AP1000 DCD SER Open Item REVIEW

Open Item Resolution

OI Response Number: OI-SRP19.0-SPLA-12 Revision: ~~2~~3

Question:

The staff is looking for more information related to Westinghouse's response to RAI-SRP19.0-SPLA-12.

Confirm that an acceptable seismic margin is maintained for HRHF sites.

(Email Chris Procter to Thom Ray, 2/5/09, "Preliminary draft list of Chapter 19 Open Items")

The Staff provided clarifying information in a phone call on October 28th. The action items discussed from that phone call included the following items;

Revise OI-SRP19.0-SPLA-12, R1 to include the following:

a. Description of the seismic margin associated with seismic testing employing a 3% critical damping response spectra and tested/analyzed at 5% critical damping will be provided. Reference will be made to the technical criteria (WCAP or EPRI document) for changes amplification factors as a function of damping and the need for maintaining the peak to zero period acceleration (ZPA) ratio.
b. An illustration will be provided to show the test required response spectra (TRRS) will include 10% margin . The illustration should indicate and clarify that 10% margin is not being "double counted."
c. Illustrations will be provided to show the test response spectra (TRS) used to demonstrate acceptability envelope the TRRS with margin.
d. Provide quantitative plots that are representative of the margins in testing.
e. Describe the testing margin in the DCD.

Further concern issued by NRC on March 30th, 2010 Teleconference:

There is concern from the NRC staff that we are not going to be in full compliance with ISG-20 when it is issued in final form. The NRC has requested that we provide a documented process for how we will ensure that we maintain the 1.4 factor as defined in ISG-20.

Westinghouse Response:

Revision 2 of the Open Item response is a complete re-write of Revision 1 and 0 and replaces both of them. Westinghouse has worked with the industry and the NRC to address the seismic issues related to high frequency ground motion. Westinghouse has participated in public meetings related to the "Interim Staff Guidance on Seismic Issues Associated with High Frequency Ground Motion in Design Certification and Combined License Applications." Recognizing the need to evaluate the high frequency seismic input, Westinghouse introduced

Appendix 3I into the AP1000 Design Control Document. In this appendix the evaluation procedure, screening criteria, and testing requirements are described along with identification of equipment with the potential to be sensitive to high frequency seismic inputs.

Following the methodology given in Appendix 3I, a Technical Report (Reference 1) was prepared and issued to the NRC. The purpose of this report is two fold: (1) to confirm that high frequency seismic input evaluated is not damaging to equipment and structures qualified by analysis for the AP1000 Certified Seismic Design Response Spectra (CSDRS); and (2) to demonstrate that normal design practices result in an AP1000 design that is safer and more conservative than that which would result if designed based on the high frequency input. The results reported in Appendix 3I demonstrate that the structural integrity demands resulting from the Hard Rock High Frequency (HRHF) excitations are enveloped by those resulting from the CSDRS. As a result, the structural integrity seismic margin assessment for the HRHF is bounded by that for the CSDRS, and no further assessment is required.

The seismic margin evaluation for the AP1000 plant is a risk-based analysis performed to demonstrate sufficient margin for those systems structures and components required to bring the plant to a safe shutdown condition when subjected to an earthquake beyond the CSDRS or plant Design Basis safe shutdown earthquake (SSE). This review incorporates an earthquake level of 0.5 g. Seismic margin is the reserve capacity expressed in terms of the earthquake motion level used to assess conditions beyond the CSDRS that could compromise plant safety and could lead to core damage or containment failures. Seismic margin based on 95% confidence of less than a 5% chance of failure is defined as the High Confidence, Low Probability of Failure (HCLPF) capacity of the plant safe shutdown systems relative to the CSDRS expressed in terms of peak ground acceleration. The U.S. NRC has approved a HCLPF capacity equal to 1.67 times the Design Basis SSE ground motion (or CSDRS) acceleration for a seismic margin evaluation (Reference 2). The NRC provided further guidance in the determination of seismic margin for new reactors in the draft interim staff guidance document DC/COL-ISG-020 (Reference 3). Section 5.1 of Reference 3 provides the NRC's guidance on the performance of a PRA-based seismic margin analysis based on design-specific information for a design certification (DC) application.

