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Subject: **Partial Response to NRC RAI Letter No. 328 Related to ESBWR Design Certification Application – DCD Tier 2 Section 3.9 – Mechanical Systems and Components; RAI Numbers 3.9-254 Revision 1 and 3.9-255 Revision 1**

The purpose of this letter is to submit the GE Hitachi Nuclear Energy (GEH) partial response to the U.S. Nuclear Regulatory Commission (NRC) Request for Additional Information (RAI) letter number 328 sent by NRC letter dated April 16, 2009 (Reference 1). Reference 2 transmitted our initial responses to RAI Numbers 3.9-254 and 3.9-255. GEH found it necessary to clarify the RAI responses in Reference 2 after interaction with the NRC staff. RAI Numbers 3.9-254 Revision 1 and 3.9-255 Revision 1 are addressed in Enclosure 1.

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 09-273 Letter from U.S. Nuclear Regulatory Commission to J. G. Head, GEH, *Request For Additional Information Letter No. 328 Related to ESBWR Design Certification* dated April 16, 2009
2. MFN 09-321 Letter from R. E. Kingston, GEH to the U.S. Nuclear Regulatory Commission *Partial Response to NRC RAI Letter No. 328 Related to ESBWR Design Certification Application – DCD Tier 2 Section 3.9 – Mechanical Systems and Components; RAI Numbers 3.9-254 and 3.9-255*

Enclosure:

1. Partial Response to NRC RAI Letter No. 328 Related to ESBWR Design Certification Application - DCD Tier 2 Section 3.9 – Mechanical Systems and Components; RAI Numbers 3.9-254 Revision 1 and 3.9-255 Revision 1

cc:	AE Cubbage	USNRC (with enclosures)
	JG Head	GEH/Wilmington (with enclosures)
	DH Hinds	GEH/Wilmington (with enclosures)
	eDRF Section	0000-0101-5568 R1(RAIs 3.9-254 R1 and 3.9-255 R1)

Enclosure 1

MFN 09-321 Revision 1

Response to Portion of NRC Request for

Additional Information Letter No. 328

Related to ESBWR Design Certification Application

DCD Tier 2 Section 3.9 – Mechanical Systems and Components

RAI Numbers 3.9-254 R1 and 3.9-255 R1

NRC RAI 3.9-254

Additional information about PISYS computer code.

In ESBWR DCD Appendix 3D Section 3D.4.1, PISYS was listed as a computer code for the static and dynamic analyses of the piping systems. The PISYS program was validated against benchmark problems in NUREG/CR-1677 and Documented in Reference 3D-1 (NEDE-24210, "PISYS analysis of NRC Benchmark problems," dated August, 1979). However, Section 3D.4.1.2 noted that the PISYS07 was used for ESBWR piping analysis. PISYS07 was validated against benchmark problems in NUREG/CR-6049. GEH is requested to:

(1) Explain why PISYS is described and listed in Appendix D in lieu of PISYS07 which is actually used for ESBWR piping analysis,

(2) Discuss the differences between PISYS and PISYS07,

(3) Clarify whether PISYS07 program is documented as part of the documentation for PISYS in Reference 3D-1 or elsewhere,

(4) Confirm that PISYS and PISYS07 were both updated to incorporate methods and guides for response spectrum analysis and time history analysis in accordance with Regulatory Guide 1.92, Revision 2, published on July 2006 for ESBWR piping analysis (Ref. Section 3.7.3),

(5) Confirm that results of PISYS07 (similar to PISYS) can be passed on to the ANSI7 runs via EZPYP computer program for performing the fatigue

analysis of piping,

(6) Clarify whether PISYS described in Section 3D.4.1 is the computer program in Reference 3D-1 where a 1979 version of PISYS was documented, and

(7) Confirm whether the validation package for PISYS07 is available for the staff review. The information should include the author, source code, dated version, and facility; the program users manual and theoretical description, the extent and limitation of the program application; and the benchmarking

problems, the QA control and maintenance of the program in accordance with 10CFR50 Appendix B and ASME NQA-1.

GEH Response

(1) Explain why PISYS is described and listed in Appendix D in lieu of PISYS07 which is actually used for ESBWR piping analysis,

PISYS is the name of GEH's verified pipe stress analysis program. The number 07 identifies the version of the program. Any change or improvement to the program will advance the number to a new version. Brookhaven National Library (BNL) has benchmarked PISYS07 for the ABWR certification. The results are documented in NUREG-1503, section 3.12.4.1. This section is excerpted as follows.

