5 sec. to 8.0 sec. (Not Correlated)

The above four figures illustrate that in the horizontal direction the N-S and E-W time histories at the RPV nozzle and the vent wall are not correlated. Additional plots for Nodes 206 and 807 in the horizontal direction are also provided for reference. The necessary conditions to have correlated time histories are:

(1) support points are on the same floor, that have exact the same mode shape and natural frequencies, or,
(2) on the same concrete slab plus the member to the support points are rigid, such as the RPV wall and the vent wall are rigid in vertical direction.

Since the vertical direction for the cases evaluated in the study met these conditions, the comparison plots show that phase correlation was present, but since the other two directions were not correlated, the results of the study still demonstrates that the SRSS method was valid when the 10% adder was applied.

Therefore, it is concluded that using SRSS group responses for ISM dynamic analysis using the support group suggested guidelines as shown in NUREG-1061 will produce conservative results. This particular study demonstrated that an SRSS combination of group responses yields conservative results for all the components in the main steam piping system and feedwater water piping system, except, at 6 node points in the feedwater system. The maximum ratio for these 6 points is 1.08 that occurs at a low stress location.

SRP 3.7.2 Paragraph II 1. (iii) States,

> (iii) Use adequate number of masses or degree of freedoms. The number is considered adequate when additional degree of freedom do not results in more than 10% increase in response.

(iv) Investigation of sufficient number of modes to ensure participation of all modes. The criterion for sufficiency is that the inclusion of additional modes does not result in more than 10 percent increase in responses.

Although this modeling requirement for the 10% rule is different then the SRSS group responses, it indicates that there are tolerances allowed in the dynamic methodology. In addition, ESBWR has committed to add a 10% margin to all piping analysis when ISM analysis is used. This further insures that all the analysis results are conservative.

In conclusion, the study demonstrates that using SRSS with the 10% increase in response is conservative for use for the main steam and feedwater lines, and that these represent typical results that can be expected for all piping within containment.

<u>DCD Impact</u>

DCD Tier 2 Section 3.7.3.9 will be revised as noted in the attached markup.

APPENDIX C-2 Feedwater Lines

Piping Stress Analysis Comparison

ESBWR Feedwater Class 1 Lines From Penetration to Header					
NO. NODE	SIZE O.D.	COMP TYPE	ISM, SRSS (ISM) Mpa	Time History (TH) Mpa	TH/ISM
			(B)	**(A)**	**(A)/(B)**
26	558.8	MPEN-0	101.67	77.23	0.76
26	558.8	TRANSI	84.73	64.36	0.76
29	558.8	ELBOW	0.04	0.04	1.00
101	558.8	ST PIP	69.12	60.86	0.88
103	558.8	ST PIP	15.39	14.18	0.92
103	558.8	ST PIP	15.39	14.18	0.92
103	558.8	ST PIP	15.39	14.18	0.92
104	558.8	ST PIP	46.31	34.95	0.75
104	558.8	ST PIP	46.31	34.95	0.75
607	558.8	ELBOW	25.71	21.31	0.83
607	558.8	ELBOW	25.71	21.31	0.83
608	558.8	ELBOW	0.96	0.70	0.73
608	558.8	ELBOW	0.96	0.70	0.73
617	558.8	ELBOW	73.97	59.71	0.81
617	558.8	ELBOW	73.97	59.71	0.81
618	558.8	ELBOW	46.59	32.40	0.70
618	558.8	ELBOW	46.59	32.40	0.70
627	558.8	ELBOW	29.93	19.58	0.65
627	558.8	ELBOW	29.93	19.58	0.65
628	558.8	ELBOW	49.58	37.97	0.77
628	558.8	ELBOW	49.58	37.97	0.77
637	558.8	ELBOW	0.92	0.67	0.73
638	558.8	ELBOW	22.85	21.21	0.93
638	558.8	ELBOW	22.85	21.21	0.93
788	558.8	ELBOW	1.72	1.24	0.72
792	558.8	ELBOW	54.21	40.24	0.74
798	558.8	ELBOW	26.94	23.09	0.86
800	558.8	ELBOW	32.07	20.48	0.64
801	558.8	ELBOW	85.64	70.91	0.83
817	558.8	ELBOW	23.89	22.50	0.94
817	558.8	ELBOW	23.89	22.50	0.94
820	558.8	ELBOW	47.45	36.07	0.76
954	558.8	TRANSI	65.04	65.03	1.00
955	**558.8**	**TRANSI**	**74.45**	**80.19**	**1.08**
956	**558.8**	**TRANSI**	**65.22**	**69.72**	**1.07**
958	558.8	ST PIP	33.36	30.33	0.91

