Response to Action Item 3-74 Section 3.7

SEB Issue List Regarding APR1400 DC FSAR 3.7

Issue #1 (AI 3-74.1)

As described in Section 3.7.1.1.1 of the DCD, the horizontal and vertical certified seismic design response spectra (CSDRS) were developed by enriching the RG 1.60 Design Response Spectra (DRS) in the high frequency range (including extending the ZPA frequency from 33 Hz to 50 Hz). In addition to the RG 1.60 DRS at damping values of 2, 5, 7, and 10 percent, the DCD also provides CSDRS at another two damping values of 3 and 4 percent. However, the DCD does not describe how these two additional RS were obtained. Therefore, please explain the method and the rationale for the method that was used to develop the CSDRS at these two additional damping values, and update the DCD, as appropriate.

Response

The CSDRS at damping values of 3 and 4 percent are developed from the CSDRS at damping value of 2 and 5 percent by linear interpolation using ASCE 4, Section 2.2.1, Equation 2.2-1, shown below.

$$S(f,\bar{\lambda}) = S(f,\lambda_1) + [S(f,\lambda_2) - S(f,\lambda_1)]\,\frac{\ln\frac{\bar{\lambda}}{\lambda_1}}{\ln\frac{\lambda_2}{\lambda_1}}$$

The method used in obtaining the CSDRS values for 3 and 4 percent damping values from the CSDRS values at 2 and 5 percent damping values will be described in Section 3.7.1.1.1 of the DCD.

Impact on DCD

DCD Section 3.7.1.1.1 will be revised as indicated in the attached markup.

Impact on PRA

There is no impact on the PRA

Impact on Technical Specifications

There is no impact on the Technical Specifications

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report

3.7.1.1 Design Ground Motion

The design response spectra of the site-independent SSE are now referred to as the certified seismic design response spectra (CSDRS). The CSDRS and design time histories compatible with CSDRS are described in the following subsections.

3.7.1.1.1 Design Ground Motion Response Spectra

The peak ground acceleration (PGA) of the CSDRS has been established as 0.3g for the APR1400 design for both the horizontal and vertical directions.

The horizontal and vertical CSDRS for the APR1400 are based on the NRC Regulatory Guide (RG) 1.60 (Reference 3) response spectra, enriched in the high frequency range in the following manner.

a. The spectral amplitudes of the horizontal and vertical response spectra at control frequencies 9 Hz and below are equal to those of the NRC RG 1.60 response spectra.

b. The control frequency at which the PGA is reached is changed from 33 Hz to 50 Hz for both the horizontal and vertical spectra.

c. A control frequency at 25 Hz is added. The spectral amplitudes at 25 Hz are set to the ... for both the ho...

d. Linearly vary the modified spectra, on a log-log-scale, between the control frequencies 9 Hz, 25 Hz, and 50 Hz.

The CSDRS at damping values of 3 and 4 percent are developed from the CSDRS at damping values of 2 and 5 percent by linear interpolation using ASCE 4, Section 2.2.1, Equation 2.2 - 1.

The digitized values of the resulting APR1400 horizontal and vertical CSDRS for 2, 3, 4, 5, 7, and 10 percent damping values are provided in Table 3.7-1. The APR1400 horizontal and vertical CSDRS are presented in Figures 3.7-1 and 3.7-2, respectively.

The CSDRS are applied at the finished grade in the free-field as an additional requirement from 10 CFR Part 50, Appendix S. Figures 3.7A-12 and 3.7A-13 in Appendix 3.7A show

Response to Action Item 3-74 Section 3.7

SEB Issue List Regarding APR1400 DC FSAR 3.7

Issue #2 (AI 3-74.2)

DCD Section 3.7.1.1.2 states that "*V/A and AD/V^2 should be consistent with characteristic values for the magnitude and distance of appropriate controlling events defining the uniform hazard response spectra*." The staff consider a check of V/A and AD/V^2 to be not appropriate for DC because there are no characteristic events and other site-specific information associated with the synthetic acceleration time histories. The discussion of V/A and AD/V^2 in the SRP is intended to be used for site-specific applications. Please explain why the information related to the check of V/A and AD/V^2 is included in the APR1400 DCD.

Response

The discussions in DCD Section 3.7.1.1.2 with respect to the check of V/A and AD/V^2 of the APR1400 design time histories developed to be compatible with the CSDRS and HRHF DRS will be removed.

Impact on DCD

DCD Section 3.7.1.1.2 will be revised as indicated in the attached markup.

Impact on PRA

There is no impact on the PRA

Impact on Technical Specifications

There is no impact on the Technical Specifications

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental report

Correlation coefficient for H1 and VT = 0.079

Correlation coefficient for H2 and VT = 0.029

The design time histories are statistically independent because the correlation coefficients between the design time histories are less than 0.16 as specified in Standard Review Plan (SRP) 3.7.1 (Reference 5). Therefore, the representative maximum response of interest of the APR1400 SSCs can be obtained either by performing separate analyses for each of the three components of design time histories or by performing a single analysis with all three components of design time histories applied simultaneously.

