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Subject: **Response to Portion of NRC Request for Additional Information Letter No. 67 Related to ESBWR Design Certification Application – Steam Separator Skirt – RAI Number 3.9-56**

Enclosure 1 contains GEH's response to the subject NRC RAI 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

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NRO

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 07-426 – Response to Portion of NRC Request for Additional Information Letter No. 67 Related to ESBWR Design Certification Application – Steam Separator Skirt – RAI Number 3.9-56

cc:	AE Cubbage	USNRC (with enclosures)
	DH Hinds	GEH (with enclosures)
	RE Brown	GEH (w/o enclosures)
	eDRF	0000-0064-1894/1

Enclosure 1

MFN 07-426

Response to Portion of NRC Request for

Additional Information Letter No. 67

Related to ESBWR Design Certification Application

Steam Separator Skirt – RAI Number 3.9-56

NRC RAI 3.9-56

It is stated in DCD Tier 2, Section 3.9.2.3 that it can be shown that the excitation frequency of the steam separator skirt is very different from the natural frequency of the skirt. No additional rationale or analysis has been provided to demonstrate the validity of this statement. Provide the analysis or test data to show that the excitation frequency of the steam separator skirt is substantially different from the natural frequency of the skirt.

GE Response

The dynamic loads caused by flow-induced vibration of the steam separators had been determined using a full-scale separator test under reactor conditions. During the test, the flow rate through the steam separator was 499,000 lbm/hr at 7% quality. This is higher than the ESBWR maximum separator flow of 222,000 lbm/hr at rated power. Test results show a maximum flow induced vibration stress less than 7200 psi, well below the GE acceptance criteria of 10,000 psi. Thus it can be concluded that separator flow induced vibration effects are acceptable. Jet impingement from feedwater flow has no significant effect on the steam separator assembly since the separator skirt is above the feedwater flow impingement area.

DCD Impact

DCD Tier 2, Rev. 2, Subsection 3.9.2.3 was initially revised, and Rev. 4 will complete the revision as noted in the attached markup.

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.

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. The vibration forcing functions for operational flow transients and steady state conditions are determined by first postulating the source of the forcing function, such as forces due to flow turbulence, symmetric and asymmetric vortex shedding, pressure waves from steady state and transient operations. Based on these postulates, prior startup and other test data from similar or identical components are examined for the evidence of the existence of such forcing functions. 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. Based on these examinations, the magnitudes of the forcing functions and/or response amplitudes are derived. These magnitudes are then used to calculate the expected ESBWR responses for each component of interest during steady state and transient conditions. 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.
- Data from previous plant vibration measurements are assembled and examined to identify predominant vibration response modes of major components. In general, response modes are similar but response amplitudes vary among BWRs of differing size and design.

- Parameters are identified which are expected to influence vibration response amplitudes among the several reference plants. These include hydraulic parameters such as velocity and steam flow rates and structural parameters such as natural frequency and significant dimensions.
- Correlation functions of the variable parameters are developed which, multiplied by response amplitudes, tend to minimize the statistical variability between plants. A correlation function is obtained for each major component and response mode.
- Predicted vibration amplitudes for components of the prototype plant are obtained from these correlation functions based on applicable values of the parameters for the prototype plant. The predicted amplitude for each dominant response mode is stated in terms of a range, taking into account the degree of statistical variability in each of the correlations. The predicted mode and frequency are obtained from the dynamic modal analyses.

The dynamic modal analysis forms the basis for interpretation of the initial startup test results (Subsection 3.9.2.4). Modal stresses are calculated and relationships are obtained between sensor response amplitudes and peak component stresses for each of the lower normal modes.

Details of the special signal analyses of the vibration sensors are given below:

The test data from sensors (accelerometers, strain gages, and pressure sensors) installed on reactor internal components are first analyzed through signal processing equipment to determine the spectral characteristics of these signals. The spectral peak magnitudes and the frequencies at the spectral peaks are then determined. These spectral peak frequencies are then classified as natural frequencies or forced frequencies. If a spectral peak is classified as being from a natural frequency, its amplitude is then determined using a band-pass filter if deemed necessary. The resultant amplitude is then identified as the modal response at that frequency. This process is used for all frequencies of interest. Thus the modal amplitudes at all frequencies of interest are determined. If a spectral peak is identified are being from a forced frequency, the source (such as a vane passing frequency of a pump) is identified. Again, its magnitude is determined using a band-pass filter if deemed necessary.