The goal of the seismic margin evaluation is to demonstrate a minimum seismic margin of 1.67 between the equipment CSDRS or plant level SSE seismic demand and the seismic qualification SSE capacity. Contributors to seismic margin are the margins in industry design rules of standards and requirements for equipment and seismic qualification testing of equipment (e.g. IEEE Std 323, IEEE Std 344), generic enveloping (plants and locations), and design margin over the seismic demand. Seismic qualification testing of equipment is performed based on design and qualification criteria that often take into account generic applications (multiple plant locations and multiple plants) and margins also resulting from over-testing. Seismic testing is performed to demonstrate the equipment will operate and maintain structural integrity under specified seismic conditions associated with the certified seismic design. Equipment failures during seismic testing are usually related to the operability of devices mounted at different locations within the structure. For electrical equipment the failure mechanism is often related to chatter or lost of electrical connection. Because safety-related equipment designs are robust they rarely fail to perform their intended safety function due to a structural failure.

Fragility testing to demonstrate the maximum seismic level at which the equipment will survive is seldom performed. Therefore, the reserve margin in the equipment to survive the beyond the CSDRS or Design Basis SSE seismic demand in most cases is estimated based on test and industry experience. Other potential sources of margin are strength of materials and the effects of changes in equipment damping as the magnitude of the earthquake increases. These seismic margin contributors will be the sources used to produce the seismic capacity level needed to meet or exceed the seismic margin factor of 1.67 for the design basis and plant specific applications. If the equipment seismic qualification capacity falls below 1.67 times the CSDRS or the plant specific SSE, expressed in terms of peak ground acceleration level, then further evaluation needs to be performed. For the AP1000 program, the minimum acceptable HCLPF capacity is 0.5g (1.67 x 0.3g) using the CSDRS and HRHF. The seismic capacity is considered to be the nominal scaled spectral acceleration capacity at 5% critical damping at the as-installed system fundamental frequency of the safety-related equipment times the appropriate margin factors.

As part of the seismic margins evaluation, a systems analysis is performed to identify the principal equipment with the potential to contribute to the risk of core damage frequency caused by an earthquake beyond the Design Basis SSE. The list of safety-related equipment necessary to implement the success path determined through a plant systems evaluation and their seismic response are identified in Table 19.55-1 of AP1000 Design Control Document (DCD) Chapter 19. The AP1000 equipment design process produces robust equipment that reflects substantial margin beyond the Design Basis SSE as demonstrated by the values given in Table 19.55-1. The values given in Table 19.55-1 are being evaluated as part of the revised response to RAI-SRP19.0-SPLA-21 and 22. If any changes to the table are required those updates will be provided in those revised responses.

A High Frequency screening test is performed after completion of seismic qualification testing to demonstrate that potential high frequency sensitive equipment can perform their safety-related function during the HRHF SSE without adversely effecting plant safety. Equipment determined to be high frequency sensitive are screened out and replaced with more robust equipment. The following contributing sources and magnitudes are considered for addressing seismic margin at AP1000 CSDRS and HRHF sites:

- Seismic testing for AP1000 HRHF will employ a 5% critical damping test required response spectra (TRRS) which envelop as a minimum the 3% critical damping AP1000 HRHF in-structure response spectra associated with the mounting location of the equipment. The result will produce a seismic amplification margin of 1.3 over the

AP1000 HRHF in-structure response spectra at 5% critical damping (Refer to Section A.3 of EPRI NP-5223 (Reference 4)).

- Seismic test margin factor of 1.1 required by IEEE Std 323.
- Seismic test margin factor of 1.1 - 1.25 factor for over testing (TRS vs. RRS). Because seismic test margin can vary during a test program a minimum margin values of 1.1 and 1.2 for HRHF and CSDRS SSE testing, respectively should be verified to exist at the time of testing as a minimum.
- The qualification testing is not typically performed as a fragility test and reserve seismic capacity will exist beyond the Design Basis CSDRS and HRHF SSE level. A conservative seismic test margin factor of 1.1 should be used for reserve seismic capacity since fragility testing beyond the Design Basis CSDRS and HRHF SSE is not performed.
- Testing beyond the Design Basis CSDRS SSE level would produce higher damping in the building structure due to the increased stress levels in the structure, which would result in a lower response at the equipment mounting locations. A conservative seismic test margin factor of 1.15 should be used for the higher damping in the building structure cause by testing beyond the Design Basis CSDRS SSE.

