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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 3.9-24, 3.9-25, 3.9-28, 3.9-31, 3.9-33, 3.9-45, 3.9-111, 3.9-112 through 3.9-119, 3.9-123 through 3.9-126, and 3.9-175**

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 07-086 – Response to Portion of NRC Request for Additional Information Letter No. 67 Related to ESBWR Design Certification Application – DCD Section 3.9 – RAI Numbers 3.9-24, 3.9-25, 3.9-28, 3.9-31, 3.9-33, 3.9-45, 3.9-111, 3.9-112 through 3.9-119, 3.9-123 through 3.9-126, and 3.9-175

cc: AE Cubbage USNRC (with enclosures)
GB Stramback GE/San Jose (with enclosures)
eDRFs 0000-0063-5062

Enclosure 1

MFN 07-086

Response to Portion of NRC Request for

Additional Information Letter No. 67

Related to ESBWR Design Certification Application

DCD Section 3.9

RAI Numbers 3.9-24, 3.9-25, 3.9-28, 3.9-31, 3.9-33, 3.9-45, 3.9-111, 3.9-112 through 3.9-119, 3.9-123 through 3.9-126, and 3.9-175

NRC RAI 3.9-24

A list of snubbers on systems which experience sufficient thermal movement to measure snubber travel from cold to hot position should be provided as part of the testing program, when the piping analysis is completed. This item should be identified as an action item for the Combined Operating License (COL) applicant and included in the list of action items to be completed by the COL applicant in the DCD Tier 2.

GE Response

The DCD will be revised as shown in the attached Markup of DCD subsection 3.9.3.7.1 (3) c. Incorporation of this revision identifies the requirement for this list as an action item for the Combined Operating License (COL) applicant.

DCD Impact

DCD Tier 2 Section 3.9.3.7.1 (3) c. will be revised as noted in the attachment.

NRC RAI 3.9-25

Provide a more detailed description of the thermal motion monitoring program for verification of snubber movement, adequate clearances and gaps, including acceptance criteria and how snubber motion will be measured. Alternately the applicant may provide a reference document which contains details of the thermal motion monitoring program.

GE Response

DCD Tier #2 Section 3.9.3.7.1(3) b. Inspection, Testing, Repair and/or Replacement of Snubbers will be revised to add a requirement of the thermal motion monitoring program.

DCD Impact

DCD Tier 2 Section 3.9.3.7.1 (3) b. will be revised as noted in the attachment.

NRC RAI 3.9-28

DCD Tier 2, Section 3.7.3.3.1, states that the equivalent linear stiffness of the snubbers is based on actual dynamic tests performed on prototype snubber assemblies or on data provided by the vendor. Discuss the methods used to calculate the representative snubber stiffness for each different size, type, and design of snubbers.

GE Response

The vendor's standard procedures for stiffness measurement typically provide equivalent linear stiffness of snubber assemblies. The vendor's data are based on certified test results, which would not typically require separate independent verification, by the applicant.

DCD Impact

DCD Tier 2 Section 3.7.3.3.1 will be revised as noted in the attachment.

NRC RAI 3.9-31

DCD Tier 2, Section 3.7.3.3.3, states that when the special engineered supports, described in Section 3.9.3.7.1(6), are used, modifications to the linear-elastic piping analysis methodology used with conventional pipe supports are needed to account for greater damping of the energy absorbers and the non-linear behavior of the limit stops. Discuss in detail the modifications involved, and the acceptability of the modeling and analytical methodology used. In addition, describe the information required by Regulatory Guide 1.84, Revision 33, August 2005, that shall be provided to the NRC for review.

GE Response

Special Engineered Supports will not be used. Please refer to response provided for RAI 3.12-13.

DCD Impact

DCD Tier 2 Section 3.7.3.3.3 will be revised as noted in the attachment.

NRC RAI 3.9-33

In DCD Tier 2, Section 3.7.3.9, in regard to the effects of relative support displacements on the overall response of multi-supported systems (equipment and piping), the application states that the support displacements are imposed on the supported systems in a conservative manner and static analysis is performed for each orthogonal direction. Clarify what this "conservative manner" implicates, and how it would be compared to the criteria of SRP 3.7.3.II.9, which requires that the support displacements be imposed on the supported item in the "most unfavorable combination" using static analysis procedures.

GE Response

This revision is consistent with SRP 3.7.3.II.9. It simply clarifies what is meant by the term conservative in the DCD. The word **Multiply** in the section title is revised to **Multiple.**

DCD Impact

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

NRC RAI 3.9-45

DCD Tier 2, Section 3.9.2.2.2, states that for the case of equipment having supports with different dynamic motions, the most severe floor response spectrum is applied to all of the supports. This is not consistent with the general guidance provided in SRP 3.9.2, Draft Revision 3, April 1996, Section II.2.g, where an upper bound envelope, instead of the most severe, of all the individual response spectra is required to calculate maximum inertial responses of multiply supported items. Revise the statement accordingly.

GE Response

This revision makes the affected paragraph consistent with the second paragraph of SRP 3.9.2 Draft Revision 3 dated April 1996, Section II.2.g.

DCD Impact

DCD Tier 2 Section 3.9.2.2.2 will be revised as noted in the attachment.

NRC RAI 3.9-111

DCD Tier 2, Section 3.9.3.7, does not discuss Seismic Category IIA pipe supports. Clarify and discuss how the provisions of Regulatory Guide 1.29, Revision 3, September 1978, are addressed in regard to Seismic Category IIA pipe supports.

GE Response

This response includes a design consideration for Class IIA pipe supports.

DCD Impact

DCD Tier 2, Section 3.9.3.7.1 will be revised as noted in the attached markup.

NRC RAI 3.9-112

DCD Tier 2, Section 3.9.3.7.1, states that the building structure component supports designed in accordance with ANSI/AISC N690 or the AISC Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings correspond to those used for design of the supported pipe. Provide a discussion on the types of component supports which are being designed in accordance with the ANSI/AISC N690 or AISC Specification, and explain how these component supports correspond to those used for design of the supported pipe. In addition, since the staff accepts ANSI/AISC N690, 1994 Edition, for certain types of component supports, only if it is applied in conjunction with Supplement No. 2 to the standard, confirm that the correct edition and supplement are being used.

GE Response

The revision of Section 3.9.3.7.1 adds clarifications on design of pipe support structure with the building structure.

DCD Impact

DCD Tier 2, Section 3.9.3.7.1 will be revised as noted in the attached markup.

NRC RAI 3.9-113

In DCD Tier 2, Section 3.9.3.7, sufficient information is not provided for component support service stress limits and deformation limits under both static and dynamic loadings. Provide the following information:

(1) for each loading combination considered for each component support, describe the designation of the appropriate service stress limit, and discuss its conformance to the criteria provided in Section II.3 and Appendix A of SRP 3.9.3, Draft Revision 2, April 1996,Section II.3, and Regulatory Guides 1.124, Revision 1, January 1978, and 1.130, Revision 1, October 1978;

(2) discuss how the support deformation limits are incorporated into the operability assurance determination and seismic qualification program of the components;

(3) provide examples of the deformation limits considered for the supports, considering the types of supports, their characteristics (such as stiffness), and the components or structures that they are attached to; and

(4) clarify whether the above design criteria also apply to snubbers used as supports for active components.

