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Subject: **Response to Portion of NRC Request for Additional Information Letter No. 16 Related to ESBWR Design Certification Application – Piping Design – RAI Numbers 3.12-14 S01 and 3.12-18 S01**

Enclosure 1 contains GEH's response to the subject NRC RAIs transmitted via e-mail on May 9, 2007. GE's original response was provided in the Reference 1 letter.

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

D068
NRO

Reference:

1. MFN 06-119, Letter from David Hinds to U.S. Nuclear Regulatory Commission, *Response to Portion of NRC Request for Additional Information Letter No. 16 Related to ESBWR Design Certification Application – Piping Design – RAI Numbers 3.12-1 through 3.12-37,* May 3, 2006

Enclosure:

1. MFN 06-119, Supplement 3 – Response to Portion of NRC Request for Additional Information Letter No. 16 Related to ESBWR Design Certification Application – Piping Design – RAI Numbers 3.12-14 S01 and 3.12-18 S01

cc:	AE Cubbage	USNRC (with enclosures)
	DH Hinds	GEH (with enclosures)
	RE Brown	GEH (w/o enclosures)
	GB Stramback	GEH (w/o enclosures)
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Enclosure 1

MFN 06-119, Supplement 3

Response to Portion of NRC Request for

Additional Information Letter No. 16

Related to ESBWR Design Certification Application

Piping Design

RAI Numbers 3.12-14 S01 and 3.12-18 S01

NRC RAI 3.12-14 S01

DCD Tier 2, Section 3D.4.1 of Appendix 3D, indicates that the PISYS program has been benchmarked against NRC piping models. The results are documented in GE report NEDO-24210, dated August 1979 (Reference 3D-1 of Appendix 3D), for mode shapes and uniform support motion response spectrum analysis (USMA) options. The ISMA option has been validated against NUREG/CR-1677. With regard to the benchmarking of the PISYS program, provide the following information:

(a) The version of the PISYS program used for the ESBWR analysis should be benchmarked against NUREG/CR-6049, "Piping Benchmark Problems for the GE ABWR." The piping benchmark problems in NUREG/CR-6049 are more recent and more representative of the current piping systems in the ESBWR. If NUREG/CR-6049 will not be used to benchmark the piping computer code used by COL applicants, then provide an explanation.

(b) Indicate where the requirement for the COL applicant to benchmark the use of any piping analysis program(s) in accordance with the current DCD validation methods is located.

GE RESPONSE - MFN 06-119, May 3, 2006

(a) Appendix 3D Paragraph 3D.4.1 last paragraph will add the following in DCD Revision 2: "Subsequently, the PISYS07 program, which is used for ESBWR piping analysis, has been benchmarked against NUREG/CR-6049." If applicable, COL applicants are also required to benchmark piping computer codes against NUREG/CR-6049.

(b) Appendix 3D paragraph 3D.4.1 last paragraph will be modified in DCD Revision 2 as shown in the (a) response.

STAFF EVALUATION

(a) Unresolved

To be confirmed by BNL (during audit). Need to review GE document that compares PISYS07 against NUREG/CR-6049. The last sentence of the response needs clarification: under what circumstances is the COL applicant required to benchmark the PISYS07 or other computer codes

(b) Technically Resolved

This statement must be included in the DCD.

CONCLUSION

GE is currently finalizing the draft benchmark report verifying the PISYS code results against the piping models given in NUREG/CR-6049.

Unresolved, pending completion of the draft report. This is an audit followup item (see RAI 3.12-11).

GE REVISED RESPONSE - MFN 06-119, Supplement 1, December 11, 2006

No revised response available.

STAFF EVALUATION

To be discussed during second audit.

AUDIT RESULTS

The staff indicated that the use of the piping computer codes specified in the DCD cannot be modified without staff review (i.e., they should be Tier 2 criteria). In addition, DCD Subsection 3D.4.1 will be revised to delete the last sentence of the last paragraph regarding benchmarking of other computer codes. See RAI 3.12-11.*

Based on GE's markup of the DCD revision, the proposed change is acceptable.

GE Response

DCD subsection 3D.4.1 was revised in Revision 3 by deleting the last sentence which read "If applicable, COL applicants are also required to benchmark piping computer codes against NUREG/CR 6049".

DCD Impact

DCD Tier 2, Section 3D.4.1 was revised as noted in the attached markup.

NRC RAI 3.12-18 S01

Note 12 to DCD Tier 2, Table 3.9-2 provides a modification to the ASME Class 2 and 3 criteria to address SSE seismic anchor motion stresses. However note 12 did not include any additions/changes to the Class 1 piping requirements of ASME Code, Section III, Subsection NB-3600, for Equations 10, 11 and 12 (similar to the additions/changes made for Class 2 and 3 piping). Clarify whether there are any additions or changes for the Class 1 piping requirements and what earthquake level (for inertia and SAM) will be used to satisfy the ASME Code equations.

