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Subject: **Response to Portion of NRC Request for Additional Information Letter No. 67 Related to ESBWR Design Certification Application – DCD Section 3.9 – RAI Numbers 3.9-19, 3.9-21, 3.9-22, 3.9-37, 3.9-41, and 3.9-69**

Enclosure 1 contains GE's response to the subject NRC RAIs transmitted via 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
Project Manager, ESBWR Licensing

D068

Reference:

1. MFN 06-378, Letter from U.S. Nuclear Regulatory Commission to David Hinds, *Request for Additional Information Letter No. 67 Related to ESBWR Design Certification Application,* October 10, 2006

Enclosure:

1. MFN 07-020 – Response to Portion of NRC Request for Additional Information Letter No. 67 Related to ESBWR Design Certification Application – DCD Section 3.9 – RAI Numbers 3.9-19, 3.9-21, 3.9-22, 3.9-37, 3.9-41, and 3.9-69

cc:	AE Cubbage	USNRC (with enclosures)
	GB Stramback	GE/San Jose (with enclosures)
	eDRF	0000-0061-6944/1

Enclosure 1

MFN 07-020

Response to Portion of NRC Request for

Additional Information Letter No. 67

Related to ESBWR Design Certification Application

DCD Section 3.9

RAI Numbers 3.9-19, 3.9-21, 3.9-22, 3.9-37, 3.9-41, and 3.9-69

NRC RAI 3.9-19

It is stated in DCD Tier 2, Section 3.9.2.1.1 that for steady state vibration, the Level 1 criteria are based on 68.95 MPa (10,000 psi) maximum stress to assure no failure from fatigue over the life of the plant. The corresponding Level 2 criteria are based on one half the 68.95 MPa (10,000 psi) or 34.5 MPa (5,000 psi). Provide a detailed discussion to explain how these stress levels envelop all the piping systems, configurations, environments and materials. Alternately, provide a reference document which describes the vibration monitoring program.

GE Response:

The vibration criteria are based on ASME OM-S/G-1990 Standard, paragraph 3.2.1.2. For stainless steel, the Level 1 criteria are 10,880 psi (75 MPa) and 5440 psi (37.5 MPa) for Level 2. For carbon steel and low alloy steel, the Level 1 criteria is 7692 psi (53 MPa)and 3846 psi (27.5 MPa) for Level 2. These are the applicable piping materials as defined in DCD Tier 2 tables 5.2-4 and 6.1-1.

DCD Impact:

DCD changes are shown in the attached markup of subsection 3.9.2.1.1.

NRC RAI 3.9-21

Under 'Test and Evaluation Criteria' in DCD Tier 2, Section 3.9.2.1.2, it is stated that acceptable thermal expansion limits are determined after completion of piping system stress analysis and provided in piping test specification. No details are provided regarding the analytical methodology. Discuss methods used to anticipate piping movements and deflections. Also identify and discuss any computer codes used in the analysis and indicate whether or not these codes have been benchmarked or approved by the NRC. Alternately provide a reference document which describes the piping system stress analysis methodology.

GE Response:

NUREG-1677 Benchmark Activities

On May 12, 1979, the NRC sent a letter to the General Electric Company requesting that a set of five NRC generated benchmarks problems be solved with the PISYS Code. In August 1979, all benchmark problem results were compared and documented in GE NEDO-24210, which has about 1000 pages. Excellent agreements for all five cases were found and all the NRC requirements were met. Attachment A shows the cover page, introduction and conclusion of NEDO-24210 for your reference.

The NRC published the benchmark problems in NUREG-1677 in August 1985.

NUREG/CR-6409 , BNL-NUREG-52377. (Attachment B)

This NUREG describes the piping benchmark problems for General Electric Advanced Boiling Water Reactor. The benchmark problems were performed by Brookhaven National Laboratory (BNL) to compare with PISYS analysis results. The piping systems selected for the analyses are ABWR feedwater piping and safety relief discharge piping. BNL completed their analysis using their computer program. The results of comparisons showed that PISYS analysis results were very close to the BNL results. Because PISYS program was used for the analysis of FOAKE project for the NRC, they were satisfied with BNL benchmark comparisons.