GE Response

The revision of Section 3.9.3.7 adds clarifications on design of pipe support structure with respect to design limits.

DCD Impact

DCD Tier 2, Section 3.9.3.7, component Supports, will be revised as noted in the attached markup.

NRC RAI 3.9-114

In DCD Tier 2, Section 3.9.3.7.1(3), sufficient information is not provided for potential snubber end fitting clearance and lost motion. Discuss how snubber end fitting clearance and lost motion are managed, and how they affect the calculations of snubber reaction loads and stresses using a linear analysis methodology. In multiple snubber applications where mismatch of end fitting clearance and lost motion exist, discuss their potential impact on the synchronism of activation level or release rate, and, consequently, the assumption of the load sharing of multiple snubber supports.

GE Response

Snubber design detail is added in DCD Tier 2, Section 3.9.3.7.1 (3) c.

DCD Impact

DCD Tier 2, Section 3.9.3.7.1 (3) c will be revised as noted in the attached markup.

NRC RAI 3.9-115

In DCD Tier 2, Section 3.9.3.7.1(3), sufficient information is not provided for the characterization of snubber mechanical properties (i.e., spring rates) in the analytical model. Provide a detailed discussion on the characterization of effective stiffness for the snubber support assembly (i.e., the snubber plus clamp, transition tube extension,back-up support structure, etc.) used in the analytical model, both during the initial estimation and the refined piping analysis.

GE Response

Please refer to response for RAI 3.9-114

DCD Impact

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

NRC RAI 3.9-116

In DCD Tier 2, Section 3.9.3.7.1(3), sufficient information is not provided for the specific design rules of Subsection NF used for snubbers. Provide such design rules for snubbers, namely, the rules for design by analysis, by experimental stress analysis, or by load rating. Discuss in detail how the load capacity for design, normal,upset, emergency and faulted conditions will be calculated and examined for both mechanical and hydraulic snubbers.

GE Response

Snubber designs are based on the requirements set forth in ASME Section III Division 1, Subsection NF. The rules and sections of subsections NF that are established for these designs are at the discretion of the snubber vendor. The selection of the vendor will be based on an approved vendor list where snubber suppliers will required to provide sufficient documentation that their in-house programs comply with all ASME Code requirements and QA/QC requirements.

The vendor's snubber design and load ratings are based on certified analysis/test results, which would not typically require a separate independent verification, by the COL applicant.

DCD Impact

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

NRC RAI 3.9-117

In DCD Tier 2, Section 3.9.3.7.1(3)c(ii), certain test requirements are provided for snubbers to ensure that they can perform as required under all pertinent loading conditions. In connection with the stated test requirements,

(1) discuss the procedure and scope of production test and the qualification test programs, separately, for both the mechanical and hydraulic snubbers, of different sizes and manufacturers;

(2) discuss how the criteria of each pertinent snubber functional parameters are met in the testing; and

(3) provide the codes and standards used for the programs.

GE Response

Responses included in this DCD satisfy the above question.

DCD Impact

DCD Tier 2, Section 3.9.3.7.1 (3) c will be revised as noted in the attached markup.

NRC RAI 3.9-118

DCD Tier 2, Section 3.9.3.7.1(3)c(ii), states that snubbers are subjected to force or displacement versus time loading at frequencies within the range of significant modes of the piping system. Clarify how the force or displacement versus time loading as stated are related to the velocity and acceleration parameters measured in a snubber testing. Also explain how displacements are measured to determine the performance characteristics specified in the test.

GE Response

See response to RAI 3.9-117. Additionally, snubber testing requirements are stated in Subsection 3.9.3.7.1 (3).

DCD Impact

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

NRC RAI 3.9-119

In conformance with DCD Tier 2, Section 3.9.3.7.1, COL holders should verify the operability of essential snubbers by verifying the proper installation of the snubbers, and by performing visual inspections and measurements of the cold and hot positions of the snubbers as required during plant heat-up to verify that the snubbers are performing as intended. This issue is not currently addressed in Section 3.9.9 of the DCD Tier 2. Provide the rationale for the exclusion of this item from the listing of COL action items.

GE Response

Refer DCD Tier 2 Section 3.9.3.7.1(3) b (titled: Inspection, Testing, repair and/or Replacement, 3.9.3.7.1(3) d (titled: Snubber Installation Requirements), and 3.9.3.7.1(3) e (titled: Snubber Pre-service Inspection).

Refer response to RAI 3.9-24

These existing paragraphs state that a snubber installation manual as required by the pipe support design specification will be furnished by the snubber supplier. This manual contains instructions for the erection, testing, maintenance, repair, and adjustment of each individual snubber. This includes procedures for compliance with the specified hot and cold settings.

DCD Impact

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

NRC RAI 3.9-123

To ensure that the plant-specific snubber programs will be readily available for a site audit, demonstrate, such as by a COL action item, that the plant-specific design specification will include the following specific snubber information:

(i) the general functional requirement,

(ii) operating environment,

(iii) applicable codes and standards,

(iv) materials of construction and standards for hydraulic fluids and lubricants,

(v) environmental, structural, and performance design verification tests,

(vi) production unit functional verification tests and certification,

(vii) packaging, shipping, handling, and storage requirements, and

(viii) (viii)description of provisions for attachments and installation.

In addition, confirm that the snubber manufacturer will be submitting its quality assurance and assembly quality control procedures for review and acceptance by the purchaser.

GE Response

DCD Tier #2, Section 3.9.3.7.1 (3) Snubbers - A new subsection "f." will be added as follows:

f. Snubber audit support data.

To ensure that the plant-specific snubber programs will be readily available for a site audit, the plant-specific design specification provided by the COL holder will include the following specific snubber information:

(i) the general functional requirement,

(ii) operating environment,

(iii) applicable codes and standards,

(iv) materials of construction and standards for hydraulic fluids and lubricants,

(v) environmental, structural, and performance design verification tests,

(vi) production unit functional verification tests and certification,

(vii) packaging, shipping, handling, and storage requirements, and

(viii) description of provisions for attachments and installation. (

(ix) quality assurance and assembly quality control procedures for review and acceptance by the purchaser.

DCD Impact

DCD Tier 2, Section 3.9.3.7.1 (3) Snubbers, will be revised as noted in the attached markup.