GE RESPONSE - MFN 06-119, May 3, 2006

Table 3.9-2 specifies SSE load. This includes the inertia and the anchor motion effect. This is the same designation as other dynamic loads. The SAM is included in Equation 10, 12, 13 and 14 evaluations. The piping design specification for Service Level A and B is shown below as an example.

Table 2. Main Steam Piping System

Condition Load Combination for All Terms(1)(2)(3) Acceptance Criteria(7) Service Levels A & B PP, TE, ΔT1(4), ΔT2(5), TA-TB(6), RV1, RV2I, Eq 12 & 13 #2.4 Sm RV2D, TSV, SSEI, SSED Fatigue - NB-3653 U < 0.1

STAFF EVALUATION

Unresolved

The load combination table included in the response corresponds to Class 2 piping components. GE should define the SRV and LOCA loads consistent with the DCD Table 3.9-2. Original RAI needs to be addressed. According to Table 3.9-2, the term SSE does not appear to include SAM. SAM is only addressed in Note 12 for Class 2 and 3 piping systems.

CONCLUSION

During the meeting, GE provided the proposed text to be added in Note 12 of DCD Table 3.9-2. The proposed changes to the DCD are consistent with the staff position and hence are acceptable.

Unresolved, pending revision of the DCD.

GE REVISED RESPONSE - MFN 06-119, Supplement 1, December 11, 2006

No revised response available..

STAFF EVALUATION

To be discussed during second audit.

AUDIT RESULTS

GE provided a markup of Footnote 12 to DCD Table 3.9-2. The proposed changes to the DCD are consistent with the staff position and hence are acceptable.

Based on GE's markup of the DCD revision, the proposed change is acceptable.

GE Response

DCD Table 3.9-2, Footnote 12 was revised in Revision 3 in accordance with the changes provided during NRC audit as noted above.

DCD Impact

DCD Tier #2, Table 3.9-2, Footnote 12 has been revised as noted in the attached markup.

3D.3.5.3 Extent of Application

This program will be used for elastic and plastic stress analysis in addition to temperature distribution analysis of the reactor pressure vessel. The program calculates stresses for level D, faulted limits, but only ASME Code Section III elastic analysis defined in F1321.3 requirements.

3D.3.6 FEMFL

3D.3.6.1 Description

This FORTRAN program was created by Babcock-Hitachi K.K. to evaluate elastic stresses.

3D.3.6.2 Validation

Hand calculations using theoretical equations published in literature are performed to demonstrate the program's applicability and validity.

3D.3.6.3 Extent of Application

This program will be used for elastic stress analysis using axisymmetric structural shell and solid elements. The static loading may be axisymmetric or non-axisymmetric. The program is used in the analysis of the reactor pressure vessel. The program calculates stresses for level D, faulted limits, but only ASME Code Section III elastic analysis defined in F1321.3 requirements.

3D.3.7 SEISM03

3D.3.7.1 Description

See Subsection 4.1.4.1.3.

3D.3.7.2 Validation

Test cases analyzed and compared with previous design problems are performed to demonstrate the program's applicability and validity.

3D.3.7.3 Extent of Application

In addition to those applications outlined in Chapter 4, this program will be used to evaluate non-linear fuel lift analysis with spring, stop and friction elements.

3D.4 PIPING

3D.4.1 Piping Analysis Program – PISYS

3D.4.1.1 Description

PISYS is a computer code for analyzing piping systems subjected to both static and dynamic piping loads. Finite element models of a piping system formed by assembling stiffness matrices represent standard piping components. The piping elements are connected to each other via nodes called pipe joints. It is through these joints that the model interacts with the environment, and loading of the piping system becomes possible. PISYS is based on the linear elastic analysis

in which the resultant deformations, forces, moments and accelerations at each joint are proportional to the loading and the superposition of loading is valid.

PISYS has a full range of static dynamic load analysis options. Static analysis includes dead weight, uniformly distributed weight, thermal expansion, externally applied forces, moments, imposed displacements and differential support movement (pseudo-static load case). Dynamic analysis includes mode shape extraction, response spectrum analysis, and time-history analysis by modal combination or direct integration. In the response spectrum analysis [i.e., uniform support motion response spectrum analysis (USMA) or independent support motion response spectrum analysis (ISMA)], the user may request modal response combination in accordance with Regulatory Guide 1.92. In the ground motion (uniform motion) or independent support time history analysis, the normal mode solution procedure is selected. In analysis involving time varying nodal loads, the step-by-step direct integration method is used.