Testing Specifications

For test specification, there are two Level of Limits,

Limits on the pipe motion are established as "Level 1" and "Level 2" criteria to facilitate evaluation of the tests results. The limits are described in the following paragraphs.

Level 1: "Level 1" is that specified level of pipe motion which, if exceeded, mandates that the test be placed either on hold or terminated.

Level 2: "Level 2" is that specified level of pipe motion, which, if exceeded, requires that the responsible Piping Design Engineer, be advised. If a Level 2 limit is not satisfied, plant operating and startup testing plans will not necessarily be altered. However, an investigation of the measurements and of the criteria and calculations used to generate the pipe motion limits should be initiated. All appropriate and involved parties must reach an acceptable resolution to complete the evaluation of this test condition. Depending upon the nature of such resolution, the applicable tests may or may not have to be repeated.

Level 2 thermal displacement limits are the same as the calculated displacements for the test mode. Level 1 displacement limits are the displacements that the expansion stresses, EQ 12 of the ASME code, are equal to or less than the 3 Sm limit for the mode tested.

DCD Impact:

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

NRC RAI 3.9-22

There is insufficient information in DCD Tier 2, Section 3.9.2.1.1, relative to the flow modes of operation and transients. Therefore the applicant is requested to provide a listing of the different flow modes of operation and transients (such as pump trips, valve closures, etc.) to which the components will be subjected during the test. For example, the transients associated with the reactor coolant system heatup tests should include, but not necessarily be limited to:

(1) Reactor coolant pump start

(2) Reactor coolant pump trip

(3) Operation of pressure-relieving valves

(4) Closure of a turbine stop valve

GE Response

Refer to DCD Tier 2 Table 14.2-1, which identifies the Power Ascension Test matrix, for the additional testing information requested.

DCD Impact:

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

NRC RAI 3.9-37

DCD Tier 2, Section 3.7.3.16, states the acceptable criteria for decoupling small branch pipes from the analytical model used for the analysis of the main run piping to which the branch lines are attached. Address the following questions:

(1) the basis of using the ratio of run to branch pipe moment of inertia of 25 to 1 as one of the decoupling criteria;

(2) since the "Suggested Piping Support Spacing" as tabulated in Table NF-3611-1 is for horizontal straight runs of standard and heavier piping, confirm that the small branch pipes in question are indeed all laid out horizontally;

(3) since the above suggested pipe span is derived based on the assumption that there are no concentrated loads (such as flanges, valves, specialties,etc.) existing between supports, and that it is aimed to ensure that the pipe stress and deflection remain within allowable limits, explain how the suggested support span would ensure an adequate measure of branch line flexibility;

(4) Explain why the branch line would still offer sufficient flexibility to the main run pipe, if a concentrated mass, such as valve, is placed at the first one-half span length from the main run pipe, as stated in the DCD;

(5) explain how the small branch line would still have adequate flexibility if its first anchor or restraint to movement is at one-half pipe span from the main run pipe, as stated in the DCD;

(6) provide the basis of using one-half pipe span as the criteria for flexibility; and

(7) demonstrate that the small branch pipe so designed will indeed offer adequate flexibility, in all three orthogonal directions, to the response of the main run pipe.

GE Response (1):

This criterion is established based on a common industrial practice. The intersectional point of run/branch pipes from the stiffness distribution (using the ratio of run to branch pipe moment of inertia of 25 to 1) is considered to be a fixed point for small branch pipe.

GE Response (2):

No, it is not necessary that the small branch pipes are indeed all laid out horizontally. The basis to generate the "Suggested Piping Support Spacing" takes consideration of pipe weight under 1.0g and the limited allowable stress in compliance with the applicable code. NF-3611-1 also conservatively applies to the vertical branch pipes.