NRC RAI 3.9-124

DCD Tier 2, Section 3.9.3.7.1, should say that COL holders should provide, consistent with the requirements of SRP 3.9.3, Draft Revision 2, April 1996, Subsection II.3.b(7), a table in the FSAR which contains all safety-related components utilizing snubbers in their support systems, and includes (i) identification of the systems and components in those systems which utilize snubbers; (ii) the number of snubbers utilized in each system and on components in that system; (iii) the type(s) of snubber (hydraulic or mechanical) with the corresponding supplier identified; (iv) specify whether the snubber was constructed to the rules of ASME Code Section III, Subsection NF, or others as specified; (v) state whether the snubber is used as a shock, vibration, or dual purpose snubber; and (vi) for snubbers identified as either dual purpose or vibration arrester type, indicate if both snubber and component were evaluated for fatigue strength.

This item is not included in Section 3.9.9 of DCD Tier 2. Provide rationale for excluding this item from the listing of COL action items.

GE Response

See response in the DCD mark up.

DCD Impact

DCD Tier 2, Section 3.9.3.7.1 (3) c will be revised as noted in the attached markup.

NRC RAI 3.9-125

DCD Tier 2, Section 3.9.3.7.1(5), does not provide sufficient information regarding the design of frame-type pipe supports. Discuss the following:

(1) the hot and cold gaps to be used between the pipe and the frametype support,

(2) the coefficients of friction used for different pipe and support material combinations, and the calculation of friction forces induced by the pipe on the support; and

(3) how the seismic excitation of a large frame-type support structure itself is considered in the design of the support anchorage.

GE Response

See response in the attached DCD mark up.

DCD Impact

DCD Tier 2, Section 3.9.3.7.1 (5) will be revised as noted in the attached markup.

NRC RAI 3.9-126

In DCD Tier 2, Section 3.9.3.7, provide a discussion of the analytical models and the methods of analysis used for all major ASME Code Class 1 component supports, including snubbers.

GE Response

Analytical models and methods of analysis for all major ASME Code Class 1 component supports, including snubbers, are fully defined in the users' manuals of whatever pipe stress computer programs are selected and approved for qualifying the Class 1 piping systems to the applicable ASME Section III Code of Reference.

DCD Impact

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

NRC RAI 3.9-175

Describe the method for functional design and qualification for snubbers.

GE Response

The functional design and qualification of snubbers is covered in DCD Tier #2 Subsection 3.9.3.7.1(3)c and in ASME Section III, Subsection NF.

DCD Impact

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

support points or the Independent Support Motion (ISM) at each support. Additional considerations associated with the ISM response spectrum method of analysis are given in Subsection 3.7.3.9. ~~For piping analysis, the ZPA cutoff frequency for modal response analysis of subsystems for seismic and other building loads is 100 Hz.~~ For equipment analysis, refer to the requirements of Step 1 of Section 3.7.2.7 for ZPA cutoff frequency determination.

3.7.3.2 Determination of Number of Earthquake Cycles

The SSE is the only design earthquake considered for the ESBWR Standard Plant. To account for the cyclic effects of the more frequent occurrences of lesser earthquakes and their aftershocks, the fatigue evaluation for ASME Code Class 1, 2, and 3 components and core support structures takes into consideration two SSE events with 10 peak stress cycles per event for a total of 20 full cycles of the peak SSE stress. This is equivalent to the cyclic load basis of one SSE and five OBE events as currently recommended in the SRP 3.7.3. Alternatively, a number of fractional vibratory cycles equivalent to 20 full SSE vibratory cycles may be used (with an amplitude not less than one-third of the maximum SSE amplitude) when derived in accordance with Appendix D of IEEE-344.

For equipment seismic qualification performed in accordance with IEEE-344 as endorsed by Regulatory Guide 1.100, the equivalent seismic cyclic loads are five 0.5 SSE events followed by one full SSE event. Alternatively, a number of fractional peak cycles equivalent to the maximum peak cycles for five 0.5 SSE events may be used in accordance with Appendix D of IEEE-344 when followed by one full SSE.

3.7.3.3 Procedures Used for Analytical Modeling

The mathematical modeling of equipment and piping is generally developed according to the finite element technique following the basic modeling procedures described in Section 3.7.2.3 for primary systems.

3.7.3.3.1 Piping Systems

Mathematical models for Seismic Category 1 piping systems are constructed to reflect the dynamic characteristics of the system. The continuous system is modeled as an assemblage of pipe elements (straight sections, elbows, and bends) supported by hangers and anchors, and restrained by pipe guides, struts and snubbers. Pipe and hydrodynamic fluid masses are lumped at the nodes and connected by zero-mass elastic elements, which reflect the physical properties of the corresponding piping segment. The mass node points are selected to coincide with the locations of large masses, such as valves, pumps, and motors, and with locations of significant geometry change. All concentrated weights on the piping systems, such as the valves, pumps, and motors, are modeled as lumped mass rigid systems if their fundamental frequencies are greater than the cutoff frequency in Subsection 3.7.2.1.1. Additional criteria regarding lump masses for components are specified in Subsection 3.7.3.3.2. On straight runs, mass points are located at spacing no greater than the span which would have a fundamental frequency equal to the cutoff frequency stipulated in Subsection 3.7.2.1.1, when calculated as a simply supported beam with uniformly distributed mass. The torsional effects of valve operators and other equipment with offset center of gravity with respect to the piping center line are included in the analytical model. Furthermore, all pipe guides and snubbers are modeled so as to produce representative stiffness. The equivalent linear stiffness of the snubbers is based on ~~actual~~

dynamic tests performed on prototype snubber assemblies or on data certified test results provided by the vendor.

Pipe supports will be designed and qualified to satisfy stiffness values used in the piping analysis. For struts, and snubbers, the stiffness to consider is the combined stiffness of strut, snubber, pipe clamp and piping support steel.

In general, pipe support component weights, which are directly attached to a pipe such as a Clamp, Strut, Snubber, and Trapeze are considered in the piping analysis. Frame type supports will be designed to carry its own mass and will be subjected to deflection requirements. A maximum deflection of 1/16 inch is used for normal operating conditions, and 1/8 inch is used for abnormal conditions. For other types of supports, either demonstrate that the support is dynamically rigid, or demonstrate that one half of the support mass is less than 10% of the mass of the straight pipe segment of the span at the support location, to preclude amplification. Otherwise, the contribution of the support weight amplification is added into the piping analysis. Piping supports will be evaluated to include the impact of self-weight excitation on support structure and anchorage in detail along with piping analyzed loads where this effect may be significant.

The stiffness of the building steel/structure (i.e., beyond the NF jurisdictional boundary) is not considered in pipe support overall stiffness. Response spectra input to the piping system includes flexibility of the building structure. When attachment to a major building structure is not possible, any intermediate structures are included in the analysis of the pipe support.

