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Our ref: DCP/NRC2144

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Subject: AP1000 Responses to Requests for Additional Information (SRP3.10)

Westinghouse is submitting responses to the NRC requests for additional information (RAIs) on SRP Section 3.10. These RAI responses are submitted in support of the AP1000 Design Certification Amendment Application (Docket No. 52-006). The information included in the responses is generic and is expected to apply to all COL applications referencing the AP1000 Design Certification and the AP1000 Design Certification Amendment Application.

Responses are provided for RAI-SRP3.10-EMB-01 through -05 and RAI-SRP3.10-EMB-08 and -09, as sent in emails from Mike Miernicki to Sam Adams dated April 16, 2008 and April 30, 2008 respectively. These responses complete seven of nine requests received to date for SRP Section 3.10. Responses to RAI-SRP3.10-EMB-06 and -07 are scheduled to be submitted by June 6, 2008.

Questions or requests for additional information related to the content and preparation of these responses should be directed to Westinghouse. Please send copies of such questions or requests to the prospective applicants for combined licenses referencing the AP1000 Design Certification. A representative for each applicant is included on the cc: list of this letter.

Very truly yours,

Robert Sisk, Manager
Licensing and Customer Interface
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/Enclosure

1. Responses to Requests for Additional Information on SRP Section 3.10

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NRO

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ENCLOSURE 1

Responses to Requests for Additional Information on SRP Section 3.10

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-SRP3.10-EMB-01
Revision: 0

Question:

What is your specific screening process for potential high frequency sensitive mechanical and electrical equipment and components, in addition to what was described in Section 6.4.5 of TR-115? Your description should be at a level of detail such that the staff can understand the basis for screening in or out each piece of equipment and component. Staff expects a list of equipment including the justification for screening in or out. For example, AP1000 DCD Tables 3.2-3 and 3.11-1 could be used to reflect that the equipment was screened out with a justification. For those screened-in equipment/components, provide methods of resolution and/or justifications. For electrical/electronic equipment/components, justify how fasteners, connections, mountings, and interfaces are taken into account. Equipment/components must be qualified to IEEE 344-1987.

Westinghouse Response:

The AP1000 screening process for potential high frequency sensitive equipment is consistent with the guidelines identified in the EPRI White Paper, "Considerations for NPP Equipment and Structures Subjected to Response Levels Caused by High Frequency Ground Motions," transmitted to the NRC on March 16, 2007. The goal of the screening process is to identify those potential safety-related equipment and components which are HRHF-sensitive and show them to be acceptable for their specific application or remove them from use.

Criteria to Determine Need for High Frequency Susceptibility Review

A susceptibility review of AP1000 safety-related equipment will be performed to determine HRHF sensitivity when all of the following factors are met:

1. Plant specific Hard Rock High Frequency (HRHF) Ground Motion Response Spectra (GRMS) exceeds the AP1000 CSDRS in the high frequency range at 5% critical damping.
2. HRHF seismic demand is greater than 2g in the HRHF exceedance region.
3. The safety-related equipment has potential failure modes involving change of state, chatter, signal change/drift, and connection problems.

Table 6.4.5-1 in AP1000 Standard Technical Report TR-115 provides a list of types of equipment which may be potentially vulnerable. Table A-1 of Westinghouse document APP-GW-GLN-144, "AP1000 Design Control Document High Frequency Seismic Tier 1 Changes," dated December 2007 also provides a list of AP1000 safety-related equipment with the potential of being high frequency sensitive or have high frequency sensitive components. This list was developed from Table 3.11-1 of AP1000 Design Control Document (DCD) Rev. 16. None of the AP1000 DCR Table 3.2-3 equipment is considered to be HRHF sensitive. Mechanical and fluid systems components and equipment listed in Table 3.2-3 of the DCD may experience high frequency excitation but this will not impact structural integrity or operability.

A HRHF susceptibility review of AP1000 safety-related equipment will not be performed for potential failure modes associated with mounting, connections and fasteners, joints, and structural interface. These failure modes are addressed through the seismic qualification of the safety-related equipment to the AP1000 In-Structure Response Spectra (ISRS) developed from AP1000 Certified Design Seismic Response Spectra (CSDRS) performed in compliance with IEEE Std 344-1987. The AP1000 ISRS would produce comparable or higher stresses due to larger displacement and velocity requirements of the ISRS seismic demand than the HRHF seismic demand.

HRHF Susceptibility Review

HRHF susceptibility review is to verify that the subject equipment is capable of performing its safety-related function under HRHF seismic demand. All AP1000 safety-related equipment will be qualified to the AP1000 ISRS and dominant natural frequencies of the equipment determined.