GE Response(3):

When the concentrated load such as flange, valve, or pipe riser, etc. exists in the pipe system, a two-way restraint (i.e., U-bolts for Sway Brace, etc.) shall be immediately selected to be installed adjacent to this concentrated load. The support load is calculated based on its concentrated load and the associated seismic/dynamic g values, unless justified otherwise.

GE Response(4):

The DCD does not permit placing a concentrated mass, such as valve, at the first one-half span length from the main run pipe and a decoupled branch pipe from the main run in the piping analysis.

DCD Subsection 3.7.3.16 in the first section states "In addition to the moment of inertia criterion for acceptable decoupling, these small branch lines shall be designed with no concentrated masses, such as valves, in the first one-half span length from the main run pipe; and with sufficient flexibility to prevent restraint of movement of the main run pipe."

GE Response (5):

Due to branch decoupling, the thermal displacements at the run pipe are combined with associated pressures and temperatures for the flexibility analyses of the branch pipe. All the stresses must meet the ASME Code requirements. The branch pipe analysis results will also insure adequate flexibility and proper design of all the restraints on the branch pipe.

Since there is no need to specify the additional restraint requirements, sentences in Subsection 3.7.3.16 will be removed from the DCD

GE Response(6):

The one-half pipe span will be removed from the DCD. Refer to GE response (5).

GE Response(7):

Refer to GE response (5)

DCD Impact:

As identified in response #5, DCD Tier 2, Subsection 3.7.3.16 will be revised as noted in the attached markup.

NRC RAI 3.9-41

Provide the analytical methodologies and criteria used for the design of the Seismic Category C-I and C-II buried piping and components. Clarify if buried piping will be in contact with the soil or routed in tunnels. DCD Tier 2, Section 3.7.3.13, outlines information for the analysis of Seismic Category C-I or C-II buried piping, conduits, tunnels, and auxiliary systems. Provide the analytical methodologies and criteria used for the design of the buried piping and components, including references, codes, and standards used. Also, clarify whether the buried piping within the scope of design certification will be in contact with the soil or routed in tunnels.

GE Response:

Refer to GE response for RAI 3.12-9. The DCD Revision 2 for Tier 2, Subsection 3.7.3.13 has deleted Category II from the paragraph scope. ESBWR does not contain buried piping.

DCD Impact:

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

NRC RAI 3.9-69

The discussion provided in DCD Tier 2, Section 3.9.2.4 does not specifically state how the ESBWR plant parameters would be trended. With respect to the steam, feedwater and condensate systems and components, discuss the methods which would be used for trending the plant parameters during the ESBWR startup tests.

GE Response:

DCD Tier 2, Subsection 3.9.2.1.1 "Vibration and Dynamic Effects Testing", and subparagraph "Reconciliation and Corrective Actions" provide a description of trended prediction and action requirements for system piping and components.

DCD Impact:

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

Attachment A

NEDO-24210
79NED295
Class I
August 1979

PISYS ANALYSIS OF NRC BENCHMARK PROBLEMS

(Nos. 5, 323A, 6, 101, and 803)*

Approved: E. Kiss
E. Kiss, Manager
Applied Mechanics
Nuclear Technology
Department

Approved: R. Gridley
R. L. Gridley, Manager
Operating Plant Licensing
Safety and Licensing Operation

*After June 1, 1979, NRC Problem No. 5 became NRC Problem No. 2, and NRC Problem No. 6 became NRC Problem No. 4.

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1.0 INTRODUCTION AND SUMMARY

On May 12, 1979, the United States Nuclear Regulatory Commission (NRC) sent a letter (Reference 1) to the General Electric Company requesting that a set of five NRC generated benchmarks problems be solved with the PISYS code.