3.7.3.3.2 Equipment

For dynamic analysis, equipment is represented by lumped-mass system, which consists of discrete masses connected by zero-mass elements. The criteria used to lump masses are as follows:

- The number of modes of a dynamic system is controlled by the number of masses used; therefore, the number of masses is chosen so that all significant modes are included. The number of masses or dynamic degrees of freedom is considered adequate when additional degrees of freedom do not result in more than a 10% increase in response. Alternatively, the number of dynamic degrees of freedom is no less than twice the number of modes below the cutoff frequency of Subsection 3.7.2.1.1.
- Mass is lumped at any point where a significant concentrated weight is located. Examples are the motor in the analysis of a pump stand, and the impeller in the analysis of a pump shaft.
- If the equipment has free-end overhang span whose flexibility is significant compared to the center span, a mass is lumped at the overhang span.
- When equipment is concentrated between two existing nodes located between two supports in a finite element model, a new node is created at that location. Alternatively, the equipment mass can be concentrated at the nearest node to either side which tends to shift the natural frequency to the higher amplification region of the input motion response spectrum. When the approximate location of the equipment mass is shifted toward the mid-span between the supports the natural frequency is lowered and when the approximate location is shifted toward either support the natural frequency is increased.

Moving the natural frequencies of the equipment into the higher amplification region of the excitation thereby conservatively increases the equipment response level.

Similarly, in the case of live loads (mobile) and variable support stiffness, the location of the load and the magnitude of the support stiffness are chosen to lower the system natural frequencies. Similar to the above discussion, this ensures conservative dynamic responses because the lowered equipment frequencies tend to be shifted to the higher amplification range of the input motion spectra. If not, the model is adjusted to give more conservative responses.

3.7.3.3.3 Modeling of Special Engineered Pipe Supports

Modifications to the normal linear-elastic piping analysis methodology used with conventional pipe supports are required to calculate the loads acting on the supports and on the piping components when the special engineered supports, described in Subsection 3.9.3.7.1 (6), are used. These modifications are needed to account for greater damping of the energy absorbers and the non-linear behavior of the limit stops. The use of special engineered pipe supports is not expected, and the need to use it during the detailed design phase is not foreseen. If its use should be essential at any point during the development of detailed engineering, the modeling and analytical methodology will be based on applicable design codes and allowables approved by the NRC. In addition, the information required by Regulatory Guide 1.84 shall be provided to the regulatory agency.

Examples of energy absorbers are stiff spring struts which are modeled with the design linear spring rate along the axis of the strut. Limit stops are modeled as rigid restraints with gaps in the direction of restraint in accordance with the techniques specified in the pipe stress program being used and in compliance with Section III Sub-Section NF, Division 1. Any ASME Code Cases used in the design of engineered supports will be identified as such in the FSAR and will be used only as permitted by Regulatory Guide 1.84 Revision 33, August 2005.

3.7.3.4 Basis for Selection of Frequencies

Where practical, in order to avoid adverse resonance effects, equipment and components are designed/selected such that their fundamental frequencies are less than half or more than twice the dominant frequencies of the support structure. Moreover, in any case, the equipment is analyzed and/or tested to demonstrate that it is adequately designed for the applicable loads considering both its fundamental frequency and the forcing frequency of the applicable support structure.

3.7.3.5 Analysis Procedure for Damping

Damping values for equipment and piping are shown in Table 3.7-1 and are consistent with Regulatory Guide 1.61. For ASME Section III, Division 1 Class 1, 2, and 3, and ASME~~/ANSI~~ B31.1 piping systems, alternative damping values specified in Figure 3.7-37 may be used. For systems made of subsystems with different damping properties, the analysis procedures described in Subsection 3.7.2.13 are applicable.

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.

3.7.3.7 Combination of Modal Responses

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

3.7.3.8 Interaction of Other Systems with Seismic Category I Systems

Each non-Category I (i.e., C-II or NS) 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.

3.7.3.9 Multiple~~Multiply~~-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 responses caused by motions of supports in two or more different groups are combined by the SRSS procedure.

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 (SAM) are included in Service Level D load combinations.

The fixture design simulates the actual service mounting and causes no dynamic coupling to the equipment.

Prototype Testing

When possible equipment testing is conducted on prototypes of the equipment to be installed in the plant. If not, a detailed inspection and justification of the capacity of the equipment tested shall be made.

3.9.2.2.2 Qualification of Safety-Related Mechanical Equipment

The following subsections discuss the testing or analytical qualification of the safety-related major mechanical equipment, and other ASME III equipment including equipment supports.

CRD and CRD Housing

The qualification of the CRD housing (with enclosed CRD) is done analytically, and the stress results of the analysis establish the structural integrity of these components. Dynamic tests are conducted to verify the operability of the control rod drive during a dynamic event. A simulated test, imposing dynamic deflection in the fuel channels up to values greater than the expected seismic response, is performed.

The correlation of the test with analysis is via the channel deflection, not the housing structural analysis, because insertability is controlled by channel deflection, not housing deflection.

Core Support (Fuel Support and CR Guide Tube)

A detailed analysis imposing dynamic effects due to seismic and other RBV events is performed to show that the maximum stresses developed during these events are much lower than the maximum allowed for the component material.

Hydraulic Control Unit (HCU)

The HCU is analyzed for the seismic and other RBV loads faulted condition and the maximum stress on the HCU frame is calculated to be below the maximum allowable for the faulted condition. As discussed in Subsection 3.9.1.4, the faulted condition loads are calculated to be below the HCU maximum capability.

Fuel Assembly (Including Channel)

GE ESBWR fuel channel design bases, analytical methods, and seismic considerations are similar to those contained in References 3.9-1 and 3.9-2. The resulting combined acceleration profiles, including fuel lift for all normal/upset and faulted events are to be shown less than the respective design basis acceleration profiles.

Standby Liquid Control Accumulator

The standby liquid control accumulator is a cylindrical vessel. The standby liquid control accumulator is qualified by analysis for seismic and other RBV loads.

The results of this analysis confirm that the calculated stresses at all investigated locations are less than their corresponding allowable values

Main Steamline Isolation Valves

The main steamline isolation valves (MSIV) are qualified for seismic and other RBV loads. The fundamental requirement of the MSIV following an SSE or other faulted RBV loadings is to close and remain closed after the event. This capability is demonstrated by the test and analysis as outlined in Subsection 3.9.3.5.

Standby Liquid Control Valve (Injection Valve)

The standby liquid control injection valve is qualified by type test to IEEE 344 for seismic and other RBV loads. The qualification test as discussed in Subsection 3.9.3.5 demonstrates the ability to remain operable after the application of horizontal and vertical dynamic loading in excess of the required response spectra. The valve is qualified by dynamic analysis and the results of the analysis indicate that the valve is capable of sustaining the dynamic loads without overstressing the pressure retaining components.

Main Steam Safety/Relief Valves

Due to the complexity of the structure and the performance requirements of the valve, the total assembly of the SRV (including electrical and pressure devices) is tested at dynamic accelerations equal to or greater than the combined SSE and other RBV loadings determined for the plant. Tests and analysis as discussed in Subsection 3.9.3.5 demonstrate the satisfactory operation of the valves during and after the test.

Other ASME Code Section III Equipment

Other equipment, including associated supports, is qualified for seismic and other RBV loads to ensure its functional integrity during and after the dynamic event. The equipment is tested, if necessary, to ensure its ability to perform its specified function before, during, and following a test.