From a dynamic perspective HRHF susceptibility is a concern for potential HRHF-sensitive equipment with natural frequencies within the HRHF exceedance region. For HRHF-sensitive equipment with dominant natural frequencies below or above the exceedance region structural integrity is demonstrated by the seismic qualification performed to the AP1000 ISRS to IEEE Std 344-1987 requirements. Structural integrity of the equipment is acceptable because the seismic testing to AP1000 ISRS requirements will produce larger seismic loadings (displacements, velocities and accelerations) than that experienced by the equipment under the HRHF seismic demand. The HRHF seismic demand will not impact dynamic response and structural integrity of the equipment since there are no equipment frequencies in this HRHF exceedance region. From equipment operability perspective, functionality was demonstrated under the AP1000 ISRS loading. The question that needs to be addressed is "Does the test data contain sufficient HRHF excitation content?"

From the HRHF evaluations performed by Westinghouse it is noted that the majority of the seismic test programs performed in recent years had HF content of greater than or equal to 2g at 5% critical damping. This spectral magnitude for a random vibration input lends itself to very low background vibration of test with a peak displacement less than 0.01 inches. It is Westinghouse's position that if the HRHF seismic demand is 2g or less in the HRHF exceedance region then no supplemental HRHF supplemental evaluation is required.

For HRHF evaluation of replacement components the same process would be followed except the HRHF SSE test input would be determined from in-equipment response spectra (IERS) generated from the HRHF test program or a test would be performed at 15g peak spectral acceleration at 5% critical damping in the 25 Hz to 50 Hz frequency range.

The EPRI White Paper identifies the following three evaluation methods to demonstrate that potential HRHF-sensitive safety-related equipment is not HRHF vulnerable.

1. Existing seismic qualification test data for potential high frequency sensitive equipment should be reviewed for applicability and adequacy of the test method to demonstrate sufficient high frequency content.
2. Systems/circuits containing potentially sensitive items should be reviewed for inappropriate/unacceptable system actions due to assumed change of state, contact chatter/intermittency, set point drifts or loss of calibration.
3. HF vibration screening tests should be conducted to identify any HRHF sensitivities/abnormalities of the components. Several conventional test methods are recommended. Component function should be monitored and documented, followed by post-test functional testing.

These three methods are discussed in more detail below.

Method 1: Review of Existing Test Data

The first method can be used for AP1000 HRHF plant applications when previous seismic testing of potential HRHF-sensitive safety-related equipment is qualified for the certified design AP1000 ISRS and the test inputs had sufficient energy content in the HRHF region to verify the safety-related equipment is not vulnerable to HRHF seismic demand. This is shown by reviewing the safe shutdown earthquake (SSE) seismic test data from test programs performed in compliance with IEEE Std 344-1987 and demonstrating that the safety-related functional requirements have been met under the HRHF excitation associated with the mounting location of the equipment. No additional seismic testing is required for safety-related equipment previously tested and whose qualification level envelops the HRHF required response spectra (RRS).

To verify acceptability of previous SSE seismic test data for HRHF seismic content it is necessary to demonstrate there was sufficient acceleration amplitude, time duration and frequency content in the seismic test in the HRHF-exceedance region to verify its acceptability. Methods of demonstrating acceptability are documented in IEEE Std 344-1987. To demonstrate acceptability for frequency content, it is necessary to show that the frequency content of the test waveform is at least as broad as the frequency content of the amplified region of the RRS except at the low-frequency where non-enveloping is permitted under certain conditions (see IEEE Standard 344-1987 sub-clauses 7.6.3.1(10) and 7.6.3.1(13)). Techniques for demonstrating adequate frequency content include:

1. The enveloping of the RRS by the TRS is obtained with similar spectrum shapes so that similar amplifications at significant spectral peaks in the amplified regions of the spectra result.
2. The frequency content of the Fourier transform of the test waveform is compatible with the amplified portion of the RRS
3. The frequency content of the test waveform PSD is compatible with the amplified portion of the RRS.

If this cannot be shown then an additional supplemental screening evaluation (Method 2 or 3) would be required.

Method 2: Review of Equipment Specific System Actions

The second method involves review of circuits containing potentially sensitive items for inappropriate system actions due to assumed change of state, contact chatter/intermittency, set point drifts or loss of calibration can be a viable alternative. For the AP1000 plant application this method is only beneficial for potential HRHF-sensitive safety-related equipment which does not meet the criteria in the first method. This method would require a detailed review of the functional logic of equipment and the safety system to demonstrate that the potential HRHF-sensitive equipment would not perform in a manner causing an inappropriate action or lack thereof leading to a malfunction or inappropriate plant operation for an accident scenario previously considered.