Combining the seismic margin contributing factors for Design Basis HRHF sites noted above results in a seismic margin factor in the range of 1.73 to 1.97. An example of using the above seismic margin factors (except for the fifth bullet) is shown in Figures 1 and 2. The above seismic margin contributors (except for the first bullet) are also applicable to demonstrating the seismic capacity level of at least 1.67 for the CSDRS design basis. Therefore, based on the above there is sufficient seismic margin associated with the CSDRS qualification process and the HRHF screening for potential high frequency sensitive equipment to demonstrate compliance with the 1.67 factor recommended in References 2 and 3.

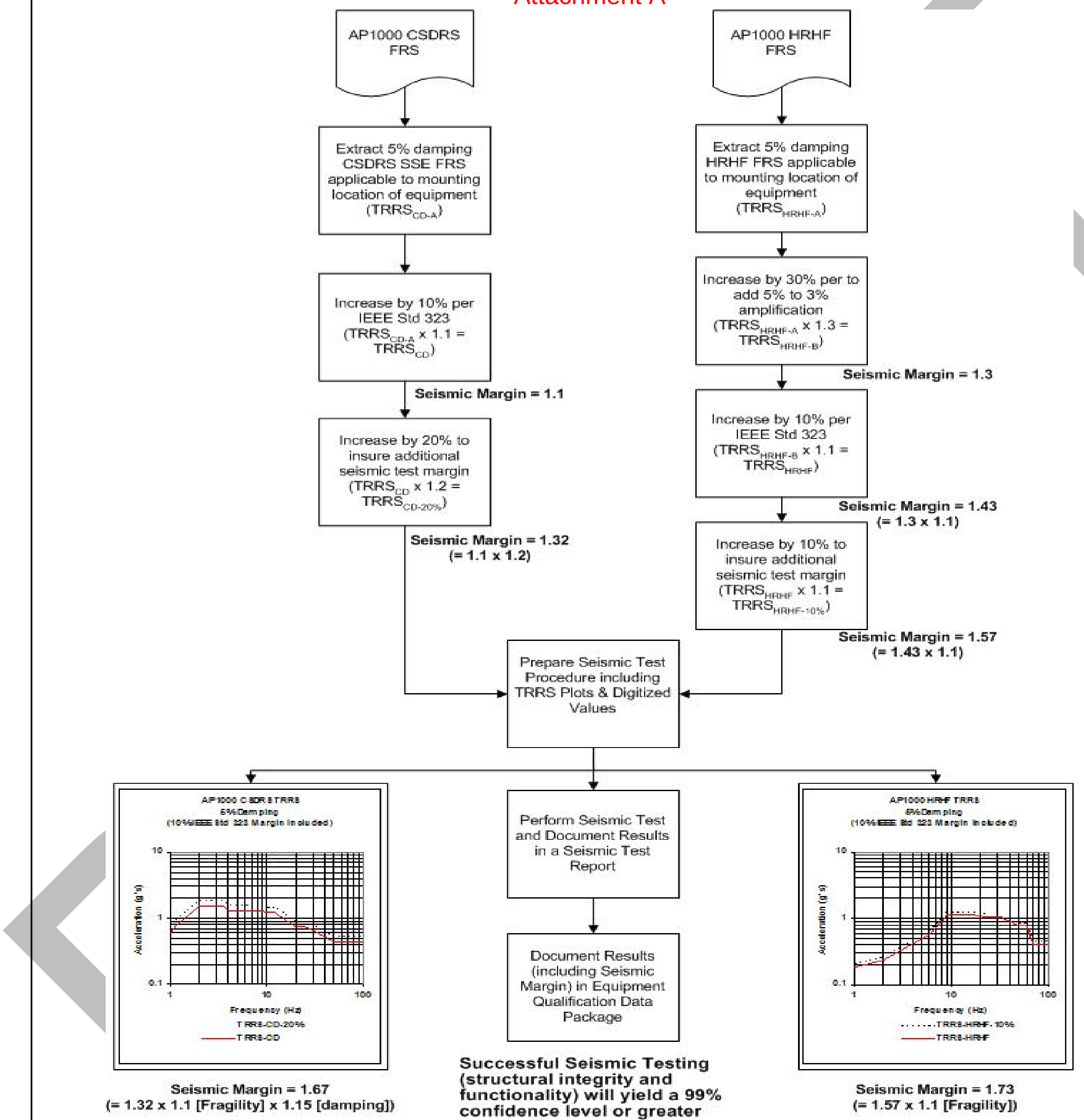
Westinghouse Response (Rev. 3):

Please see attachment A for the requested process for Seismic Margin verification in Seismic Testing. There are no DCD mark-ups specified in this revision but the track changes are being maintained to see what changes have been made to the DCD in Rev. 2.