ESBWR Feedwater Class 1 Lines
From Penetration to Header

NO. NODE	SIZE O.D.	COMP TYPE	ISM, SRSS (ISM) Mpa	Time History (TH) Mpa	TH/ISM
			(B)	**(A)**	**(A)/(B)**
960	**558.8**	**ST PIP**	**58.36**	**60.58**	**1.04**
966	558.8	ST PIP	38.20	31.84	0.83
966	558.8	ST PIP	38.20	31.84	0.83
967	558.8	TEE SM	100.77	84.09	0.83
967	558.8	TEE SM	66.77	51.87	0.78
967	558.8	TEE SM	152.74	111.84	0.73
968	558.8	ELBOW	37.55	23.35	0.62
968	558.8	ELBOW	37.55	23.35	0.62
969	558.8	ELBOW	24.70	21.49	0.87
969	558.8	ELBOW	3.08	2.24	0.73
969	323.9	SWEEPO	120.34	103.46	0.86
970	558.8	ELBOW	30.90	20.54	0.66
970	558.8	ELBOW	30.90	20.54	0.66
971	558.8	ELBOW	25.64	18.81	0.73
971	558.8	ELBOW	25.64	18.81	0.73
972	558.8	ELBOW	0.04	0.04	1.00
973	558.8	ELBOW	31.90	20.70	0.65
973	558.8	ELBOW	38.90	29.23	0.75
973	**323.9**	**SWEEPO (Max stress)**	**201.47**	**158.92**	**0.79**
974	558.8	ELBOW	82.73	68.15	0.82
974	558.8	ELBOW	82.73	68.15	0.82
975	558.8	ELBOW	65.31	52.01	0.80
975	558.8	ELBOW	65.31	52.01	0.80
976	558.8	ELBOW	56.96	44.58	0.78
976	558.8	ELBOW	56.96	44.58	0.78
977	558.8	ELBOW	22.28	21.12	0.95
977	558.8	ELBOW	2.96	2.15	0.73
977	558.8	ELBOW	25.44	24.10	0.95
977	323.9	SWEEPO	109.06	101.49	0.93
978	558.8	ELBOW	30.32	22.15	0.73
978	558.8	ELBOW	30.32	22.15	0.73
979	558.8	ELBOW	24.13	19.10	0.79
982	558.8	ST PIP	52.02	42.82	0.82
982	558.8	ST PIP	52.02	42.82	0.82
986	558.8	ST PIP	65.72	51.34	0.78
986	558.8	ST PIP	65.72	51.34	0.78
990	558.8	ELBOW	22.00	19.20	0.87
990	558.8	ELBOW	22.00	19.20	0.87

ESBWR Feedwater Class 1 Lines From Penetration to Header					
NO. NODE	SIZE O.D.	COMP TYPE	ISM, SRSS (ISM) Mpa	Time History (TH) Mpa	TH/ISM
			(B)	**(A)**	**(A)/(B)**
962F	**558.8**	**ELBOW**	**114.34**	**118.73**	**1.04**
962N	**558.8**	**ELBOW**	**107.31**	**108.45**	**1.01**
963F	558.8	ELBOW	82.65	81.29	0.98
963N	**558.8**	**ELBOW**	**108.37**	**111.12**	**1.03**
964F	558.8	ELBOW	106.77	98.53	0.92
964N	558.8	ELBOW	84.02	82.75	0.98
964N	558.8	ELBOW	84.03	82.75	0.98
965F	558.8	ELBOW	81.92	75.93	0.93
965F	558.8	ST PIP	43.08	39.94	0.93
965N	558.8	ELBOW	104.01	94.97	0.91
Average & Ratio:			54.50	46.75	0.84