PISYS is a General Electric Company Proprietary computer code used by General Electric to perform seismic piping analysis calculations for General Electric Boiling Water Reactor (BWR) nuclear steam supply systems. PISYS is capable of analyzing piping systems subjected to both static and dynamic loading. It uses the finite element method, utilizing the direct stiffness matrix method, to obtain displacements, forces, moments and stresses resulting from a static loading and either modal extraction or direct integration to obtain the response to dynamic loading. The technique relies on dividing the pipe model into several discrete substructures called pipe elements which 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 structure becomes possible. PISYS is based on linear classical elasticity in which the resultant deformation and stresses are proportional to the loading and superposition of loading is valid.

After an examination of the benchmark problems, General Electric provided a schedule for the completion of the PISYS analysis (Reference 2). A status report on the progress of the work as of June 30, 1979, and a description of the information to be reported for each of the benchmark problems, was also provided (Reference 3).

This report provides the results of PISYS analysis of the five NRC benchmark problems.* For each of the problems, an isometric plot of the PISYS models are model is given. The node and element number used in the PISYS models are identical to those given in the NRC problem figures. A complete copy of the PISYS input and output is provided for each problem. The resultant displacements and force response to the x, y, and z earthquake components are also given. A table of total ASME pipe stresses at arbitrarily selected pipe joints is provided for each problem. Calculations are given for both straight pipes and elbows.

*The original problems, transmitted in Reference 1, were numbered 5, 323A, 6, 101 and 803. After June 1, 1979, the NRC changed the number (only) of Problem No. 5 to Problem No. 2, and the number (only) of Problem No. 6 to Problem No. 4.

For all five benchmark problems, the PISYS results for the frequencies and the modal participation factors are in excellent agreement with the values given with the NRC problem definition. The agreement, in general, is within three or four significant digits.

Attachment B

NUREG/CR-6049
BNL-NUREG-52377

Piping Benchmark Problems for the General Electric Advanced Boiling Water Reactor

Manuscript Completed: June 1993
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Prepared by
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NRC FIN L2440

ABSTRACT

To satisfy the need for verification of the computer programs and modeling techniques that will be used to perform the final piping analyses for the General Electric Advanced Boiling Water Reactor (ABWR), three benchmark problems were developed. The problems are representative piping systems subjected to representative dynamic loads with solutions developed using the methods being proposed for analysis for the ABWR standard design. It will be required that the combined license licensees demonstrate that their solutions to these problems are in agreement with the benchmark problem set.

- added to the hydrostatic pressure at that level to determine the hoop tension in the tank shell.
- Either the tank top head is located at an elevation higher than the slosh height above the top of the fluid or else is designed for pressures resulting from fluid sloshing against this head.
- At the point of attachment, the tank shell is designed to withstand the seismic forces imposed by the attached piping. An appropriate analysis is performed to verify this design.
- The tank foundation is designed to accommodate the seismic forces imposed on it. These forces include the hydrodynamic fluid pressures imposed on the base of the tank as well as the tank shell longitudinal compressive and tensile forces resulting from M_o.
- In addition to the above, a consideration is given to prevent buckling of tank walls and roof, failure of connecting piping, and sliding of the tank.

3.7.3.16 Design of Small Branch and Small Bore Piping

(1) Small branch lines are defined as those lines that can be decoupled from the analytical model used for the analysis of the main run piping to which the branch lines attach. Branch lines can be decoupled when the ratio of run to branch pipe moment of inertia is 25 to 1, or greater. In addition to the moment of inertia criterion for acceptable decoupling, these small branch lines shall be designed with no concentrated masses, such as valves, in the first one-half span length from the main run pipe; and with sufficient flexibility to prevent restraint of movement of the main run pipe. Due to branch decoupling, the thermal displacements at the run pipe are combined with associated pressures and temperatures for the flexibility analyses of the branch pipe. All the stresses must meet the ASME Code requirements. The branch pipe analysis results will insure adequate flexibility and proper design of all the restraints on the branch pipe. ~~The small branch line is considered to have adequate flexibility if its first anchor or restraint to movement is at least one-half pipe span in a direction perpendicular to the direction of relative movement between the pipe run and the first anchor or restraint of the branch piping. A pipe span is defined as the length tabulated in Table NF-3611-1, Suggested Piping Support Spacing, ASME B&PV Code Section III, Subsection NF. For branches where the preceding criteria for sufficient flexibility cannot be met, the applicant shall demonstrate acceptability by using an alternative criterion for sufficient flexibility, or by accounting for the effects of the branch piping in the analysis of the main run piping.~~