References:

1. APP-GW-GLR-115, “Effect of High Frequency Seismic Content on SSCs,” Rev.1, October 6, 2008, Westinghouse Electric Company LLC.
2. NRC Policy Issue SECY-93-087, “Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor (ALWR) Designs,” April 2, 1993. [As amended by the Commissioners response letter from the U.S. NRC Office of the Secretary dated July 21, 1993.]
3. NRC Draft Interim Staff Guidance, DC/COL-ISG-20, “Interim Staff Guidance on Implementation of a Probabilistic Risk Assessment Based Seismic Margin Analysis for New Reactors,” October 2009.
4. EPRI NP-5223, “Generic Seismic Ruggedness of Power Plant Equipment,” dated August 1991.

Attachment A



Determination and Documentation of Test Required Response Spectra for AP1000 Equipment Requiring Seismic Margin to meet NRC ISG DC/COL-ISG-020

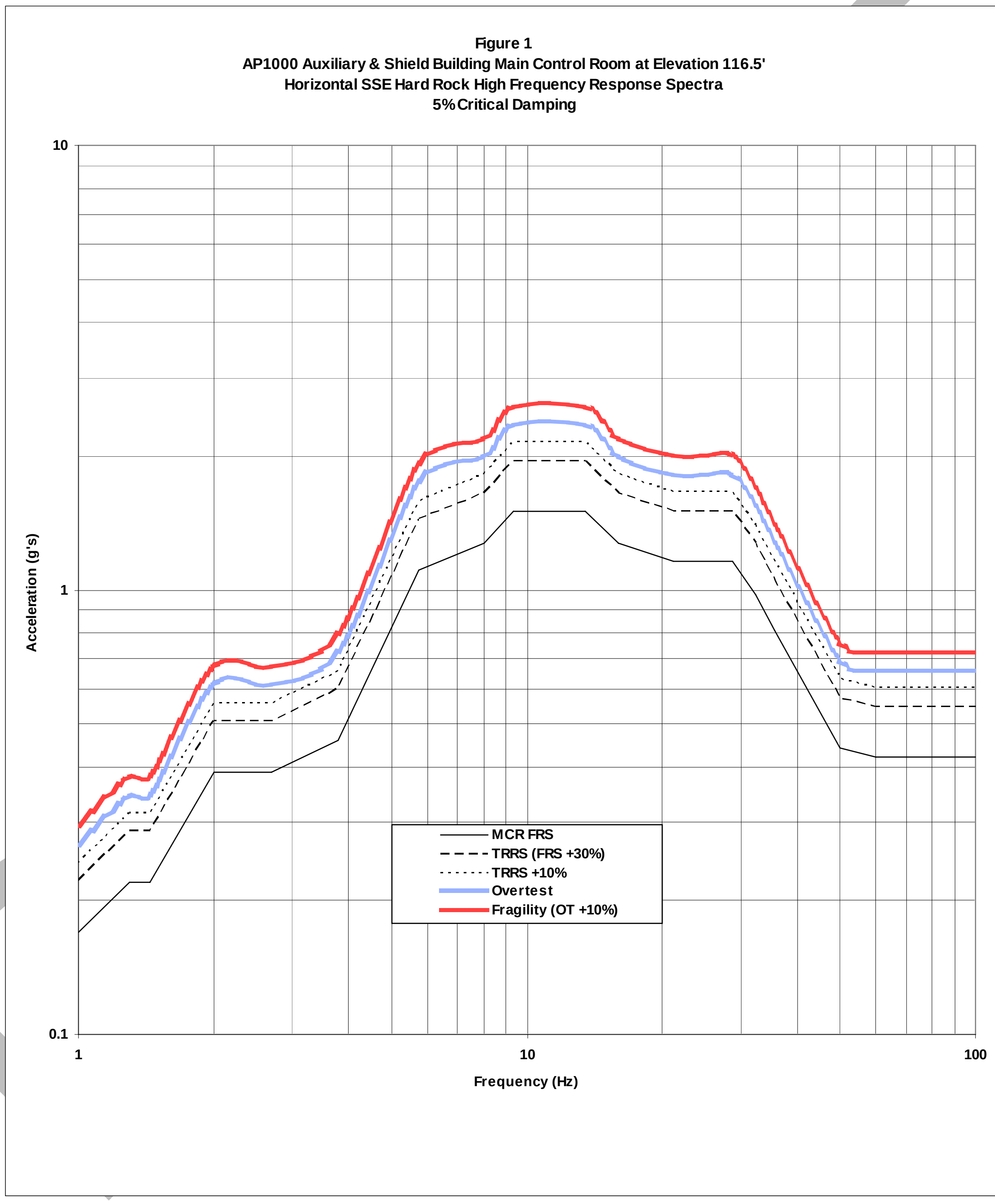


Figure 1
AP1000 Auxiliary & Shield Building Main Control Room at Elevation 116.5'
Horizontal SSE Hard Rock High Frequency Response Spectra
5% Critical Damping
Acceleration (g's)
10
1
0.1
1
10
100
Frequency (Hz)
MCR FRS
TRRS (FRS +30%)
TRRS +10%
Overtest
Fragility (OT +10%)