ESBWR Feedwater Class 1 Lines
From Header to RPV nozzles

NO. NODE	SIZE O.D.	COMP TYPE	ISM, SRSS (ISM) Mpa	Time History (TH) Mpa	TH/ISM
			(B)	**(A)**	**(A)/(B)**
37	323.9	ST PIP	147.46	131.61	0.89
47	323.9	ST PIP	67.32	64.14	0.95
47	323.9	ST PIP	67.32	64.14	0.95
48	323.9	ST PIP	95.85	91.82	0.96
48	323.9	TAPER<	95.85	91.82	0.96
52	323.9	ST PIP	126.76	108.81	0.86
52	323.9	ST PIP	126.76	108.81	0.86
65	323.9	ST PIP	81.01	81.21	1.00
65	323.9	ST PIP	81.01	81.21	1.00
66	323.9	ST PIP	114.34	114.50	1.00
66	323.9	TAPER<	114.34	114.50	1.00
70	323.9	ST PIP	112.85	105.79	0.94
70	323.9	ST PIP	112.85	105.79	0.94
83	323.9	ST PIP	77.68	67.91	0.87
83	323.9	ST PIP	77.68	67.91	0.87
84	323.9	ST PIP	110.15	97.44	0.88
84	323.9	TAPER<	110.15	97.44	0.88
388	323.9	ST PIP	69.34	55.95	0.81
553	323.9	ST PIP	70.56	54.72	0.78
771	323.9	ST PIP	58.01	47.53	0.82
771	323.9	ST PIP	58.01	47.53	0.82
969	323.9	ST PIP	139.41	121.03	0.87
977	323.9	ST PIP	125.87	118.88	0.94
039F	323.9	ELBOW	120.02	113.50	0.95
039F	323.9	ELBOW	120.02	113.50	0.95
039N	323.9	ELBOW	110.10	95.57	0.87
039N	323.9	ST PIP	47.90	41.58	0.87
046F	323.9	ELBOW	115.20	108.16	0.94
046F	323.9	ST PIP	50.12	47.06	0.94
046N	323.9	ELBOW	98.36	92.76	0.94
046N	323.9	ELBOW	98.36	92.76	0.94
054F	323.9	ELBOW	135.04	128.14	0.95
054F	323.9	ELBOW	135.04	128.14	0.95
054N	323.9	ELBOW	145.35	138.71	0.95
064F	323.9	ELBOW	137.97	134.59	0.98
064F	323.9	ST PIP	60.02	58.55	0.98
064N	323.9	ELBOW	105.21	93.75	0.89

ESBWR Feedwater Class 1 Lines From Header to RPV nozzles					
NO. NODE	SIZE O.D.	COMP TYPE	ISM, SRSS (ISM) Mpa	Time History (TH) Mpa	TH/ISM
			(B)	**(A)**	**(A)/(B)**
064N	323.9	ELBOW	105.21	93.75	0.89
072F	323.9	ELBOW	116.58	113.21	0.97
072F	323.9	ELBOW	116.58	113.21	0.97
072N	323.9	ELBOW	121.64	119.68	0.98
072N	323.9	ST PIP	52.55	52.06	0.99
082F	323.9	ELBOW	123.78	104.79	0.85
082F	323.9	ST PIP	53.84	45.59	0.85
082N	323.9	ELBOW	83.60	74.21	0.89
Average & Ratio:			99.85	92.08	0.92