Dynamic load qualification is done by a combination of test and/or analysis as described in Subsection 3.9.2.2. Natural frequency, when determined by an exploratory test, is in the form of a single-axis continuous-sweep frequency search using a sinusoidal steady-state input at the lowest possible amplitude, which is capable of determining resonance. The search is conducted on each principal axis with a minimum of two continuous sweeps over the frequency range of interest at a rate no greater than one octave per minute. If no resonances are located, then the equipment is considered rigid and single frequency tests at every 1/3 octave frequency interval are acceptable. Also, if all natural frequencies of the equipment are greater than ZPA defined in Subsection 3.7.2.7, the equipment may be considered rigid and analyzed statically as such. In this static analysis, the dynamic forces on each component are obtained by concentrating the mass at the center of gravity and multiplying the mass by the appropriate floor acceleration. The dynamic stresses are then added to the operating stresses and a determination made of the adequacy of the strength of the equipment. The search for the natural frequency is done analytically if the equipment shape can be defined mathematically and/or by prototype testing.

If the equipment is a rigid body while its support is flexible, the overall system can be modeled as a single-degree-of-freedom system consisting of a mass and a spring. The natural frequency of the system is computed; then the acceleration is determined from the floor response spectrum curve using the appropriate damping value. A static analysis is then performed using this acceleration value. In lieu of calculating the natural frequency, the peak acceleration from the spectrum curve is used. The critical damping values for welded steel structures from Table 3.7-1 are employed.

If the equipment cannot be considered as a rigid body, it can be modeled as a multi-degree-of-freedom system. It is divided into a sufficient number of mass points to ensure adequate representation. The mathematical model can be analyzed using modal analysis technique or direct integration of the equations of motion. Specified structural damping is used in the analysis unless justification for other values can be provided. A stress analysis is performed using the appropriate inertial forces or equivalent static loads obtained from the dynamic analysis of each mode.

For a multi-degree-of-freedom modal analysis, the modal response accelerations can be taken directly from the applicable floor response spectrum. The maximum spectral values within ±10% band of the calculated frequencies of the equipment are used for computation of modal dynamic response inertial loading. The total dynamic stress is obtained by combining the modal stresses. The dynamic stresses are added to the operating stresses using the loading combinations stipulated in the specific equipment specification and then compared with the allowable stress levels.

If the equipment being analyzed has no definite orientation, the worst possible orientation is considered. Furthermore, equipment is considered to be in its operational configuration (i.e., filled with the appropriate fluid and/or solid). The investigation ensures that the point of maximum stress is considered. Lastly, a check is made to ensure that partially filled or empty equipment does not result in higher response than the operating condition. The analysis includes evaluation of the effects of the calculated stresses on mechanical strength, alignment, electrical performance (microphonics, contact bounce, etc.) and non-interruption of function. Maximum displacements are computed and interference effects determined and justified.

Individual devices are tested separately, when necessary, in their operating condition. Then the component to which the device is assembled is tested with a similar but inoperative device installed upon it.

The equipment, component, or device to be tested is mounted on the vibration generator in a manner that simulates the final service mounting. If the equipment is too large, other means of simulating the service mounting are used. Support structures such as consoles, racks, etc., may be vibration tested without the equipment and/or devices being in operation provided they are performance tested after the vibration test. However, the components are in their operational configuration during the vibration test. The goal is to determine that, at the specified vibratory accelerations, the support structure does not amplify the forces beyond that level to which the devices have been qualified.

Alternatively, equipment may be qualified by presenting historical performance data, which demonstrates that the equipment satisfactorily sustains dynamic loads which are equal to greater than those specified for the equipment and that the equipment performs a function equal to or better than that specified for it.

Equipment for which continued function is not required after a seismic and other RBV loads event, but whose postulated failure could produce an unacceptable influence on the performance of systems having a primary safety function, are also evaluated. Such equipment is qualified to the extent required to ensure that an SSE including other RBV loads, in combination with normal operating conditions, would not cause unacceptable failure. Qualification requirements are satisfied by ensuring that the equipment in its functional configuration, complete with attached appurtenances, remains structurally intact and affixed to the interface. The structural integrity of internal components is not required; however, the enclosure of such components is required to be adequate to ensure their confinement. Where applicable, fluid or pressure boundary integrity is demonstrated. With a few exceptions, simplified analytical techniques are adequate for this purpose.

Historically, it has been shown that the main cause for equipment damage during a dynamic excitation has been the failure of its anchorage. Stationary equipment is designed with anchor bolts or other suitable fastening strong enough to prevent overturning or sliding. The effect of friction on the ability to resist sliding is neglected. The effect of upward dynamic loads on overturning forces and moments is considered. Unless specifically specified otherwise, anchorage devices are designed in accordance with the requirements of the Code, Subsection NF, or ANSI/AISC - N690 and ACI 349.

Dynamic design data are provided in the form of acceleration response spectra for each floor area of the equipment. Dynamic data for the ground or building floor to which the equipment is attached are used. For the case of equipment having multiple supports with different dynamic motions, an upper bound envelop of all the individual response spectra for these locations is used to calculate maximum inertial responses of items with multiple supports. ~~the most severe floor response spectrum is applied to all of the supports.~~

Refer to Subsection 3.9.3.5 for additional information on the dynamic qualification of valves.

Supports

Subsections 3.9.3.7 and 3.9.3.8 address analyses or tests that are performed for component supports to assure their structural capability to withstand the seismic and other dynamic excitations.

3.9.2.3 Dynamic Response of Reactor Internals Under Operational Flow Transients and Steady-State Conditions

The major reactor internal components within the vessel are subjected to extensive testing, coupled with dynamic system analyses, to properly evaluate the resulting flow-induced vibration phenomena during normal reactor operation and from anticipated operational transients.

In general, the vibration forcing functions for operational flow transients and steady-state conditions are not predetermined by detailed analysis. Special analysis of the response signals measured for reactor internals of many similar designs is performed to obtain the parameters, which determine the amplitude and modal contributions in the vibration responses. This study provides useful predictive information for extrapolating the results from tests of components with similar designs to components of different designs. This vibration prediction method is appropriate where standard hydrodynamic theory cannot be applied due to complexity of the structure and flow conditions. Elements of the vibration prediction method are outlined as follows:

- Dynamic modal analysis of major components and subassemblies is performed to identify vibration modes and frequencies. The analysis models used for Seismic Category I structures are similar to those outlined in Subsection 3.7.2.

at locations on the piping system where fluid flow changes direction, thus causing momentary reactions. The resulting loads on the SRV, the main steamline, and the discharge piping are combined with loads due to other effects as specified in Subsection 3.9.3.1. In accordance with Tables 3.9-1 and 3.9-2, the Code stress limits for service levels corresponding to load combination classification as normal, upset, emergency, and faulted are applied to the main steam and discharge pipe.

Many of the SRV design parameters and criteria are specified in Sections 5.2 and 15.2. The procurement specification for the SRV, that will be prepared by GE, define the SRV requirements that are necessary to be consistent with the SRV parameters used in the steam line stress analysis.