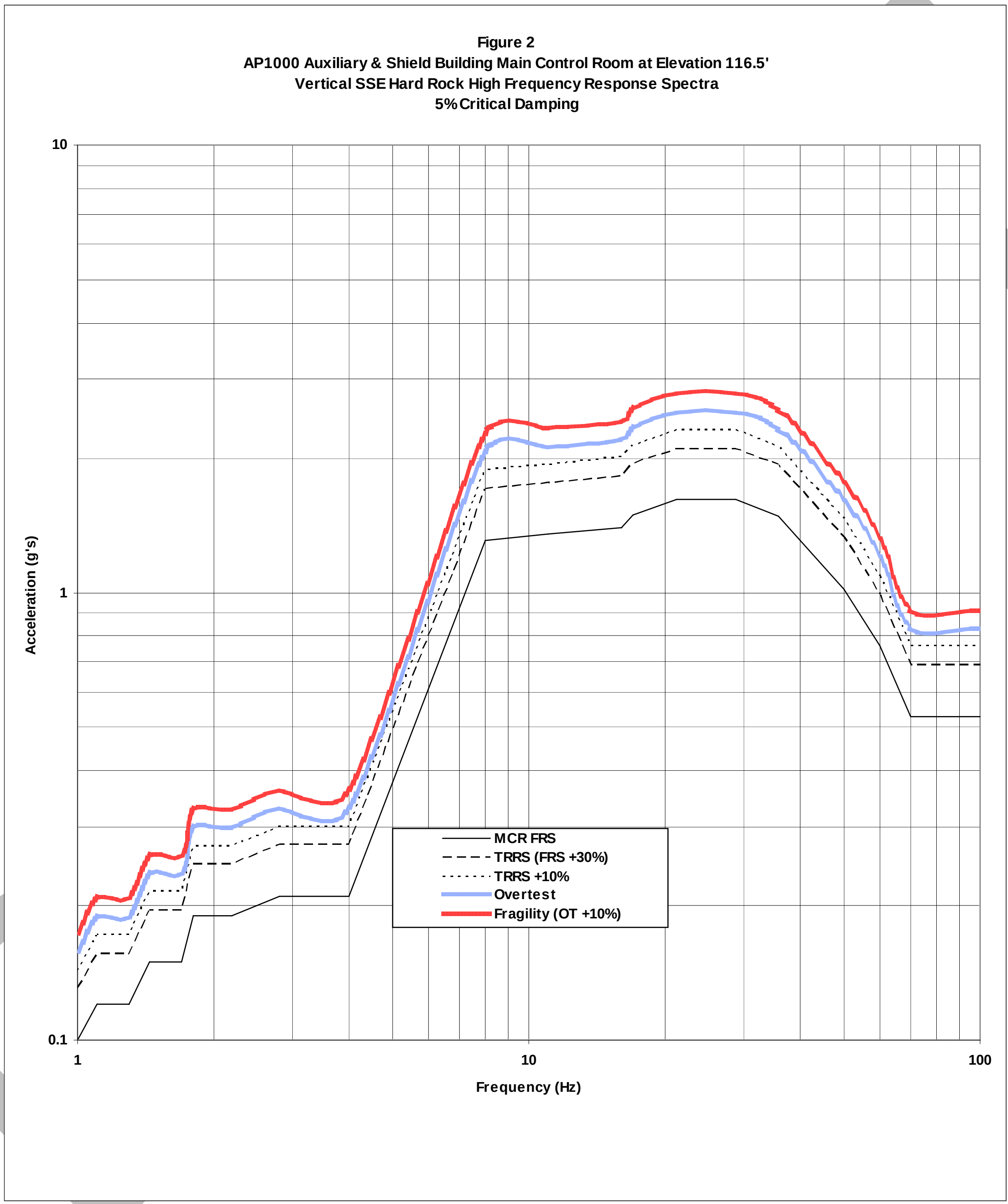


Figure 2
AP1000 Auxiliary & Shield Building Main Control Room at Elevation 116.5'
Vertical SSE Hard Rock High Frequency Response Spectra
5% Critical Damping
Acceleration (g's)
Frequency (Hz)
10
1
0.1
1
10
100
MCR FRS
TRRS (FRS +30%)
TRRS +10%
Overtest
Fragility (OT +10%)

Design Control Document (DCD) Revision:

~~None~~

Add to Section 19.55

19.55.6 Seismic Margin Evaluation

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- Seismic testing for AP1000 HRHF will employ a 5% critical damping test required response spectra (TRRS) which envelop as a minimum the 3% critical damping AP1000 HRHF in-structure response spectra associated with the mounting location of the equipment. The result will produce a seismic amplification margin of 1.3 over the AP1000 HRHF in-structure response spectra at 5% critical damping (Refer to Section A.3 of EPRI NP-5223, Reference 5).

- Seismic test margin factor of 1.1 required by IEEE Std 323.

- Seismic test margin factor of 1.1 - 1.25 factor for over testing (TRS vs. RRS). Because seismic test margin can vary during a test program a minimum margin values of 1.1 and 1.2 for HRHF and CSDRS SSE testing, respectively should be verified to exist at the time of testing as a minimum.

- The qualification testing is not typically performed as a fragility test and reserve seismic capacity will exist beyond the Design Basis CSDRS and HRHF SSE level. A conservative seismic test margin factor of 1.1 should be used for reserve seismic capacity since fragility testing beyond the Design Basis CSDRS and HRHF SSE is not performed.