Method 3: HRHF Vibration Screening Tests

The purpose of third method is to perform a supplemental HRHF screening test demonstrating that the potential HRHF-sensitive equipment is acceptable for the application. If determined to not be acceptable then the equipment shall be removed from use. The EPRI White paper identifies different types of vibration testing which can be performed. For the AP1000 application seismic testing as defined in IEEE Std 344-1987 is the preferred HRHF screening method. Seismic testing will be performed when available to the AP1000 HRHF ISRS. When AP1000 plant HRHF spectra are not available, testing will be performed using HRHF response spectra typical of that presented in the EPRI White Paper. These spectra are generated based on the 5g and 15g peak spectral acceleration at 5% critical damping in the 25 Hz to 50 Hz frequency range.

One HRHF SSE seismic test run is performed to demonstrate functionality of the safety-related equipment in its most sensitive electrical operational state. The HRHF SSE seismic test is performed in conjunction with the certified design AP1000 SSE ISRS seismic test (enveloping RRS) or it is a supplemental test performed after completion of the certified design AP1000 ISRS seismic testing.. The HRHF SSE RRS should be considered in a separate test when the potential HRHF-sensitive equipment is determined to have natural frequencies coinciding with the peak spectral acceleration of the HRHF SSE RRS.

Design Control Document (DCD) Revision:

None

PRA Revision:

None

Technical Report (TR) Revision:

None

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-SRP3.10-EMB-02
Revision: 0

Question:

With respect to TR-115 Section 6.4.5, "Screening Process," what is the justification for using the 50 Hz as the cut-off natural frequency for the Group No. 1 equipment in the screening process? Are the electrical/electronic equipment/devices with natural frequencies greater than 50 Hz going to be considered as rugged equipment? Provide justifications for not requiring additional evaluation for high frequency seismic inputs.

Westinghouse Response:

The AP1000 screening process for potential high frequency sensitive equipment is consistent with the guidelines identified in the EPRI White Paper, "Considerations for NPP Equipment and Structures Subjected to Response Levels Caused by High Frequency Ground Motions," transmitted to the NRC on March 16, 2007. This paper established the frequency range of interest for the high frequency screening as 25 Hz to 50 Hz.

For AP1000 the frequency range of interest in the screening process is also 25 Hz to 50 Hz. This range coincides with the peak region of the Hard Rock High Frequency (HRHF) ground motion. Since the AP1000 plant building structures dominant natural frequencies are considerably lower than 50 Hz, the horizontal and vertical ground motion response spectra (GMRS) above 50Hz will not be amplified significantly and their response will dissipate quickly as it travels through the building structure. The worst case seismic loading will occur when the fundamental frequencies of the potential HRHF-sensitive equipment coincide with the peak of the response spectra. In addition it is noted from review of AP1000 HRHF in-structure response spectra (ISRS) generated from the HRHF ground motions that above 50 Hz the zero period acceleration (ZPA) regions of the response spectra are being approached.

Equipment designs with dominant natural frequencies above 50 Hz are inherently rugged. The highly unlikely case of HRHF-sensitive equipment with a natural frequency of 55 Hz is a special class and would require combine screening process Groups No.'s 1 and 3. For this condition, the Group No. 3 process would govern and the equipment would be subjected to a supplemental HRHF seismic evaluation/screening test.

Design Control Document (DCD) Revision:

None

PRA Revision:

None

Technical Report (TR) Revision:

None

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-SRP3.10-EMB-03
Revision: 0

Question:

Why is no additional low level testing (5 OBEs) for high frequency sensitive equipment/components being conducted? Justifications for not doing this testing is required for staff to complete the Safety Evaluation for equipment/components identified as sensitive to high frequency motion that is located in an area with potential for high frequency seismic input motions. OBE testing requirements of IEEE Std 344-1987 and SRP 3.10 must be satisfied. The NRC Commission's Policy and staff's technical positions related to OBE issues are clearly delineated in SECY-93-087.

Westinghouse Response:

The HRHF screening test is not considered to be a qualification test. The HRHF screening test is intended as a supplemental test to the required seismic qualification performed in accordance with IEEE 344.

Fatigue is adequately addressed by OBE (1/2 SSE) testing included as part of the seismic qualification testing in compliance with IEEE Std 344. Additional OBE testing in the 25 Hz to 50 Hz is not necessary since cyclic fatigue is not an issue for the very small displacements associated with the spectral accelerations in this region.

Design Control Document (DCD) Revision:

None

PRA Revision:

None

Technical Report (TR) Revision:

None

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-SRP3.10-EMB/EEB-04
Revision: 0

Question:

Why doesn't Table 6.4.5-1 include such equipment as battery chargers and inverters? Technologies and designs of certain electronic components (relay and microprocessor-based components) have undergone significant changes and new reactor designs will have a more prevalent use of digital components in place of the traditional analog components. This should be taken into account in the screening process. Type testing is a preferred method to demonstrate seismic qualification for those electrical equipment/components determined to be high frequency sensitive.