(2) For small bore piping defined as piping 50 mm and less nominal pipe size, and small branch lines 50 mm and less nominal pipe size, as defined in (1) above, it is acceptable to use small bore piping handbooks in lieu of performing a system flexibility analysis, using static and dynamic mathematical models, to obtain loads on the piping elements and using these loads to calculate stresses per equations in NB, NC, and ND3600 in ASME Code Section III and ASME B31.1 Code, whenever the following are met:

   a. The small bore piping handbook is currently accepted by the regulatory agency for use on equivalent piping at other nuclear power plants.

   b. When the small bore piping handbook is serving the purpose of the Design Report it meets all of the ASME requirements for a piping design report. This includes the piping and its supports.

c. Formal documentation exists showing piping designed and installed to the small bore piping handbook (1) is conservative in comparison to results from a detail stress analysis for all applied loads and load combinations using static and dynamic analysis methods defined in Subsection 3.7.3, (2) does not result in piping that is less reliable because of loss of flexibility or because of excessive number of supports, (3) satisfies required clearances around sensitive components.

The small bore piping handbook methodology is not applied when specific information is needed on (a) magnitude of pipe and fittings stresses, (b) pipe and fitting cumulative usage factors, (c) accelerations of pipe-mounted equipment, or locations of postulated breaks and leaks.

The small bore piping handbook methodology is not applied to piping systems that are fully engineered and installed in accordance with the engineering drawings.

3.9.2.1.1 Vibration and Dynamic Effects Testing

The purpose of these tests is to confirm that the piping, components, restraints and supports of specified high- and moderate-energy systems have been designed to withstand the dynamic effects of steady state flow-induced vibration and anticipated operational transient conditions. The general requirements for vibration and dynamic effects testing of piping systems are specified in Regulatory Guide 1.68, "Initial Test Programs for Water-Cooled Nuclear Power Plants". More specific vibration testing requirements are defined in ASME OM S/G Part 3, "Requirements for Preoperational and Initial Startup Vibration Testing of Nuclear Power Plant Piping Systems." Detailed test specifications shall be in accordance with this standard and address such issues as prerequisites, test conditions, precautions, measurement techniques, monitoring requirements, test hold points and acceptance criteria. The development and specification of the types of measurements required, the systems and locations to be monitored, the test acceptance criteria, and the corrective actions that may be necessary are discussed in more detail below.

Measurement Techniques

There are essentially three methods available for determining the acceptability of steady state and transient vibration for the affected systems. These are visual observation, local measurements, and remotely monitored/recorded measurements. The technique used depends on such factors as the safety significance of the particular system, the expected mode and/or magnitude of the vibration, the accessibility of the system during designated testing conditions, or the need for a time-history recording of the vibratory behavior. Typically, the systems where vibration has the greatest safety implication are subject to more rigorous testing and precise instrumentation requirements and, therefore, require remote monitoring techniques. Local measurement techniques, such as the use of a hand-held vibrometer, are more appropriate in cases where it is expected that the vibration is less complex and of lower magnitude. Many systems that are accessible during the preoperational test phase and that do not show significant intersystem interactions fall into this category. Visual observations are used where vibration is expected to be minimal and the need for a time history record of transient behavior is not anticipated. However, unexpected visual observations or local indications may require that a more sophisticated technique be used. Also, the issue of accessibility is considered. Application of these measurement techniques is detailed in each testing specification consistent with the guidelines contained in ASME OM S/G Part 3.