Other Safety/Relief and Vacuum Breaker Valves

An SRV is identified as a pressure relief valve or vacuum breaker. SRVs in the reactor components and subsystems are described and identified in Subsection 5.4.13.

The operability assurance program discussed in Subsection 3.9.3.5 applies to safety/relief valves.

ESBWR safety/relief valves and vacuum breakers are designed and manufactured in accordance with the Code requirements.

The design of ESBWR SRVs incorporates SRV opening and pipe reaction load considerations required by ASME III, Appendix O, and including the additional criteria of SRP, Section 3.9.3, Paragraph II.2 and those identified under Subsection NB-3658 for pressure and structural integrity. Safety/relief and vacuum relief valve and vacuum relief operability is demonstrated either by dynamic testing or analysis of similarly tested valves or a combination of both in compliance with the requirements of SRP Subsection 3.9.3.

Depressurization Valves

The instantaneous opening of the DPV due to the explosion of the DPV operator results in a transient that produces impact loads and momentary unbalanced forces acting on the MS and DPV piping system. The impact load forcing functions associated with DPV operation used in the piping analyses are determined by test. From the test data a representative force time-history is developed and applied as input to a time-history analysis of the piping. If these loads are defined to act in each of the three orthogonal directions, the responses are combined by the SRSS method. The momentary unbalanced forces acting on the piping system are calculated and analyzed using the methods described in Subsection 3.9.3.6 for SRV lift analysis.

The resulting loads on the DPV, the main steamline, and the DPV piping are combined with loads due to other effects as specified in Subsection 3.9.3.1. In accordance with Tables 3.9-1 and 3.9-2, the code stress limits for service levels corresponding to load combination classification as normal, upset, emergency, and faulted are applied to the main steam, stub tube, and DPV discharge piping.

3.9.3.7 Component Supports

The establishment of the design/service loadings and limits will be in accordance with the ASME Section III, Division 1, Article NCA-2000 and Subsection NF. These loadings and stress limits apply to the structural integrity of components and supports when subjected to combinations of loadings derived from plant and system operating conditions and postulated plant events. The combination of loadings and stress limits are included in the Design Specification of each component and support. Where the design and service stress limits specified in the code do not necessarily provide direction for the proper consideration of operability requirements for conditions which warrant consideration, Section II.3 and Appendix A of SRP 3.9.3, and Regulatory Guides 1.124 and 1.130 will be used for guidance. Where these stress limits apply, the treatment of functional capability, including collapse, deformation and deflection limits will be evaluated and appropriate information will be developed for inclusion into the Design Specification.

ASME Section III component supports shall be designed, manufactured, installed and tested in accordance with all applicable codes and standards. Supports include hangers, snubbers, struts, spring hangers, frames, energy absorbers and limit stops. Pipe whip restraints are not considered as pipe supports.

The design of bolts for component supports is specified in the Code, Subsection NF. Stress limits for bolts are given in NF-3225. The rules and stress limits which must be satisfied are those given in NF-3324.6 multiplied by the appropriate stress limit factor for the particular service loading level and stress category specified in Table NF-3225.2-1.

Moreover, on equipment which is to be, or may be, mounted on a concrete support, sufficient holes for anchor bolts are provided to limit the anchor bolt stress to less than 68.95 MPa (10,000 psi) on the nominal bolt area in shear or tension.

Concrete expansion anchor bolts, with regard to safety factor and anchor plates flexibility, will follow all aspects of IE Bulletin 79-02, "Pipe Support Base Plate Designs Using Concrete Expansion Anchor Bolts," Revision 2 dated November 8, 1979. Expansion anchor bolts shall not be used for any safety related system components. The design and installation of all anchor bolts will be performed in accordance with Appendix B to ACI 349-01 "Anchoring to Concrete", subject to the conditions and limitations specified in RG 1.199 and all applicable requirements of IE Bulletin 79-02, Rev. 2.

It is preferable to attach pipe supports to embedded plates; however, surface-mounted base plates with undercut anchor bolts can be used in the design and installation of supports for safety related.

Pipe support base plate flexibility shall be accounted for in calculation of concrete anchor bolt loads, in accordance with IE Bulleting 79-02.

Mortar grout used for shim on the pipe support, when placed in contention areas, must be free of organic links in its composition.

3.9.3.7.1 Piping Supports

Supports and their attachments for essential Code Class 1, 2, and 3 piping are designed in accordance with Subsection NF up to the interface of the building structure, with jurisdictional boundaries as defined by Subsection NF. The building structure component supports (connecting the NF support boundary component to the existing building structure) are designed in accordance with ANSI/AISC N690, Nuclear Facilities-Steel Safety-Related Structures for Design, Fabrication and Erection (1994 edition), or the AISC specification for the Design, Fabrication, and Erection of Structural Steel. The applicable loading combinations and allowables used for design of supports are shown on Tables 3.9-10, -11, and –12. The stress limits are per ASME III, Subsection NF and Appendix F. Supports are generally designed either by load rating method per paragraph NF-3280 or by the stress limits for linear supports per paragraph NF-3143. The critical buckling loads for the Class 1 piping supports subjected to faulted loads that are more severe than normal, upset and emergency loads, are determined by using the methods discussed in Appendices F and XVII of the Code. To avoid buckling in the piping supports, the allowable loads are limited to two thirds of the determined critical buckling loads.

Maximum calculated static and dynamic deflections of the piping at support locations do not exceed the allowable limits specified in the piping design specification. The purpose of the allowable limits is to preclude failure of the pipe supports due to piping deflections.

Seismic Category IIA pipe supports will be designed so that the SSE would not cause unacceptable structural interaction or failure. Support design will follow the intent and general requirement specified in ASME III, Nonmandatory Appendix F. This will be used to evaluate the total design load condition with respect to the requirements of the safe shutdown earthquake (SSE) condition to ensure the structural integrity of the pipe supports are maintained.

The design of supports for the non-nuclear piping satisfies the requirements of ASME/ANSI B31.1 Power Piping Code, Paragraphs 120 and 121.

For the major active valves identified in Subsection 3.9.3.5, the valve operators are not used as attachment points for piping supports.

The friction loads caused by unrestricted motion of the piping due to thermal displacements are considered to act on the support with a friction coefficient of 0.3, in the case of steel-to-steel friction. For stainless steel, Teflon, and other materials, the friction coefficient could be less. The friction loads are not considered during seismic or dynamic loading evaluation of pipe support structures.

For the design of piping supports, a deflection limit of 1.6 mm for erection and operation loadings is used, based on WRC-353 paragraph 2.3.2. For the consideration of loads due to SSE and in the cases involving springs, the deflection limit is increased to 3.2 mm.

For frame type supports for directions that are loaded, the total gap is limited to 1/8 inch. In general, this gap is adequate to avoid thermal binding due to radial thermal expansion of the pipe. For large pipes with higher temperatures, this gap will be evaluated to assure that no thermal bending occurs.