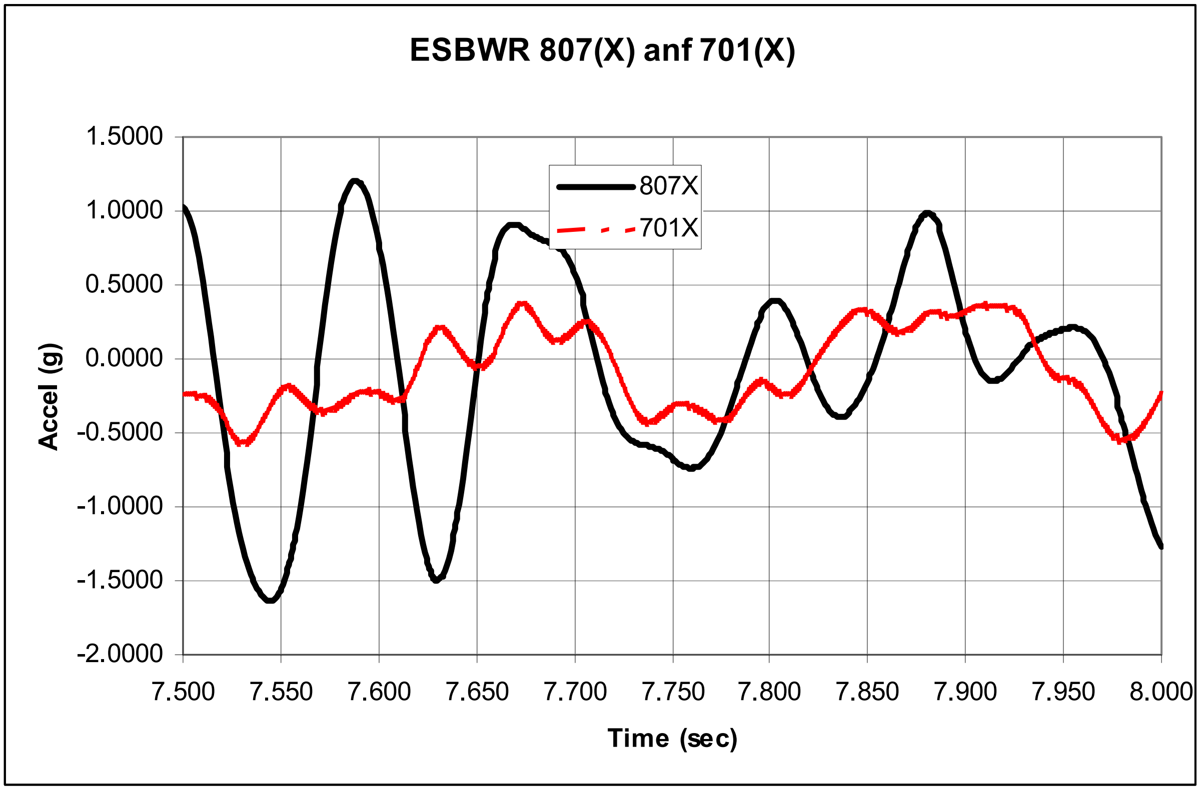

Figure B-3-5(a) Acceleration Time Histories for Vent Wall 701, and RPV Nozzle in N-S Direction from Time 7.5 sec. to 8.0 sec. (Not Correlated)