Monitoring Requirements

As described in Chapter 14, all safety-related piping systems shall be subjected to steady state and transient vibration measurements. The scope of such testing shall include safety-related instrumentation piping and attached small-bore piping (branch piping). Monitoring location selection considerations include the proximity of isolation valves, pressure or flow control valves, flow orifices, distribution headers, pumps and other elements where shock or high turbulence may be of concern. Location and orientation of instrumentation and/or measurements is detailed in each test specification. Monitored data includes actual deflections and frequencies as well as related system operating conditions. Time duration of data recording should be sufficient to indicate whether the vibration is continuous or transient. Steady state monitoring is performed at critical conditions such as minimum or maximum flow, or abnormal combinations or configurations of system pumps or valves. Transient monitoring includes anticipated system and total plant operational transients where critical piping or components are expected to show significant response. Steady state conditions and transient events to be monitored are detailed in the appropriate testing specification consistent with ASME OM S/G Part 3 guidelines.

Test Evaluation and Acceptance Criteria

The piping response to test conditions is considered acceptable if the review of the test results indicates that the piping responds in a manner consistent with predictions of the stress report and/or that piping stresses are within the Code (NB, NC, ND-3600) limits. Acceptable limits are determined after the completion of piping systems stress analysis and are provided in the piping test specifications.

To ensure test data integrity and test safety, criteria have been established to facilitate assessment of the test while it is in progress. For steady state and transient vibration the pertinent acceptance criteria are usually expressed in terms of maximum allowable displacement/deflection. Visual observation is only used to confirm the absence of significant levels of vibration and not to determine acceptability of any potentially excessive vibration. Therefore, in some cases other measurement techniques are required with appropriate quantitative acceptance criteria.

There are two stress levels of acceptance criteria for allowable vibration displacements/deflections. Level 1 criteria are bounding type criteria associated with safety limits, while Level 2 criteria are stricter criteria associated with system or component expectations. For steady state vibration, the Level 1 criteria are based on ASME OM-S/G-1990 Standard, paragraph 3.2.1.2. For stainless steel, the Level 1 criteria are 10,880 psi (75 MPa). For carbon steel and low alloy steel, the level 1 criteria is 7692 psi (53MPa). The corresponding Level 2 criteria are based on one half of the Level 1 limits. ~~68.95 MPa (10,000 psi) maximum stress to assure no failure from fatigue over the life of the plant. The corresponding Level 2 criteria are based on one half the 68.95 MPa (10,000 psi) or 34.5 MPa (5,000 psi) maximum stress~~. For transient vibration, the Level 1 criteria are based on either the ASME-III code upset primary stress limit or the applicable snubber load capacity. Level 2 criteria are based on a given tolerance about the expected deflection value.

Reconciliation and Corrective Actions

During the course of the tests, the remote measurements are regularly checked to verify compliance with acceptance criteria. If trends indicate that criteria may be violated, the measurements are monitored at more frequent intervals. The test is held for Level 2 criteria violations and terminated as soon as Level 1 criteria are violated. As soon as possible after the test hold or termination, appropriate investigative and corrective actions are taken. If practicable, a walkdown of the piping and suspension system is made in an attempt to identify potential obstructions, improperly operating suspension components, or sensor malfunction. Hangers and snubbers should be positioned such that they can accommodate the expected deflections without bottoming out or extending fully. All signs of damage to piping supports or anchors are investigated.

Instrumentation indicating criteria failure is checked for proper operation and calibration including comparison with other instrumentation located in the proximity of the excessive vibration. The assumptions used in the calculations that generated the applicable limits are verified against actual conditions and discrepancies noted are accounted for in the criteria limits. This may require a reanalysis at actual system conditions.