3D.4.1.2 Validation

Sentence deleted per RAI 3.12-14 S01

The PISYS program has been benchmarked against NRC piping models documented in Reference 3D-1 for mode shapes and USMA options. The ISMA validated against NUREG/CR-1677 (Reference 3D-2).

Subsequently, the PISYS07 program, which is used for ESBWR piping analysis, has been benchmarked against NUREG/CR-6049. ~~If applicable, COL applicants are also required to benchmark piping computer codes against NUREG/CR-6049.~~

3D.4.1.3 Extent of Application

This program will be used for elastic stress analysis of piping systems.

3D.4.2 Component Analysis - ANSI7

3D.4.2.1 Description

ANSI7 is a computer code for calculating stresses and cumulative usage factors ~~for Class 1, 2 and 3 piping components in accordance with articles NB, NC and ND-3650 of ASME Code Section III. ANSI7 is also used to combine loads~~ and to calculate combined stresses for service levels A, B, C and D loads in ~~on~~ accordance with ASME Section III article NB-3650. ~~piping supports and pipe-mounted equipment.~~ The program includes environmental fatigue effects on fatigue curves according to DG-1144 and NUREG/CR-6909.

3D.4.2.2 Validation

Hand calculations are performed to demonstrate the program's applicability and validity.

3D.4.2.3 Extent of Application

This program will be used for calculating stresses and cumulative usage factors for Class 1, 2 and 3 piping components in accordance with articles NB, NC and ND-3650 of ASME Code Section III. ANSI7 is also used to combine loads and calculate combined service levels A, B, C and D loads on piping supports and pipe-mounted equipment. The program calculates elastic stresses for level D, faulted limits, but the ASME Code Section III Appendix F requirements are not within the computer program.

Table 3.9-2

Load Combinations and Acceptance Criteria for Safety-Related, ASME Code Class 1, 2 and 3 Components, Component Supports, and Class CS Structures

Plant Event	Service Loading Combination (1), (2), (3)	ASME Service Level (4)
1. Normal Operation (NO)	N	A
2. Plant/System Operating Transients (SOT)	(a) N + TSV (b) N + SRV(5)	B B
3. NO + SSE	N + SSE	B(11), (12)
4. Infrequent Operating Transient (IOT), ATWS, DPV	(a) N(6) + SRV(5) (b) N + DPV(7)	C(13) C(13)
5. SBL	N + SRV(8) + SBL~~(9)~~	C(13)
6. SBL or IBL + SSE	N + SBL (or IBL)~~(9)~~ + SSE + SRV(8)	D(13)
7. LBL + SSE	N + LBL~~(9)~~ + SSE	D(13)
8. NLF	N + SRV(5) + TSV(10)	D(13)

Notes:

(1) See Legend on the following pages for definition of terms. Refer to Table 3.9-1 for plant events and cycles information.

The service loading combination also applies to Seismic Category I Instrumentation and electrical equipment (refer to Section 3.10).

(2) For vessels, loads induced by the attached piping are included as identified in their design specification.

For piping systems, water (steam) hammer loads are included as identified in their design specification.

(3) The method of combination of the loads is in accordance with NUREG-0484, Revision 1.

(4) The service levels are as defined in appropriate subsection of ASME Section III, Division 1.

(5) The most limiting load combination case among SRV(1), SRV(2) and SRV (ALL). For main steam and branch piping evaluation, additional loads associated with relief line clearing and blowdown into the suppression pool are included.

(6) The reactor coolant pressure boundary is evaluated using in the load combination the maximum pressure expected to occur during ATWS.

(7) This applies only to the Main Steam and Isolation Condenser systems. The loads from this event are combined with loads associated with the pressure and temperature concurrent with the event.

(8) The most limiting load combination case among SRV(1), SRV(2) and SRV (ADS). See Note (5) for main steam and branch piping.

(9) (Deleted)~~The piping systems that are qualified to the leak-before-break criteria of Subsection 3.6.3 are excluded from the pipe break events to be postulated for design against LOCA dynamic effects, viz., SBL, IBL and LBL.~~

(10) This applies only to the main steamlines and components mounted on it. The low probability that the TSV closure and SRV loads can exist at the same time results in this combination being considered under service level D.

(11) Applies only to fatigue evaluation of ASME Code Class 1 components and core support structures. See Dynamic Loading Event No. 13, Table 3.9-1, and Note 5 of Table 3.9-1 for number of cycles.

(12) For ASME Code Class 1, 2 and 3 piping the following changes and additions to ASME Code Section III Subsection NB-3600, NC-3600 and ND-3600 are necessary and shall be evaluated to meet the following stress limits:

a. ASME Code Class 1 Piping

$$S_{SAM} = C_2 \frac{D_0}{2I} M_c \leq 6.0 S_m \qquad \text{Eq. (12a)}$$

Where: S_{SAM} is the nominal value of seismic anchor motion stress

M_c is the combined moment range equal to the greater of (1) the resultant range of thermal and thermal anchor movements plus one-half the range of the SSE anchor motion, or (2) the resultant range of moment due to the full range of the SSE anchor motions alone.