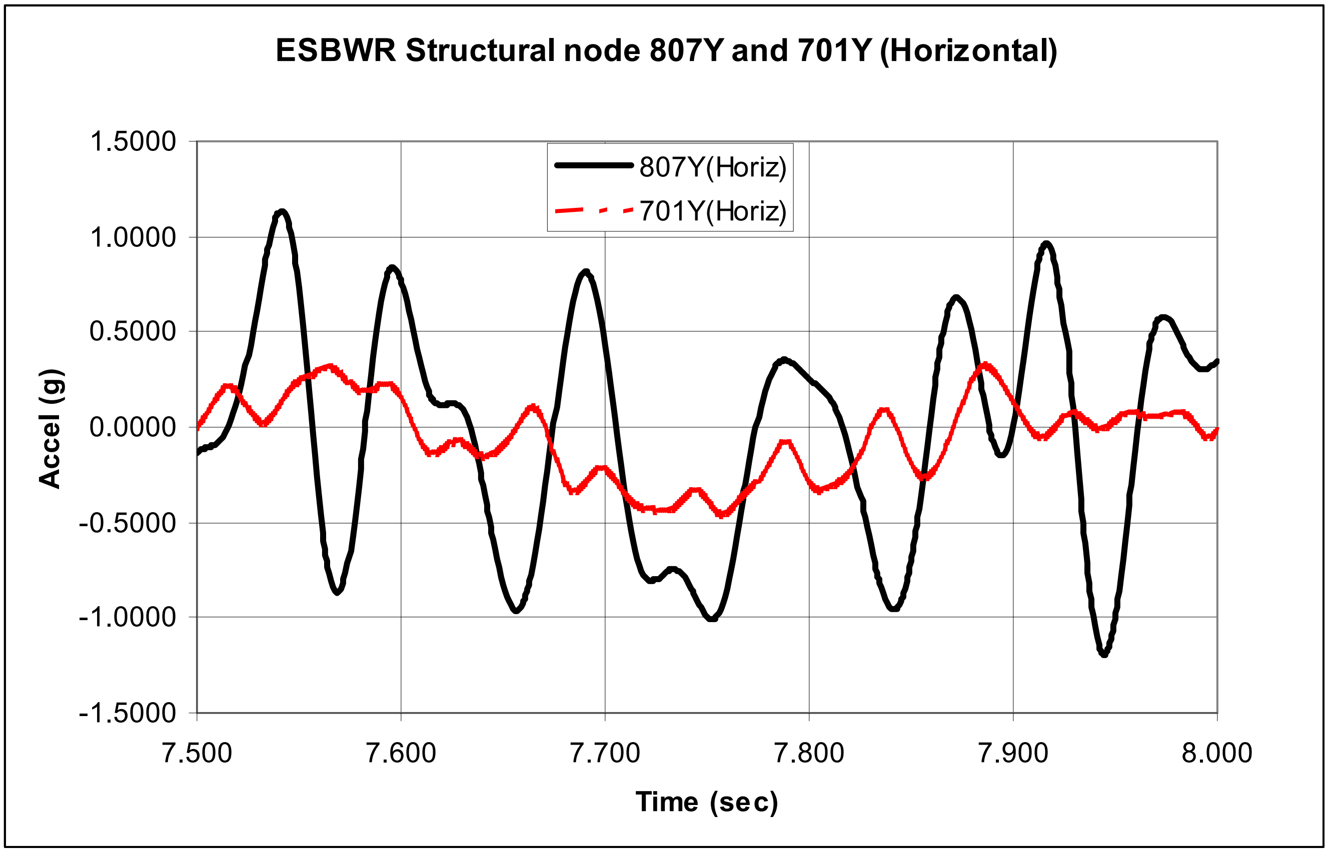

Figure B-3-5(b) Acceleration Time Histories for Vent Wall 701, and RPV Nozzle in E-W Direction from Time 7.5 sec. to 8.0 sec. (Not Correlated)