Westinghouse Response:

Electronic components such as those found in battery chargers, inverters, solid state and microprocessor-based components are currently listed in Table 6.4.5-1, "Potential Sensitive Equipment List."

Design Control Document (DCD) Revision:

None

PRA Revision:

None

Technical Report (TR) Revision:

None

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-SRP3.10-EMB-05
Revision: 0

Question:

What are the justifications for the conclusion addressing use of existing test data in Sections 6.4.1 and 6.4.7 (Summary and Conclusion)? Most of the existing qualification test data were obtained using frequency inputs to the shake table up to 33 Hz. The test response acceleration of 2.0g (zero period acceleration at 5 percent critical damping) shown in the existing test data obtained from the low frequency (less than 33 Hz) seismic tests may not represent the actual response acceleration of the electrical/electronic equipment/components with natural frequencies higher than 33 Hz, when the RRS contains the required frequency input higher than 33 Hz. In order for the existing data to be valid for resolving HF concerns, the adequacy of the time history or the adequacy of the frequency contents and the stationarity of the frequency contents of the synthesized waveform used for the shake table tests must be shown to be compatible with the amplified region of the RRS at high frequencies. IEEE 344-1987 requirements must be met.

Westinghouse Response:

The conclusions reached were based the information presented in Section 6.4.4 (Review of Existing Seismic Test Data). We believe this test data conservatively demonstrates that multiple frequency seismic testing in accordance with IEEE Std 344-1987 requirements to a spectral level of 2.0 g's (at 5% critical damping) in the 25 Hz to 50 Hz frequency range will not impact the structural integrity and functional operability of the equipment where it has been shown to be acceptable through seismic testing up to 33 Hz. The 2.0g level is considered an upper bound base input for functionality of equipment without further testing or evaluation. The test inputs typically included energy content up to 100 Hz.

Power Spectral Density (PSD) and other acceptable evaluation methods as defined IEEE Std 344-1987 are ways of determining energy content within a seismic test run. When available, PSD plots were used to evaluate seismic test data reported in Section 6.4.4 of AP1000 TR-115. For the test data reported, energy content in the 25 Hz to 50 Hz frequency range was demonstrated by meeting at least one of the following criteria:

1. Test report stated that the seismic time history inputs were developed with content in the frequency range up to 50 Hz as a minimum.
2. The test response spectra (TRS) were shown to be amplified in the 25 Hz to 50 Hz frequency and were not caused by impact or test unit rattling.
3. PSD plots indicate energy content in the high frequency region.

Figures 1 through 6 provide examples of test data which demonstrate frequency content in the 25 Hz to 50 Hz range.