> *" To review GE's computer program for ABWR piping modeling, the staff performed an independent confirmatory piping analysis of representative piping system in the ABWR standard plant. The purpose of this analysis was to verify the adequacy of the computer program used by GE to generate the sampling piping analyses that was audited by the staff on March 23 through 26, 1992 at GE 's office in San Jose, California. These were DFSER open items 3.9.1-2, 14.1.3.4.1-1 and 14.1.3.3.4.3-1. The results of confirmatory analysis verify that this computer program is adequate with acceptable accuracy. The staff concludes that the computer program verification process for ABWR is acceptable. Therefore, DFSER Open Items 3.9.1-2, 14.1.3.4.1-1 and 14.1.3.3.4.3-1 are resolved. "*

BNL has also performed a benchmark analysis of PISYS07 using a model of the number 2 and 3 ESBWR main steam lines. The benchmark results were documented in BNL report title " Piping Confirmation Analysis of the Main Steam Line for General Electric Economic simplified Boiling Water Reactor" by John Fair, M Subudhi, J Braverman and G DeGrassi, dated November 3, 2006. The report was presented by BNL in the January 2007 ESBWR Piping Stress Analysis audit in GE, San Jose, California.

PISYS program is modified from SAP4GE program. UC Berkeley developed SAP4 program originally. BNL benchmark analysis used BNL program PSAFE2. The benchmark analysis documented in NUREG-6049, it was observed that the natural frequencies and force time history analysis obtained 100% match between PISYS and PSAFE2 results.

(2) Discuss the differences between PISYS and PISYS07,

GEH Response:

PISYS01 is the first version of GEH's controlled piping analysis program. On May 12, 1979, the NRC sent a letter to GE requesting that a set of five NRC generated benchmarks problems be solved with the PISYS Code. For all five benchmark problems, the PISYS results for the frequencies and the modal participation factors were in excellent agreement with the values given in the NRC problem definition. This

agreement, in general, is within three or four significant digits. The detailed results of the benchmark calculations are documented in NEDO-24210 dated August 1979. Reg. Guide 1.92, Revision 1 was issued by the NRC in February 1976. The close spaced mode combination defined in Reg. Guide 1.92 Revision 1 has been included in the PISYS01.

Subsequently, GE made improvements to PISYS01 that resulted in versions PISYS02, PISYS03, PISYS04 and PISYS05. For each version of the program, a design record file has been created in accordance with the GEH internal Engineering Operating Procedures (EOP) Number 40.300 to document the required paper work, such as Abstract, Software Management Plan, Level 1 Design Review Report, Hardware And Software System Specification, Software Requirement Description, Software Test Report, Independent Design Verification, and Level 2 Design Review Report.

Appendix A to the Standard Review Plan (SRP), (NUREG 0800) Section 3.7.2, 'Acceptable Methodology to Account for High Frequency Modes", Revision 0, was issued in August 1989. Before this Appendix A was issued, the methodology outlined in NUREG 0800 Appendix A was available to the industry. GE modified PISYS05 program to PISYS06 to include the high frequency mode effect into the program. The complete documentations of PISYS06 is in Design Record File (DRF) DRF-A00-00996-1, dated October 3, 1989.

In September 1994, PISYS06 program material properties were updated to match the properties in ASME Section III Appendix I, Tables I-5.0 and I-6.0. In addition, the program was modified for thermal stratification load condition analysis capabilities. This version of PISYS program was known as PISYS07. The complete documentation of PISYS07 can be found in GEH DRF-A00-05798 and GEH DRF-A12-00144.

(3) Clarify whether PISYS07 program is documented as part of the documentation for PISYS in Reference 3D-1 or elsewhere,

GEH Response:

See response (2)

(4) Confirm that PISYS and PISYS07 were both updated to incorporate methods and guides for response spectrum analysis and time history analysis in accordance with Regulatory Guide 1.92, Revision 2, published on July 2006 for ESBWR piping analysis (Ref. Section 3.7.3),

GEH Response:

Response (2) describes the documentation of PISYS program versions. PISYS07 has been benchmarked with NUREG/CR-6049 for closed space modes and rigid mode

effects. The BNL benchmark results are documented in NUREG-1503, section 3.12.4.1. This is described in response (1).

a) For closed space mode effects to the modal combination, the double sum method per Reg. Guide 1.92, Rev.1 is equivalent to Reg. Guide 1.92, Rev. 2 published in July 2006.

b) For rigid mode effects, the requirements of Reg. Guide. 1.92, Rev. 2 are identical to the requirements in SRP section 3.7.2, Appendix A. PISYS06 and PISYS07 meet the requirements of Reg. Guide 1.92 Rev. 2.

(5) Confirm that results of PISYS07 (similar to PISYS) can be passed on to the ANSI7 runs via EZPYP computer program for performing the fatigue analysis of piping,

GEH Response:

Yes, all versions of the PISYS program have the same features. Results for PISYS07 can be passed on to the ANSI7 runs via EZPYP computer program for performing ASME NB-3600, NC-3600, ND-3600 and B31.1 Code evaluations for piping. In addition, ANSI7 is also used for the post processing of the PISYS results to qualify all the pipe attached components, such as strut, snubber, anchor, nozzle loads, valve acceleration flange moment, and functional capability evaluations.