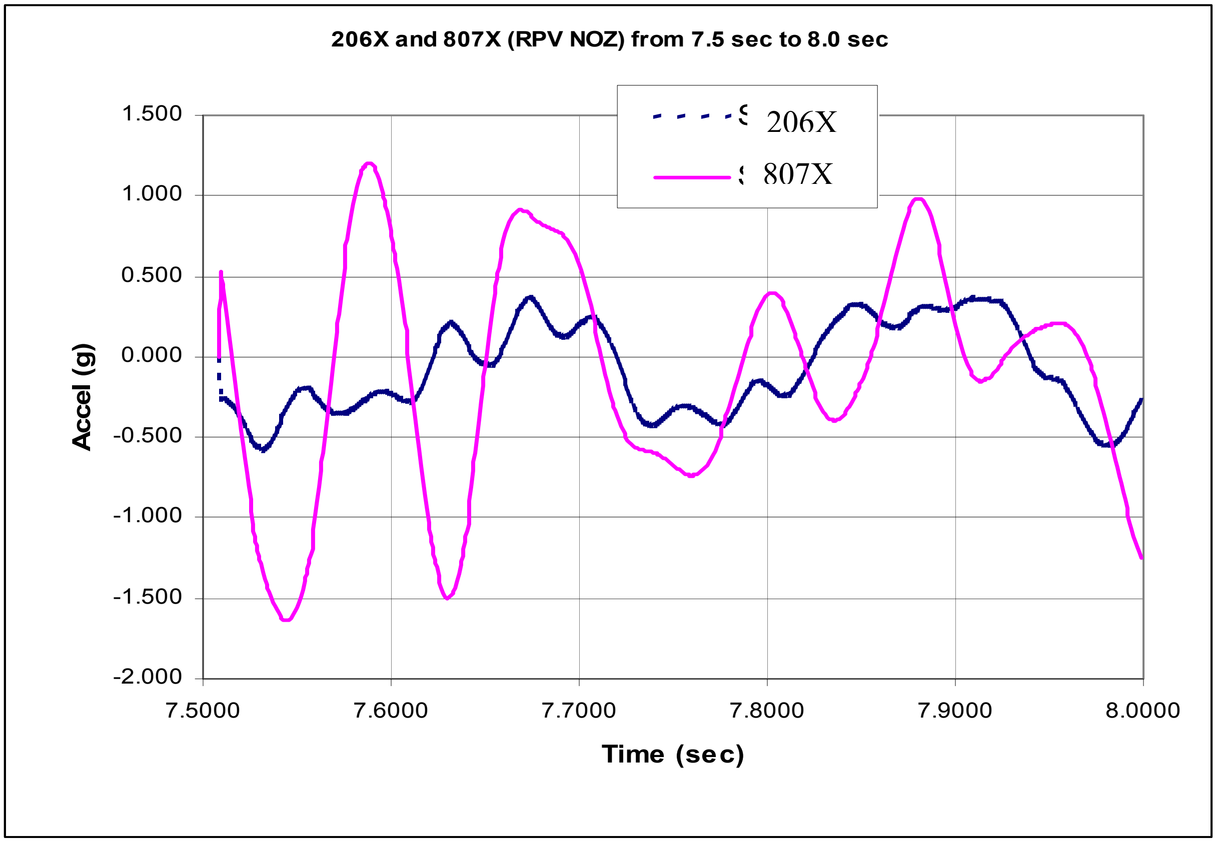

Figure B-3-2 (a) Acceleration Time Histories for Containment Node 206 and RPV Nozzle in N-S direction, from time 7.5 sec. to 8.0 sec.(Not Correlated)

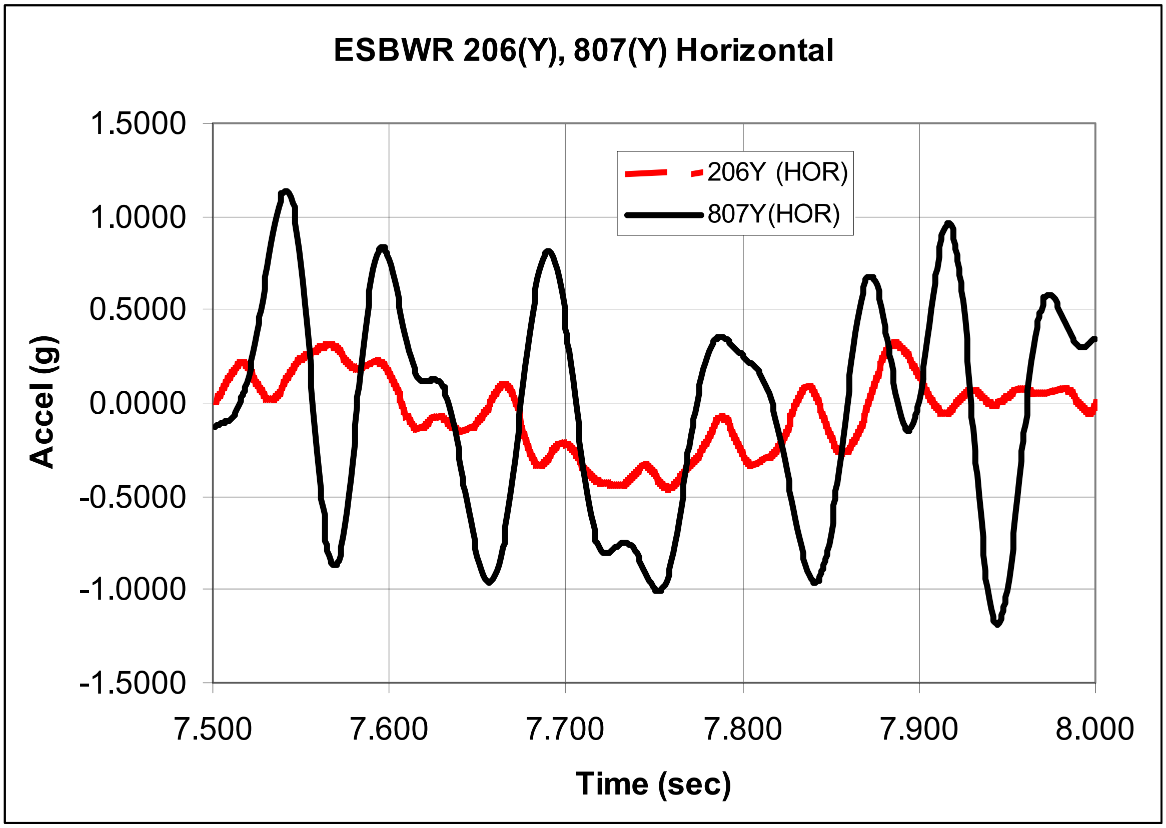

Figure B-3-2 (b) Acceleration Time Histories for Containment Node 206 and RPV Nozzle in E-W direction, from time 7.5 sec. to 8.0 sec. (Not Correlated)