The small bore lines (e.g. small branch and instrumentation lines) are supported taking into account the flexibility, and thermal and dynamic motion requirements of the pipe to which they connect. Subsection 3.7.3.16 provides details for the support design and criteria for instrumentation lines 50 mm and less where it is acceptable practice by the regulatory agency to use piping handbook methodology.

The design criteria and dynamic testing requirements for the ASME III piping supports are as follows:

(1) Piping Supports—All piping supports are designed, fabricated, and assembled so that they cannot become disengaged by the movement of the supported pipe or equipment after they have been installed. All piping supports are designed in accordance with the rules of

Subsection NF of the Code up to the building structure interface as defined by the jurisdictional boundaries in Subsection NF.

(2) Spring Hangers—The operating load on spring hangers is the load caused by dead weight. The hangers are calibrated to ensure that they support the operating load at both their hot and cold load settings. Spring hangers provide a specified down travel and up travel in excess of the specified thermal movement.

(3) Snubbers—The operating loads on snubbers are the loads caused by dynamic events (e.g., seismic, RBV due to LOCA, SRV and DPV discharge, discharge through a relief valve line or valve closure) during various operating conditions. Snubbers restrain piping against response to the dynamic excitation and to the associated differential movement of the piping system support anchor points. The criteria for locating snubbers and ensuring adequate load capacity, the structural and mechanical performance parameters used for snubbers and the installation and inspection considerations for the snubbers are as follows:

a. Required Load Capacity and Snubber Location

The loads calculated in the piping dynamic analysis, described in Subsection 3.7.3.8, cannot exceed the snubber load capacity for design, normal, upset, emergency and faulted conditions.

Snubbers are generally used in situations where dynamic support is required because thermal growth of the piping prohibits the use of rigid supports. The snubber locations and support directions are first decided by estimation so that the stresses in the piping system have acceptable values. The snubber locations and support directions are refined by performing the dynamic analysis of the piping and support system as described above in order that the piping stresses and support loads meet the Code requirements.

The pipe support design specification requires that snubbers be provided with position indicators to identify the rod position. This indicator facilitates the checking of hot and cold settings of the snubber, as specified in the installation manual, during plant preoperational and startup testing.

b. Inspection, Testing, Repair and/or Replacement of Snubbers

The pipe support design specification requires that the snubber supplier prepare an installation instruction manual. This manual is required to contain complete instructions for the testing, maintenance, and repair of the snubber. It also contains inspection points and the period of inspection.

The pipe support design specification requires that hydraulic snubbers be equipped with a fluid level indicator so that the level of fluid in the snubber can be ascertained easily.

The spring constant achieved by the snubber supplier for a given load capacity snubber is compared against the spring constant used in the piping system model. If the spring constants are the same, then the snubber location and support direction become confirmed. If the spring constants are not in agreement, they are brought in agreement, and the system analysis is redone to confirm the snubber loads. This iteration is continued until all snubber load capacities and spring constants are reconciled.

A thermal motion monitoring program is established for verification of snubber movement, adequate clearance and gaps, including motion measurements and acceptance criteria to assure compliance with ASME Section III Subsection NF.

c. Snubber Design and Testing

To assure that the required structural and mechanical performance characteristics and product quality are achieved, the following requirements for design and testing are imposed by the design specification:

(i) The snubbers are required by the pipe support design specification to be designed in accordance with the rules and regulations of the ~~Code, Subsection NF. This design requirement includes analysis for the normal, upset, emergency, and faulted loads. These calculated loads are then compared against the allowable loads to make sure that the stresses are below the code allowable limit.~~ ASME Section III Code, Subsection NF and shall consider the following:

– - Design requirement includes analysis for normal, upset, emergency and faulted loads. Calculated loads are then compared against allowable loads as established by snubber vendor.

– - Swing angle, as supplied by the snubber vendor, are incorporated into the design. Pipe movements in the horizontal and vertical direction are taken into account to prevent end bracket/paddle plate binding.

– - Snubber stiffness, as supplied by the snubber vendor, is included in the piping analysis. Other support components such as the pipe clamp/extension piece/transition tube and structural auxiliary steel stiffness values are incorporated into the final determination of the stiffness value used in the analysis.

In multiple snubber applications where mismatch of end fitting clearance and lost motion could possibly exist, the synchronism of activation level or release rate will be evaluated, if deemed necessary, in the piping analysis model when this application could be considered critical to the functionality of the system, such as a multiple snubber application located near rotating equipment. Equal load sharing of multiple snubber supports will not be assumed if a mismatch in end fitting clearances exists and will be evaluated as a part of this assessment.

(ii) A list of snubbers on systems which experience sufficient thermal movement to measure cold to hot position will be provided as part of the testing program after the piping analysis has been completed.

(iii) The snubbers are tested to ensure that they can perform as required during the seismic and other RBV events, and under anticipated operational transient loads or other mechanical loads associated with the design requirements for the plant. Production and qualification test programs for both hydraulic and mechanical snubbers are carried out by the snubber vendors in accordance with the snubber installation instruction manual required to be furnished by the snubber supplier. Acceptance criteria to assure compliance with ASME Section III Subsection NF are cited in this manual, and applicable codes and standards are referenced. The following test requirements are included:

- Snubbers are subjected to force or displacement versus time loading at frequencies within the range of significant modes of the piping system.
- Dynamic cyclic load tests are conducted for hydraulic snubbers to determine the operational characteristics of the snubber control valve.
- Displacements are measured to determine the performance characteristics specified.
- Tests are conducted at various temperatures to ensure operability over the specified range.
- Peak test loads in both tension and compression are required to be equal to or higher than the rated load requirements.
- The snubbers are tested for various abnormal environmental conditions. Upon completion of the abnormal environmental transient test, the snubber is tested dynamically at a frequency within a specified frequency range. The snubber must operate normally during the dynamic test.

(iv) All safety related components which utilize snubbers in their support systems will be identified and inserted into the FSAR in table format and will include the following:

- identification of systems and components
- number of snubbers utilized in each system and on that component
- snubber type (s) – (hydraulic or mechanical) – and name of supplier
- constructed to ASME Code Section III, Subsection NF or other
- snubber use such as shock, vibration, or dual purpose
- those snubbers identified as dual purpose or vibration arrestor type, will include an indication if both snubber and component were evaluated for fatigue strength

d. Snubber Installation Requirements

An installation instruction manual is required by the pipe support design specification. This manual is required to contain instructions for storage, handling, erection, and adjustments (if necessary) of snubbers. Each snubber has an installation location drawing that contains the installation location of the snubber on the pipe and structure, the hot and cold settings, and additional information needed to install the particular snubber.

e. Snubber ~~Pre-service~~Preservice and Inservice Examination and Testing

The pre-service examination plan of all snubbers covered by the plant-specific Technical Specifications is prepared in accordance with the requirements of the ASME Code for Operation and Maintenance of Nuclear Power Plants (OM Code), Subsection

ISTD, and the additional requirements of this Section. This examination is made after snubber installation but not more than 6 months prior to initial system pre-operational testing. The pre-service examination verifies the following:

(i) There are no visible signs of damage or impaired operability as a result of storage, handling, or installation.