TEST REPORT 53753-1 TEST RUN 27
FRONT TO BACK

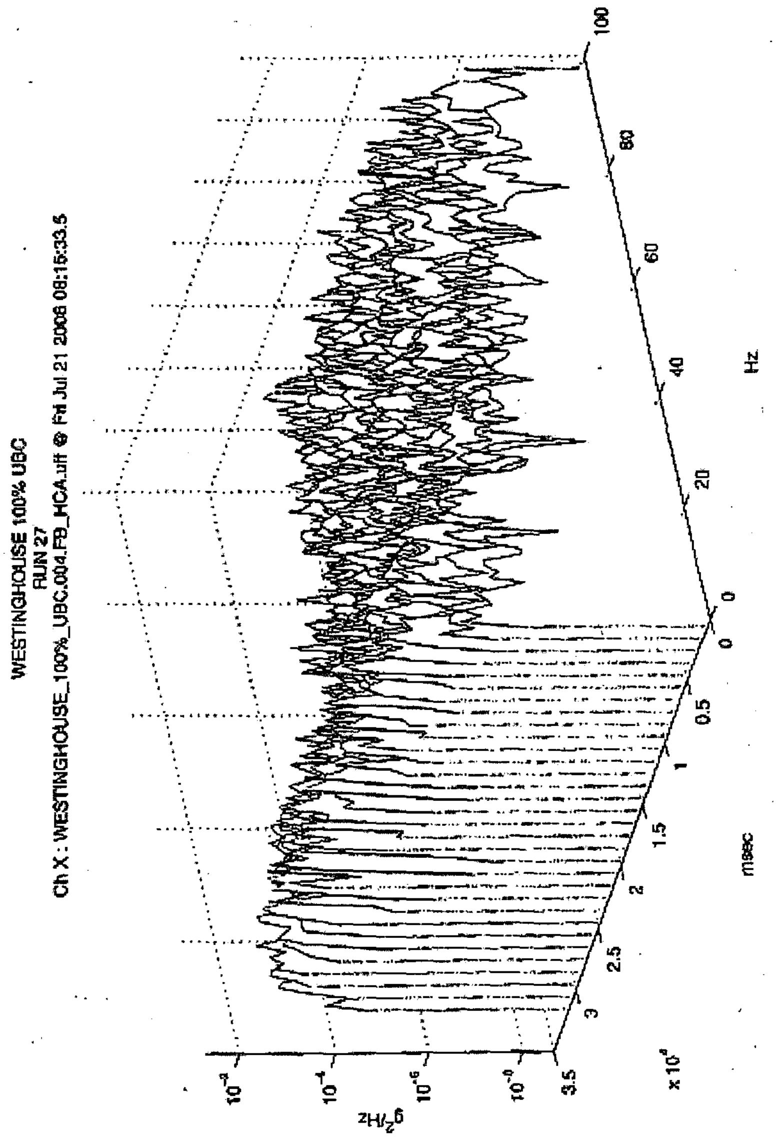

Figure 1

TEST REPORT 53753-1 TEST RUN 27
SIDE TO SIDE

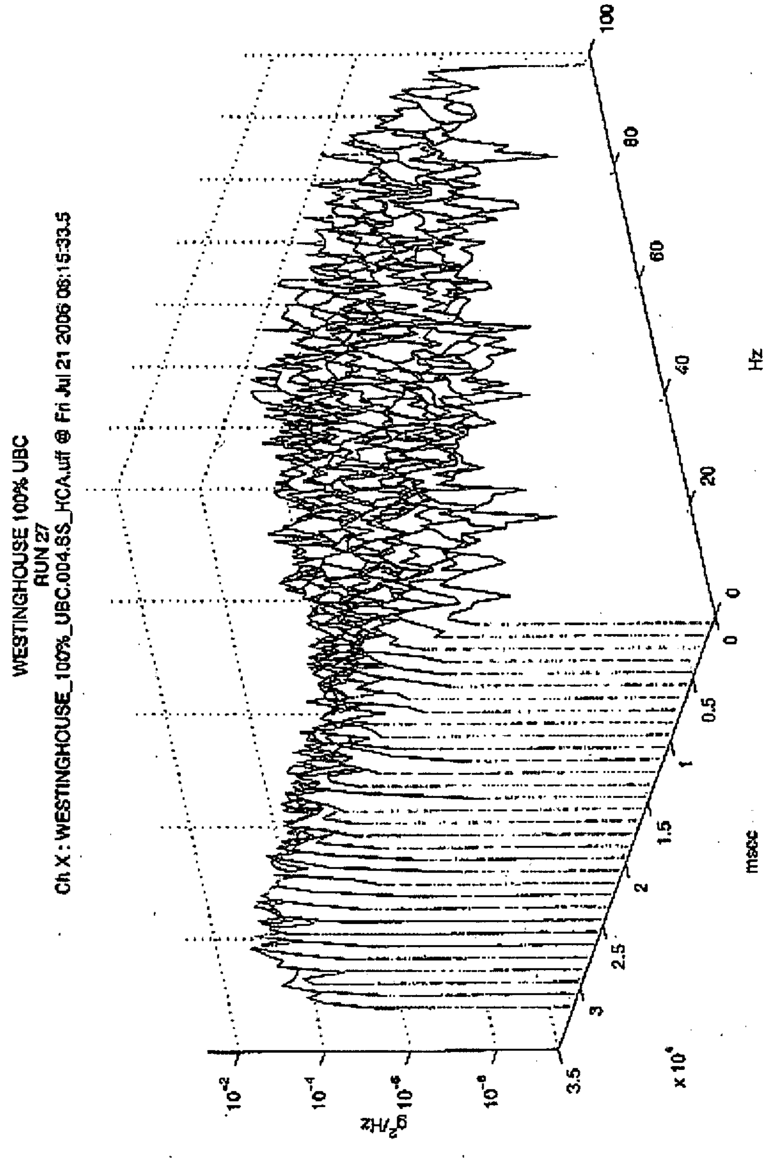

Figure 2

TEST REPORT 53753-1 TEST RUN 27
VERTICAL

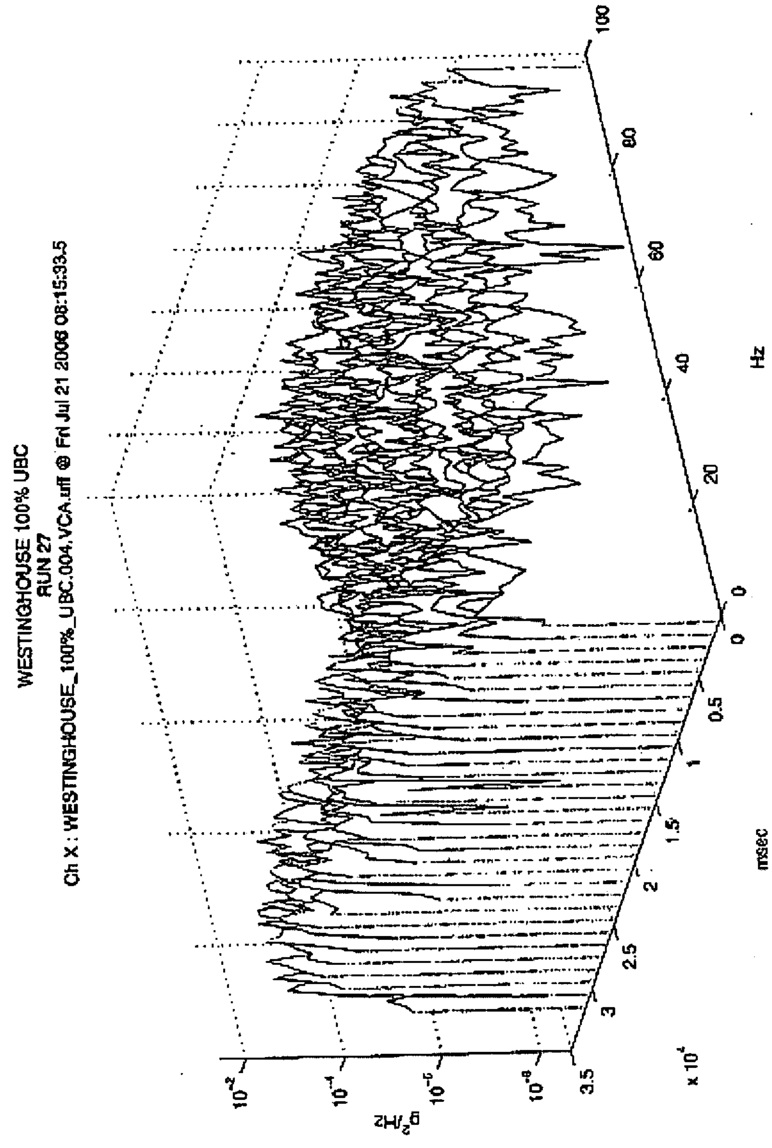

Figure 3

TEST REPORT 6328 TEST RUN SSE 2
FRONT TO BACK

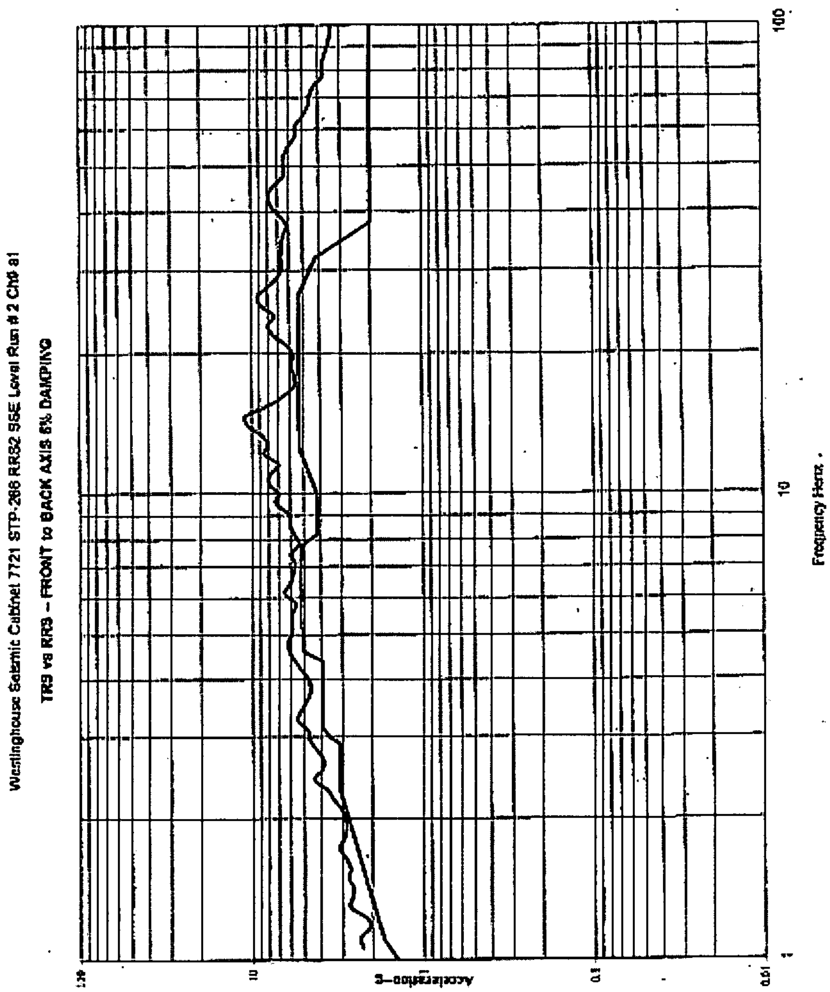

Figure 4

TEST REPORT 6328 TEST RUN SSE 2
SIDE TO SIDE

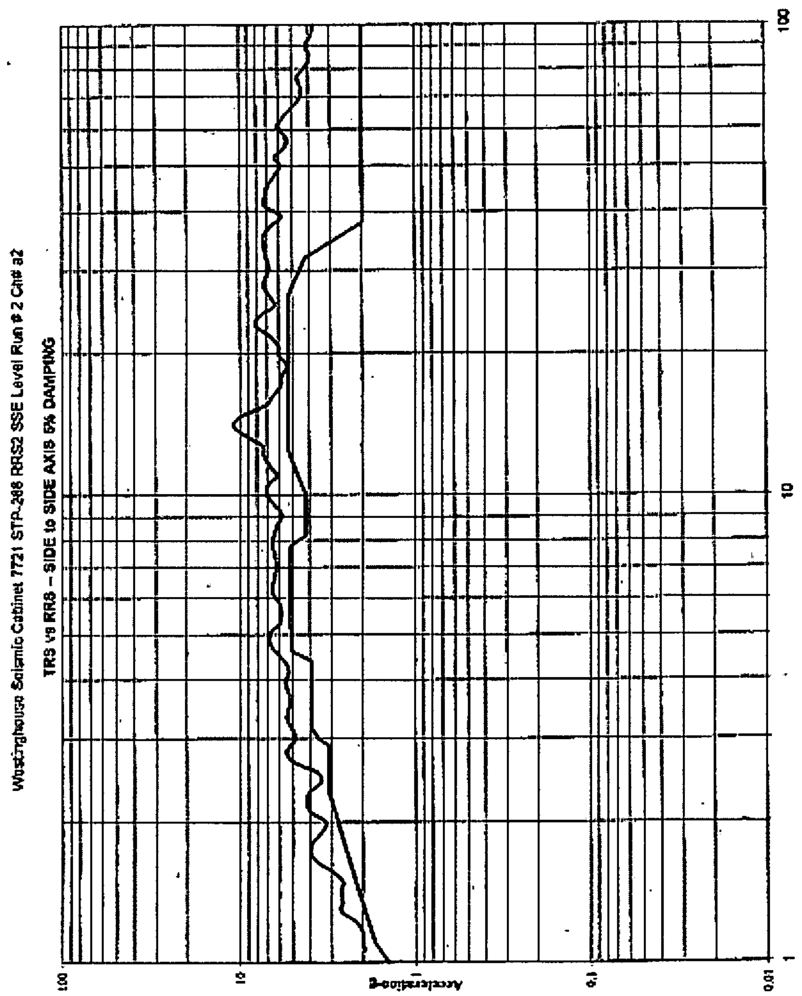

Figure 5

TEST REPORT 6328 TEST RUN SSE 2 VERTICAL

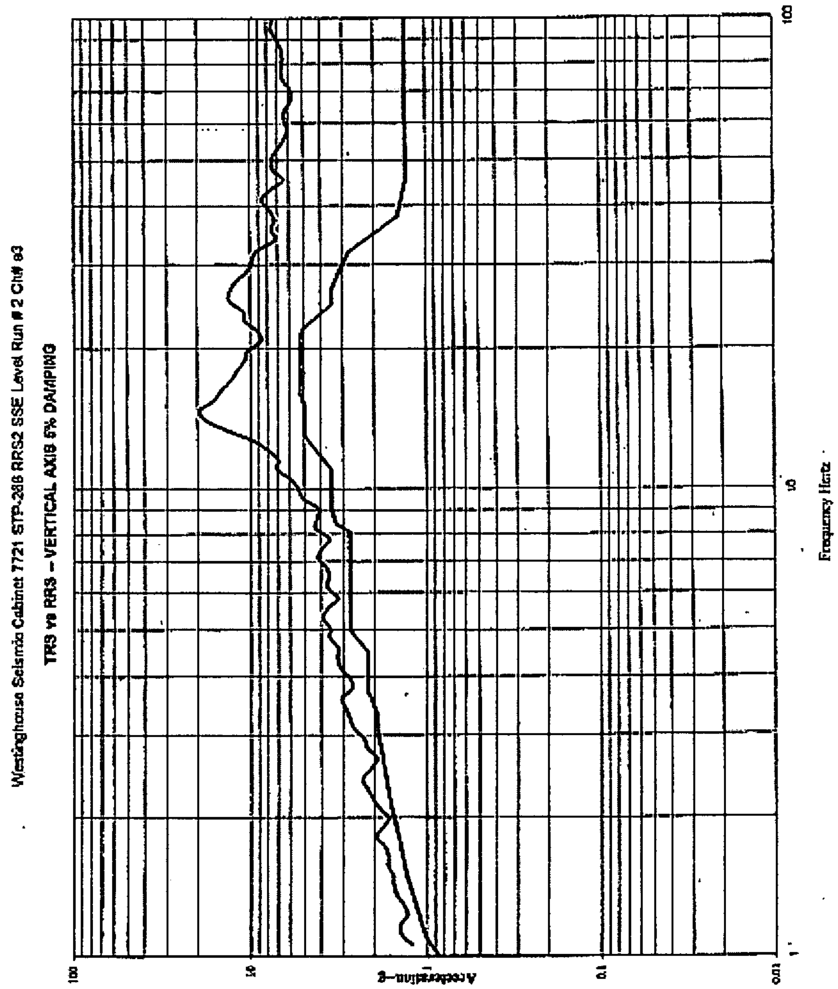

Figure 6

Design Control Document (DCD) Revision:

None

PRA Revision:

None

Technical Report (TR) Revision:

None

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-SRP3.10-EMB-08
Revision: 0

Question:

In Subsection 3.10.2.2, a rigid valve is defined as the valve with natural frequency equaling or exceeding 33 hertz (Hz). The use of Figure 1 (not Figure 6 as stated) of IEEE 382-1996 as the RIM (up to 32 Hz) for qualification of valve is adequate for Certified Seismic Design Response Spectra (CSDRS). However, the definition of rigid valve, the determination of the equivalent static load from the dynamic analysis