- Testing beyond the Design Basis CSDRS SSE level would produce higher damping in the building structure due to the increased stress levels in the structure, which would result in a lower response at the equipment mounting locations. A conservative seismic test margin factor of 1.15 should be used for the higher damping in the building structure cause by testing beyond the Design Basis CSDRS SSE.

Combining the seismic margin contributing factors for the Design Basis HRHF sites noted above results in a seismic margin factor in the range of 1.73 to 1.97. An example of using the above seismic margin factors (except for the fifth bullet) is shown in Figures 19.55-1 and 19.55-2. The above seismic margin contributors (except for the first bullet) are also applicable to demonstrating the seismic capacity level of at least 1.67 for the CSDRS design basis. Therefore, based on the above we believe there is sufficient seismic margin associated with the CSDRS qualification process and the HRHF screening for potential high frequency sensitive equipment to demonstrate compliance with the 1.67 factor recommended in References 3 and 4.

19.55.7 Results and Insights

The AP1000 seismic margin analysis has demonstrated that for structures, systems, and components required for safe shutdown, the high confidence of low probability of failures magnitudes are equal to or greater than the review level earthquake.

19.55.8 References

1. "SECY-93-087-Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor (ALWR) Designs," USNRC Memorandum, July 21, 1993, Chilk to Taylor

2. APP-GW-GLR-115, "Effect of High Frequency Seismic Content on SSCs," Rev. 1, October 6, 2008, Westinghouse Electric Company LLC.

3. NRC Policy Issue SECY-93-087, "Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor (ALWR) Designs," April 2, 1993. [As amended by the Commissioners response letter from the U.S. NRC Office of the Secretary dated July 21, 1993.]