The modal amplitudes and the forced response amplitudes are then used to calculate the expected ESBWR amplitudes for the same component. These ESBWR expected amplitudes are determined by calculating the expected changes in the forcing function magnitudes from the test component to the ESBWR component. For example, for flow turbulence excited components, the magnitudes are determined by rationing with the flow velocity squared.

A flow chart of the above process is shown in Figure 3.9-6.

The allowable amplitude in each mode is that which produces a peak stress amplitude of ±68.95 MPa (±10,000 psi). For the steam dryer and its components, a higher allowable peak stress limit is used as explained in the following paragraphs.

Vibratory loads are continuously applied during normal operation and the stresses are limited to ±68.95 MPa (±10,000 psi), with the exception of steam dryer, in order to prevent fatigue failure. Prediction of vibration amplitudes, mode shapes, and frequencies of normal reactor operations are based on statistical extrapolation of actual measured results on the same or similar components in reactors now in operation.

Extensive predictive evaluations have been performed for the steam dryer loading and structural evaluation. These evaluations are described in Section 3L.4 of Design Control Document (DCD) Tier 2 Appendix 3L. The fatigue analysis performed for the ESBWR steam dryer will use a fatigue limit stress amplitude of 93.7 MPa (13,600 psi). For the outer hood component, which is subjected to higher pressure loading in the region of the main steam lines, the fatigue limit stress amplitude of 74.4 MPa (10,800 psi). The higher limit is justified because the dryer is a non-safety related component, performs no safety functions, and is only required to maintain its structural integrity (no loose parts generated) for normal, transient and accident conditions.

The dynamic loads caused by flow-induced vibration of the steam separators had been determined using a full-scale separator test under reactor conditions. During the test, the flow rate through the steam separator was 226,000 kg/hr (499,000 lbm/hr) at 7% quality. This is higher than the ESBWR maximum separator flow of 100,700 kg/hr (222,000 lbm/hr) at rated power. Test results show a maximum flow induced vibration stress of less than 48.6 MPa (7200 psi), well below the GE acceptance criteria of 68.9MPa (10,000 psi). Thus it can be concluded that separator flow induced vibration effects are acceptable. Jet impingement from feedwater flow has no significant effect on the steam separator assembly since the separator skirt is above the feedwater flow impingement area. RAI 3.9-56

3.9.2.4 Initial Startup Flow-Induced Vibration Testing of Reactor Internals

Reactor internals vibration measurement and inspection program is conducted only during initial startup testing. This meets the guidelines of Regulatory Guide 1.20 with the exception of those requirements related to preoperational testing which cannot be performed for a natural circulation reactor.

Initial Startup Testing

Vibration measurements are made during reactor startup at conditions up to 100% rated flow and power. Steady state and transient conditions of natural circulation flow operation are evaluated. The primary purpose of this test series is to verify the anticipated effect of single- and two-phase flow on the vibration response of internals.

Vibration sensor types may include strain gauges, displacement sensors (linear variable transformers), and accelerometers.

Accelerometers are provided with double integration signal conditioning to give a displacement output. Sensor locations include the following:

- Steam dryer, bending strain and accelerations;
- Chimney and partitions, lateral displacements and accelerations;
- Chimney head, lateral displacements and accelerations;
- Standby Liquid Control (SLC) internal piping, bending strain, lateral.

In all plant vibration measurements, only the dynamic component of strain or displacement is recorded. Data are recorded and provision is made for selective on-line analysis to verify the overall quality and level of the data. Interpretation of the data requires identification of the dominant vibration modes of each component by the test engineer using frequency, phase, and amplitude information for the component dynamic analyses. Comparison of measured vibration