of the valve, and the use of Figure 1 (not Figure 6 as stated) of IEEE 382-1996 might not be adequate for HRHF required response spectra (RRS) with exceedance. For HRHF spectra, the definition of rigid valve depends on the frequency at the beginning of zero period acceleration (ZPA) of the RRS for the valve. The applicant is requested to explain why the use of Figure 1 (frequency ends at 32 Hz) of IEEE 382-1996 is still adequate for qualification of valves, and provide methodologies that would be acceptable for the case of HRHF RRS with exceedance.

Westinghouse Response:

Please note that Figure 6 of IEEE Std 382-1996 is the "Seismic qualification required input motion (RIM)." Figure 1 of IEEE Std 382-1996 is the "Qualification type test parameters inside BWR..." For AP1000 plant design safety-related equipment will be seismically qualified based on instructure response spectra (ISRS) using the AP1000 Certified Seismic Design Response Spectra (CSDRS). The cutoff frequency (zero period acceleration (ZPA)) for the AP1000 CSDRS is 33Hz based on Regulatory Guide 1.60, Revision 1 entitled "Design Response Spectra for Seismic Design of Nuclear Power Plants."

Westinghouse is performing seismic qualification of safety-related structures, systems and components (SSCs) based on AP1000 CSDRS. It is not our intent to qualify safety-related equipment for Hard Rock High Frequency (HRHF) required response spectra (RRS). The industry review of HRHF and further evaluations of SSCs performed by Westinghouse concluded that evaluations employing HRHF Ground Motion Response Spectra (GMRS) are less harmful than the CSDRS demand except for the functionality of potential HRHF-sensitive components. For potential HRHF-sensitive components an additional evaluation would be performed by Westinghouse using the HF screening process defined in AP1000 Technical Report APP-GW-GLR-115, Revision 0, "Effect of High Frequency Seismic Content on SSCs." The purpose of the HF screening is to demonstrate that the potential HRHF-sensitive equipment is acceptable for the application. In those instances where the seismic qualification of line-mounted equipment (e.g. valve appurtenances) are potential HRHF-sensitive components, seismic testing performed in compliance with IEEE Std 382-1996 Figure 6 RIM curve will be extended out for one additional octave to 64 Hz.

AP1000 DCD Tier 2 document, Section 3.7.3.5.1 defines rigid components such as rigid valves as the following: "A rigid component (fundamental frequency ≥ 33 hertz), whose support can be represented by a flexible spring, can be modelled as a single degree of freedom model in the direction of excitation (horizontal or vertical directions)."

Design Control Document (DCD) Revision:

None

PRA Revision:

None

Technical Report (TR) Revision:

None

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-SRP3.10-EMB-09
Revision: 0

Question:

Discuss the basis for deleting references to dampers in Section 3.10. In several locations in Section 3.10 of AP1000 DCD Revision 16, Westinghouse has replaced the reference to safety-related dampers with a reference to safety-related valves. See, for example, Subsection 3.10.2.2. The reason for this modification is not clear.

Westinghouse Response:

For the AP1000 plant design there are no safety-related dampers. The term "dampers" was used in error. Changes were made in Section 3.10 of AP1000 DCD Revision 16 to correctly identify the subject equipment as safety-related valves.

Design Control Document (DCD) Revision:

None

PRA Revision:

None

Technical Report (TR) Revision:

None