4. NRC Draft Interim Staff Guidance, DC/COL-ISG-20, "Interim Staff Guidance on Implementation of a Probabilistic Risk Assessment Based Seismic Margin Analysis for New Reactors," October 2009.

5. EPRI NP-5223, "Generic Seismic Ruggedness of Power Plant Equipment," dated August 1991.

TABLES 19.55-2 THROUGH 19.55-7 ARE NOT USED.

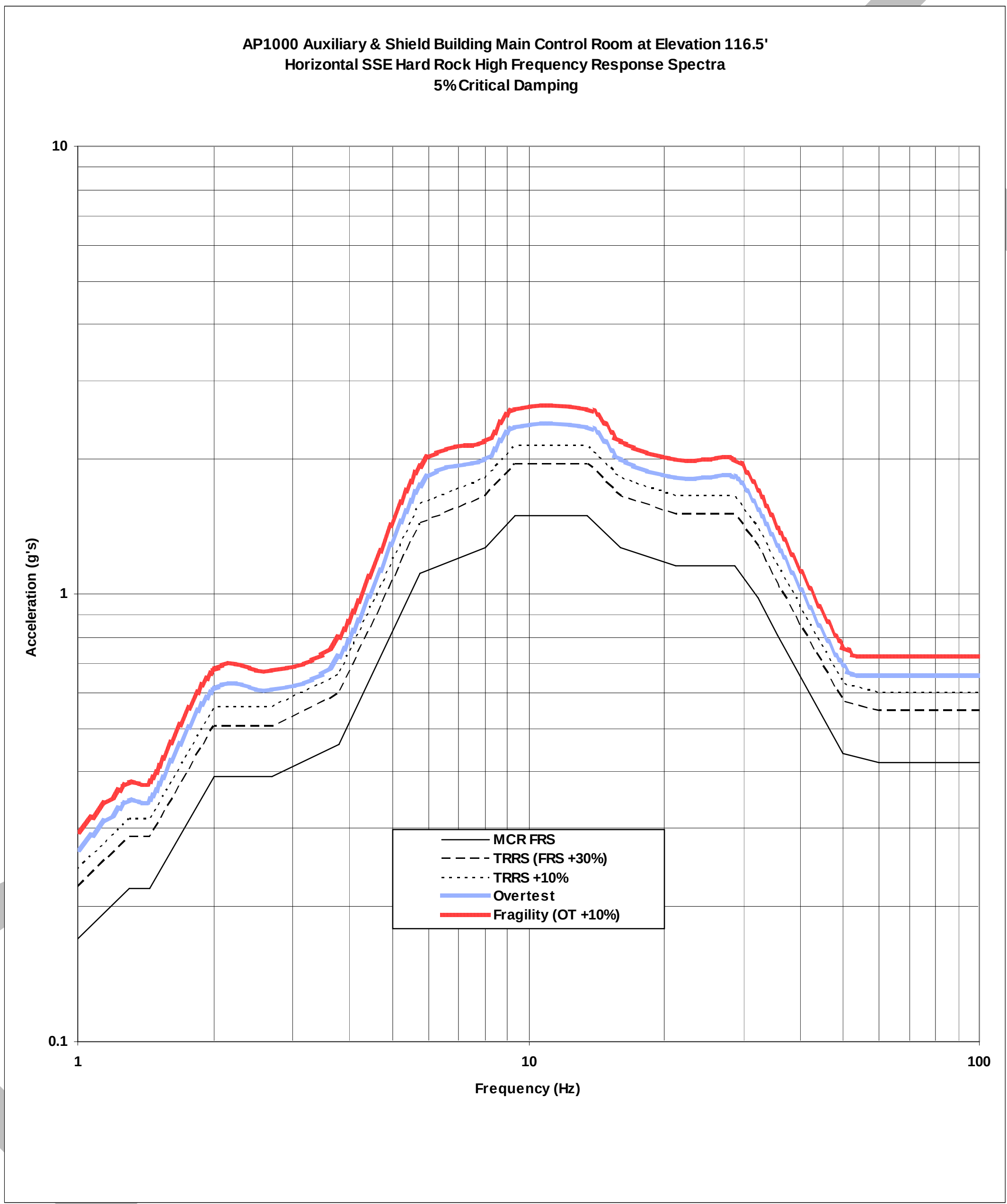

Figure 19.55-1
Seismic Margin Horizontal Direction AP1000 HRHF Response Spectra
Auxiliary & Shield Building Main Control Room at Elev. 116.5'