(ii) The snubber location, orientation, position setting, and configuration (attachments, extensions, etc.) are according to design drawings and specifications.

(iii) Snubbers are not seized, frozen or jammed.

(iv) Adequate swing clearance is provided to allow snubber movements.

(v) If applicable, fluid is to the recommended level and is not to be leaking from the snubber system.

(vi) Structural connections such as pins, fasteners and other connecting hardware such as lock nuts, tabs, wire, cotter pins are installed correctly.

If the period between the initial pre-service examination and initial system pre-operational tests exceeds 6 months, reexamination of Items i, iv, and v is performed. Snubbers, which are installed incorrectly or otherwise fail to meet the above requirements, are repaired or replaced and re-examined in accordance with the above criteria.

The inservice examination and testing plan of all snubbers covered by the plant-specific Technical Specifications is prepared in accordance with the requirements of the ASME OM Code, Subsection ISTD. Snubber maintenance, repairs, replacements and modifications are performed in accordance with the requirements of the ASME OM Code, Subsection ISTD. Details of the inservice examination and testing program, including test schedules and frequencies, are reported in the inservice inspection and testing plan, which shall be provided by the COL holder referencing the ESBWR design.

f. Snubber audit support data

To ensure that the plant-specific snubber programs will be readily available for a site audit, the plant-specific design specification provided by the COL holder will include the following specific snubber information:

(i) the general functional requirement,

(ii) operating environment,

(iii) applicable codes and standards,

(iv) materials of construction and standards for hydraulic fluids and lubricants,

(v) environmental, structural, and performance design verification tests,

(vi) production unit functional verification tests and certification,

(vii) packaging, shipping, handling, and storage requirements, and

(viii) description of provisions for attachments and installation.

(ix) quality assurance and assembly quality control procedures for review and acceptance by the purchaser.

(4) Struts — Struts are defined as ASME Section III, Subsection NF, Component Standard Supports. They consist of rigid rods pinned to a pipe clamp or lug at the pipe and pinned to a clevis attached to the building structure or supplemental steel at the other end. Struts, including the rod, clamps, clevises, and pins, are designed in accordance with the Code, Subsection NF-3000.

Struts are passive supports, requiring little maintenance and in-service inspection, and are normally used instead of snubbers where dynamic supports are required and the movement of the pipe due to thermal expansion and/or anchor motions is small. Struts are not used at locations where restraint of pipe movement to thermal expansion significantly increases the secondary piping stress ranges or equipment nozzle loads.

Because of the pinned connections at the pipe and structure, struts carry axial loads only. The design loads on struts may include those loads caused by thermal expansion, dead weight, and the inertia and anchor motion effects of all dynamic loads. As in the case of other supports, the forces on struts are obtained from an analysis, and are confirmed not to exceed the design loads for various operating conditions.

(5) Frame Type (Linear) Pipe Supports — Frame type pipe supports are linear supports as defined as ASME Section III, Subsection NF, Component Standard Supports. They consist of frames constructed of structural steel elements that are not attached to the pipe. They act as guides to allow axial and rotational movement of the pipe but act as rigid restraints to lateral movement in either one or two directions. Frame type pipe supports are designed in accordance with the Code, Subsection NF-3000.

Frame type pipe supports are passive supports, requiring little maintenance and in-service inspection, and are normally used instead of struts when they are more economical or where environmental conditions are not suitable for the ball bushings at the pinned connections of struts. Similar to struts, frame type supports are not used at locations where restraint of pipe movement to thermal expansion significantly increases the secondary piping stress ranges or equipment nozzle loads.

The design loads on frame type pipe supports include those loads caused by thermal expansion, dead weight, and the inertia and anchor motion effects of all dynamic loads. As in the case of other supports, the forces on frame type supports are obtained from an analysis, which are assured not to exceed the design loads for various operating conditions.

Any hot or cold gaps required by the qualifying pipe stress analysis results are incorporated in the design. Where friction between the pipe and frame support occurs as a result of sliding, an appropriate coefficient of friction will be used in order to calculate friction loading on the support. Seismic inertia loads as well as static seismic loads are considered in the design of frame supports covered by ASME Section III Subsection NF.

For insulated pipes, special pipe guides with one or two way restraint (two or four trunnions welded to a pipe clamp) may be used in order to minimize the heat loss of piping systems. For small bore pipe guides, it could be acceptable to cut the insulation around the support frame, although this must be indicated in the support specification.

(6) Special Engineered Pipe Supports — In an effort to minimize the use and application of snubbers there may be instances where special engineered pipe supports are used where either struts or frame-type supports cannot be applied. Examples of special engineered supports are Energy Absorbers, and Limit Stops.

Limit Stops — are passive seismic pipe support devices consisting of limit stops with gaps sized to allow for thermal expansion while preventing large seismic displacements. Limit stops are linear supports as defined as ASME Section III, Subsection NF, and are designed in accordance with the Code, Subsection NF-3000. They consist of box frames constructed of structural steel elements that are not attached to the pipe. The box frames allow free movement in the axial direction but limit large displacements in the lateral direction.

Subsection 3.7.3.3.3 provides the analytical requirements for special engineered pipe supports.

3.9.3.7.2 Reactor Pressure Vessel Sliding Supports

The ESBWR RPV sliding supports are sliding supports as defined by section NF-3124 of the Code and are designed as an ASME Code Class 1 component support per the requirements of the Code, Subsection NF. The loading conditions and stress criteria are given in Tables 3.9-1 and 3.9-2, and the calculated stresses shall meet the Code allowable stresses at all locations for various plant operating conditions. The stress level margins assure the adequacy of the RPV sliding supports.

3.9.3.7.3 Reactor Pressure Vessel Stabilizer

The RPV stabilizer is designed as a safety-related linear type component support in accordance with the requirements of ASME Boiler and Pressure Vessel Code Section III, Subsection NF. The stabilizer provides a reaction point near the upper end of the RPV to resist horizontal loads caused by effects such as earthquake, pipe rupture, and RBV. The design loading conditions and stress criteria are given in Table 3.9-2, and the calculated stresses meet the Code allowable stresses in the critical support areas for various plant operating conditions.

3.9.3.7.4 Floor-Mounted Major Equipment

Because the major active valves are supported by piping and not tied to building structures, valve "supports" do not exist (Subsection 3.9.3.7).

The PCC and IC heat exchangers are analyzed to verify the adequacy of their support structure under various plant operating conditions. In all cases, the load stresses in the critical support areas are within ASME Code allowables.

3.9.3.8 Other ASME III Component Supports

The ASME III component supports and their attachments (other than those discussed in the preceding subsection) are designed in accordance with Subsection NF of the Code up to the interface with the building structure. The building structure component supports are designed in