NRC RAI 3.12-3 S05

The staff reviewed GEH response to NRC RAI3.12-3 S04. The response did not address the staffs concern. The staff is requesting the applicant to provide technical justification to demonstrate that ESBWR proposed ISM method/criteria can be applied globally to all piping in all different locations (or in a limited set of locations, such as inside containment). In order to address this issue, the applicant has to demonstrate that the time histories from different support groups can be shown to be phase uncorrelated.

GEH response to RAI 3.12-3 S04 stated that the selections of piping systems for the response spectrum analysis, the time history analysis and the comparisons have been performed according to an agreement reached between NRC, BNL and GE. The staff's safety determination has to be based on technical justification. GEH had conducted a study based on a limited sample. The staff considered the applicant's analysis results and suggested adding 10 percent margin to SRSS method as a solution for the particular systems in the study. In order change the generic methodology, ESBWR has to provide a technical justification to allow use of the proposed ISM method globally (or in a limited application, such as inside the containment). The analysis, as written, does not show how it applies globally (or in a limited application).

GEH Response

GEH Original Response (Letter MFN 09-670, dated October 28, 2009) for reference:

When the ISM response spectrum method of analysis (Subsection 3.7.2.1.2) is used, a support group is defined by supports that have the same time-history input. This usually means all supports located on the same floor, or portions of a floor, of a structure. For piping inside the RCCV, the typical pipe routing is from the reactor pressure vessel to the containment penetration in the RCCV. As explained in supplement 4 of the this RAI, the analysis results for two typical piping systems (main steam and feedwater), that have this type of pipe routing, when using the SRSS procedure were found to be more conservative than the time history analyses method when a 10 percent margin is applied to the SRSS results. The remaining piping that is in containment that are part of the reactor coolant pressure boundary are the Isolation Condenser (IC), Reactor Water Cleanup/Shutdown Cooling (RWCU/SDC), Control Rod Drive (CRD), Standby Liquid Control (SLC) and Gravity Driven Cooling System (GDCS) system piping. All of these pipes have pipe routing that originates from the reactor vessel and connects to containment structures in a similar manner as the qualification cases. Therefore, these pipes are also sufficiently phase uncorrelated, and the SRSS criteria established in DCD subsection 3.7.3.9 is applicable.

For piping outside the RCCV, the absolute sum procedure for an ISM analysis shall be used. DCD Section 3.7.3.9 will be revised to be consistent with this statement.

GEH Revised Response (new information transmitted via this letter)

The original response remains valid. However, based on follow-up discussions with the NRC, GEH agreed to revise DCD Section 3.7.3.9 to clarify the use of the ISM methodology when the SRSS method for combining stresses is utilized for piping design within the RCCV. A revision to DCD Section 3.7.3.9 is attached.

DCD Impact

DCD Section 3.7.3.9 will be revised as noted in the attached markup.

Enclosure 2

MFN 09-670 Revision 1

Revised Response to Portion of NRC Request for

Additional Information Letter No. 368

Related to ESBWR Design Certification Application

DCD Markups for RAI Number 3.12-3 S05 Revision 1

3.7.3.6 Three Components of Earthquake Motion

[*The applicable methods of spatial combination of responses due to each of the three input motion components are described in Subsection 3.7.2.6.*]*

Text sections that are bracketed and italicized with an asterisk following the brackets are designated as Tier 2. Prior NRC approval is required to change.

3.7.3.7 Combination of Modal Responses

[*The applicable methods of modal response combination are described in Subsection 3.7.2.7.*]*

Text sections that are bracketed and italicized with an asterisk following the brackets are designated as Tier 2. Prior NRC approval is required to change.