C_2, D_0 and I are defined in ASME Code Subsection NB-3600.

SSE inertia and seismic anchor motion loads shall not be included in the calculation of ASME Code Subsection NB-3600 Equations (10) and (11).

b. For ASME Code Class 2 and 3 piping:

$$S_{SAM} = i \frac{M_c}{Z} \leq 3.0 S_h \ (\leq 2.0 S_y) \qquad \text{Eq. (12b~~a~~)}$$

Where: S_{SAM} and M_c are defined in (a) above. ~~is the nominal value of seismic anchor motion stress~~

~~M_c is the combined moment range equal to the greater of (1) the resultant range of thermal and thermal anchor movements plus one-half the range of the SSE anchor motion, or (2) the resultant range of moment due to the full range of the SSE anchor motions alone.~~

i and Z are defined in ASME Code Subsections NC/ND-3600

SSE inertia and seismic anchor motion loads shall not be included in the calculation of ASME Code Subsections NC/ND-3600 Equation (9), Service Levels A and B and Equations (10) and (11).

(13) ASME Code Class 1, 2 and 3 Piping systems, which are essential for safe shutdown under the postulated events are designed to meet the requirements of NUREG-1367. Piping system dynamic moments can be calculated using an elastic response spectrum or time history analysis.

Load Definition Legend for Table 3.9-2	
Normal (N)	Normal and/or abnormal loads associated with the system operating conditions, including thermal loads, depending on acceptance criteria.
SOT	System Operational Transient (Subsection 3.9.3.1).
IOT	Infrequent Operational Transient (Subsection 3.9.3.1).
ATWS	Anticipated Transient Without Scram.
TSV	Turbine stop valve closure induced loads in the main steam piping and components integral to or mounted thereon.
RBV Loads	Dynamic loads in structures, systems and components because of reactor building vibration (RBV) induced by a dynamic event.
NLF	Non-LOCA Fault.
SSE	RBV loads induced by safe shutdown earthquake.
SRV(1), SRV(2)	RBV loads induced by safety/relief valve (SRV) discharge of one or two adjacent valves, respectively.
SRV (ALL)	RBV loads induced by actuation of all safety/relief valves, which activate within milliseconds of each other (e.g., turbine trip operational transient).
SRV (ADS)	RBV loads induced by the actuation of safety/relief valves in Automatic Depressurization Subsystem operation, which actuate within milliseconds of each other during the postulated small or intermediate break LOCA, or SSE.
DPV	Depressurization Valve opening induced loads in the stub tubes and Main Steam system piping and pipe-mounted equipment.
LOCA	The loss-of-coolant accident associated with the postulated pipe failure of a high-energy reactor coolant line. The load effects are defined by LOCA1 through LOCA7. LOCA events are grouped in three categories, SBL, IBL or LBL, as defined here.
LOCA1	Pool swell (PS) drag/fallback loads on essential piping and components located between the main vent discharge outlet and the suppression pool water upper surface.
LOCA2	Pool swell (PS) impact loads acting on essential piping and components located above the suppression pool water upper surface.
LOCA3	(a) Oscillating pressure induced loads on submerged essential piping and components during main vent clearing (VLC), condensation oscillations (COND), or chugging (CHUG), or (b) Jet impingement (JI) load on essential piping and components as a result of a postulated IBL or LBL event. Piping and components are defined essential, if they are required for shutdown of the reactor or to mitigate consequences of the postulated pipe failure without off-site power (refer to introduction to Subsection 3.6).
LOCA4	RBV load from main vent clearing (VLC).
LOCA5	RBV loads from condensation oscillations (COND).
LOCA6	RBV loads from chugging (CHUG).

Load Definition Legend for Table 3.9-2	
LOCA7	Annulus pressurization (AP) loads due to a postulated line break in the annulus region between the RPV and shieldwall. Vessel depressurization loads on reactor internals (Subsection 3.9.2.4) and other loads due to reactor blowdown reaction and jet impingement and pipe whip restraint reaction from the broken pipe are included with the AP loads.
SBL	Loads induced by small break LOCA (Subsection 3.9.3.1); the loads are: LOCA3(a), LOCA4 and LOCA6.~~ See Note (9).~~
IBL	Loads induced by intermediate break LOCA (Subsection 3.9.3.1); the loads are: LOCA3(a) or LOCA3(b), LOCA4, LOCA5 and LOCA6.~~ See Note 9 of Table 3.9-2.~~
LBL	Loads induced by large break LOCA (Subsection 3.9.3.1); the loads are: LOCA1 through LOCA7.~~ See Note (9).~~