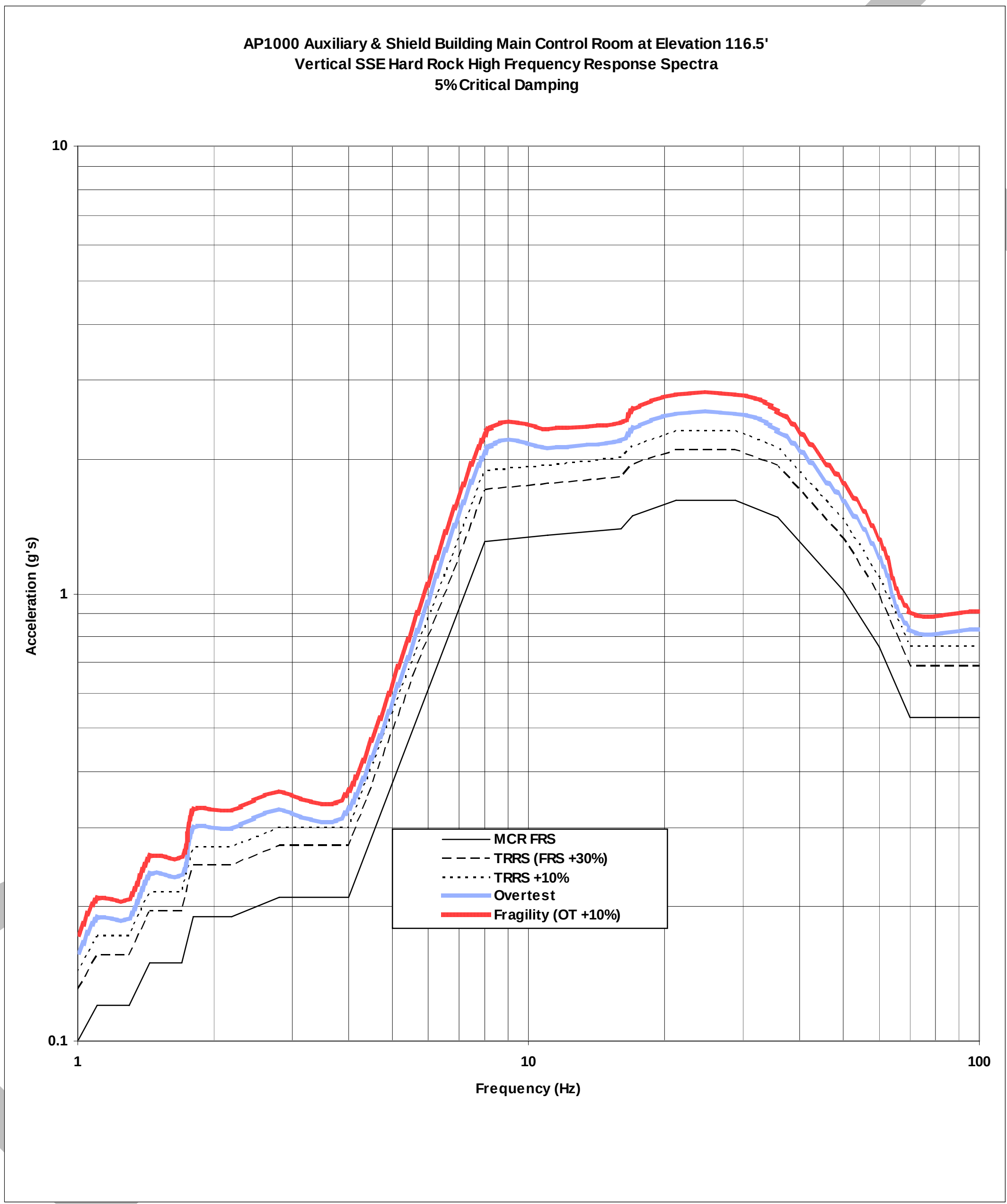

Figure 19.55-2

Seismic Margin Vertical direction AP1000 HRHF Response Spectra Auxiliary & Shield Building Main Control Room at Elev. 116.5'

PRA Revision:
None

Technical Report (TR) Revision:
None