3.7.3.8 Interaction of Other Systems with Seismic Category I Systems

Each non-Category I (i.e., Seismic Category II or non-seismic) system is designed to be isolated from any Seismic Category I system by either a constraint or barrier, or is remotely located with regard to the Seismic Category I system. [*If it is not feasible or practical to isolate the Seismic Category I system, adjacent non-Category I systems are analyzed according to the same seismic criteria as applicable to the Seismic Category I systems. For non-Category I systems attached to Seismic Category I systems, the dynamic effects of the non-Category I systems are simulated in the modeling of the Seismic Category I system.*]* The attached non-Category I systems, up to the first anchor beyond the interface, are also designed in such a manner that during an earthquake of SSE intensity it does not cause a failure of the Seismic Category I system.

Text sections that are bracketed and italicized with an asterisk following the brackets are designated as Tier 2. Prior NRC approval is required to change.

3.7.3.9 Multiple-Supported Equipment and Components with Distinct Inputs

For multi-supported systems (equipment and piping) analyzed by the response spectrum method for the determination of inertial responses, either of the following two input motions are acceptable:

- Envelope response spectrum with USM applied at all support points for each orthogonal direction of excitation; or
- ISM response spectrum at each support for each orthogonal direction of excitation.

When the ISM response spectrum method of analysis (Subsection 3.7.2.1.2) is used, a support group is defined by supports that have the same time-history input. This usually means all supports located on the same floor, or portions of a floor, of a structure. The highest response spectrum for any support in a given group is used as input for the entire support group. This approach is appropriate since the time histories for supports within each group are time phase correlated. In most cases, the support at the highest elevation has the highest response spectrum and is used for the group. For piping inside the RCCV, the responses caused by motions of supports in two ~~or more different~~ groups are combined by the SRSS procedure since it has been demonstrated that the phases for the independent support motions are sufficiently uncorrelated, and the analysis results for two typical piping systems (main steam and feedwater) using the SRSS procedure are more conservative than the time history analysies method when a 10 percent margin is applied to the SRSS results. In most cases, the number of support groups can be restricted to two ISM groups (RPV and inside RCCV), but in piping analysis cases where additional support motion groups are used within the RCCV, the absolute sum procedure for an ISM analysis shall be used. For piping outside the RCCV, the SRSS method can be used if it is established that the support motions are reasonably phased uncorrelated; otherwise, the absosoeslute sum procedure for an ISM analysis shall be used.

[*To use the SRSS method for independent support response spectrum analysis, it is required to include 10 percent margin in the design requirements for piping stress and piping support loads to address the uncertainties that may exist from the use of the SRSS method rather than the absolute sum method for the group combination method when performing an ISM analysis.*]*

In addition to the inertial response discussed above, the effects of relative support displacements are considered. The maximum relative support displacements are obtained from the dynamic analysis of the building, or as a conservative approximation, by using the floor response spectra. For the latter option, the maximum displacement of each support is predicted by $S_d = S_a g/\omega^2$, where S_a is the spectral acceleration in "g's" at the high-frequency end of the spectrum curve (which, in turn, is equal to the maximum floor acceleration), g is the gravity constant, and ω is the fundamental frequency of the primary support structure in radians per second. The support displacements are imposed on the supported systems in a conservative (i.e., most unfavorable combination) manner and static analysis is performed for each orthogonal direction. The resulting responses are combined with the inertia effects by the SRSS method. Because the OBE design is not required, the displacement-induced SSE stresses due to seismic anchor motion are included in Service Level D load combinations.

In place of the response spectrum analysis, the ISM time history method of analysis is used for multi-supported systems subjected to distinct support motions, in which case both inertial and relative displacement effects are already included.

* Text sections that are bracketed and italicized with an asterisk following the brackets are designated as Tier 2*. Prior NRC approval is required to change.

3.7.3.10 Use of Equivalent Vertical Static Factors

[*Equivalent vertical static factors are used when the requirements for the static coefficient method in Subsection 3.7.2.1.3 are satisfied.*]*

Text sections that are bracketed and italicized with an asterisk following the brackets are designated as Tier 2. Prior NRC approval is required to change.

3.7.3.11 Torsional Effects of Eccentric Masses

[*Torsional effects of eccentric masses are included for subsystems similar to that for the piping systems discussed in Subsection 3.7.3.3.1.*]*

Text sections that are bracketed and italicized with an asterisk following the brackets are designated as Tier 2. Prior NRC approval is required to change.