(6) Clarify whether PISYS described in Section 3D.4.1 is the computer program in Reference 3D-1 where a 1979 version of PISYS was documented, and

GEH Response:

NEDO-24210 August 1979 referenced in Section 3D.4.1 of the ESBWR DCD is the fundamental design document for the first version and subsequent versions of the PISYS program. Each new version of the PISYS program documents any program modifications in electronic design record files (eDRFs). The eDRF is used to document program changes, improvements, verifications, design reviews and the results of program benchmarks. The eDRFs on the PISYS program maintain all documentation in accordance with GEH Engineering Operating Procedures (EOP) Number 40.300 for computer programs. Each new version of PISYS is an improvement of the previous version. The new version must be benchmarked with previous version for all defined test cases.

(7) Confirm whether the validation package for PISYS07 is available for the staff review. The information should include the author, source code, dated version, and facility; the program users manual and theoretical description, the extent and limitation of the program application; and the benchmarking problems, the QA

control and maintenance of the program in accordance with 10CFR50 Appendix B and ASME NQA-1.

GEH Responses:

Refer to response (1) and (2) for the validation package for PISYS07. During the audit held from January 9th thru January 13th of 2007, San Jose, CA., the NRC staff and BNL representatives had reviewed PISYS07 validation package. Please refer to NRC Audit Trip ReportML070930012.pdf "NRC Second Audit of GE at San Jose, CA on ESBWR Piping Design Criteria and Confirmation Analyses January 9 through 12, 2007" for the results of their audit findings.

Refer to response (1), PISYS07 program design record file meets GE Engineering Procedures (EOP). The EOP is developed to meet or exceeding the requirements specified in 10CFR50 Appendix B "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants" and ASME NQA-1.

DCD Impact

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

NRC RAI 3.9-255

Fatigue analysis including the environmental effects for piping and components in accordance with NRC Regulatory Guide 1.207 and NUREG/CR-6909.

ESBWR Tier 2 Rev. 5 Appendix 3D, Section 3D.4.2 states that ANSI7 computer program performs the fatigue analysis including the environmental effects for piping and components in accordance with NRC Regulatory Guide 1.207 and NUREG/CR-6909. GEH is requested to provide a summary of description of calculation on how the maximum stress intensity differences between two load sets were determined for the fatigue evaluation and on how the maximum strain rate was calculated for determining the environmental correction factor, Fen, in accordance with RG 1.207.

GEH Response

The alternating stress intensity between two load sets determined for the fatigue evaluation are performed in accordance with NB-3650 Equations 10, 11 and 14. The environmental correction factor, Fen, is performed in accordance with RG 1.207. For the strain rate effect, the maximum strain rate effect outlined in NUREG/CR-6909, Appendix A is used. This is illustrated in detail below.

The following equations are excerpted from NUREG/CR-6909, Appendix A for stainless steel from NUREG-CR- 6909, ANL-06-08 to calculate Fen.

For wrought and cast austenitic stainless steels,

$$F_{en,nom} = \exp(0.734 - T' O' \dot{\varepsilon}') \quad (A.9)$$

where T', $\dot{\varepsilon}'$, and O' are transformed temperature, strain rate, and DO level, respectively, defined as:

$$\begin{aligned} T' &= 0 && (T < 150°C) \\ T' &= (T - 150)/175 && (150 \le T < 325°C) \\ T' &= 1 && (T \ge 325°C) \end{aligned} \quad (A.10)$$

$$\begin{aligned} \dot{\varepsilon}' &= 0 && (\dot{\varepsilon} > 0.4\%/s) \\ \dot{\varepsilon}' &= \ln(\dot{\varepsilon}/0.4) && (0.0004 \le \dot{\varepsilon} \le 0.4\%/s) \\ \dot{\varepsilon}' &= \ln(0.0004/0.4) && (\dot{\varepsilon} < 0.0004\%/s) \end{aligned} \quad (A.11)$$

$$O' = 0.281 \quad \text{(all DO levels).} \quad (A.12)$$

For wrought and cast austenitic stainless steels, a threshold value of 0.10% for strain amplitude is defined below which environmental effects on the fatigue life of these steels do not occur. Thus,

$$F_{en,nom} = 1 \quad (\varepsilon \le 0.10\%). \quad (A.13)$$

These equations indicate that F_{en} is a function of three parameters: T*, O* and ε'*. For ESBWR evaluations, the most conservative strain rate effect is assumed with the exception of dynamic cycles. For dynamic cycles, such as seismic load, there are many cycles per second. The strain rate is very high but the strain rate effect is negligible. For the other thermal transient or pressure transient, The strain rate is not a constant value. There are no guidelines on how to select the strain rate from two sets that are used to calculate the alternating stress. The methodology and the results to calculate the environment fatigue effect have been presented in PVP2007-26143, "Application Of Draft Regulatory Guide DG-1144 Guidelines For Environmental Fatigue Evaluation To A BWR Feedwater Piping System", By Har Mehta and Henry Hwang. The environmental correction factor, Fen, is calculated for each load set pair.

DCD Impact

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