The design time histories have a total time duration equal to 20.48 seconds and a corresponding stationary phase, which is the strong-motion duration defined as the time required for the Arias Intensity rise from 5 percent to 75 percent in more than 6 seconds.

The design time histories are developed following the spectrum matching acceptance criteria of Option 1, Approach 1, in Section II of SRP 3.7.1. The comparison plots of the response spectra of the design time histories versus the design response spectra for 2, 3, 4, 5, 7, and 10 percent critical damping are shown in Figures 3.7-6, 3.7-7, and 3.7-8. The figures demonstrate that the design time histories envelop the design response spectra for those damping values, satisfying the requirement of SRP 3.7.1 that no more than 5 points fall below and by no more than 10 percent below the design response spectra. The response spectra are computed at the frequency intervals given in Table 3.7.1-1 of SRP 3.7.1.

[Deleted.]

~~According to SRP 3.7.1, the ratios V/A and AD/V^2, where A, V, D are peak ground acceleration, ground velocity, and ground displacement, respectively, should be consistent with characteristic values for the magnitude and distance of the appropriate controlling events defining the uniform hazard response spectra. The target and target ranges of values for the other design ground motion time history parameters are the median (m) values and the median (m) ± one standard deviation (σ) (i.e., m ± σ), ranges. The determination of these target and target ranges of values is based on the methodologies and ground motion databases as described in NRC RG 1.60 and relevant NUREG reports, namely, NUREG-0003 (Reference 6) and NUREG/CR-6728 (Reference 7). Table 3.7-2 shows a comparison of the ratios V/A and AD/V^2 for the time histories and the guidance in NUREG/CR-6728 and that the ratios are between the target values, target median ± σ.~~

Response to Action Item 3-74 Section 3.7

SEB Issue List Regarding APR1400 DC FSAR 3.7

Issue #3 (AI 3-74.3)

DCD Section 3.7.1.1.2 provides a comparison of the power spectral density (PSD) functions to the target PSDs but does not describe how the PSDs were estimated for the CSDRS acceleration time histories. Technical Report, APR1400-E-S-NR-14001-P, Rev. 0, "Seismic Design Parameters," does not provide sufficient details on this subject either. The staff notices there is a detailed discussion on the PSD calculation for the HRHF time histories. Please clarify the method used to estimate PSDs for the CSDRS time histories. If the same method for the HRHF time histories was used for the CSDRS time histories, this should be reflected in the DCD or the "Seismic Design Parameters" technical report, as appropriate.

Response

The response will be provided during the face to face meeting on October 5th & 6th.

Response to Action Item 3-74 Section 3.7

SEB Issue List Regarding APR1400 DC FSAR 3.7

Issue #4 (AI 3-74.4)

DCD Section 3.7.1.1.1 indicates that the horizontal components of the CSDRS in the free-field at the foundation level are in Figures 3.7A-12 and 3.7A-13. It is not immediately clear to the staff why the motion (spectral magnitude) at the surface is lower than the motion at depth. The general expectation is that the motion at the ground surface is higher than the motion at depth. As such, please explain why that does not occur in Figures 3.7A-12 and 3.7A-13.

Response

The purpose of Figures 3.7A-12 and 3.7A-13 is to show that the response spectra of the input motion for the horizontal component of the SSE at the foundation level in the free-field are higher than the RG 1.60 spectra anchored at the PGA of 0.1g. These comparisons, which use SHAKE outcrop motion, are made in accordance with Section 3.1.3 of NEI White Paper, "Consistent Site-Response/Soil-Structure Interaction Analysis and Evaluation," (June 12, 2009). The outcrop motion at the surface is not always higher than the motion at depth, in contrast to the in-layer motion, which is generally higher than the motion at depth.

The control point of the APR1400 CSDRS is the ground surface. If the FIRS is calculated by in-layer motion, spectral magnitude at surface and depth are consistent with the general expectation. For example, Figure 1 and Figure 2, using the SHAKE in-layer option, indicate that the motion at the ground surface is higher than the motion at depth, as expected. Figure 3 through Figure 8 show comparisons of the FIRS for the nuclear island (NI) building, the emergency diesel generator building (EDGB), and the diesel fuel oil tank (DFOT) for the nine generic soil columns.

Impact on DCD

There is no impact on the DCD

Impact on PRA

There is no impact on the PRA

Impact on Technical Specifications

There is no impact on the Technical Specifications

Response to Action Item 3-74 Section 3.7

SEB Issue List Regarding APR1400 DC FSAR 3.7

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report

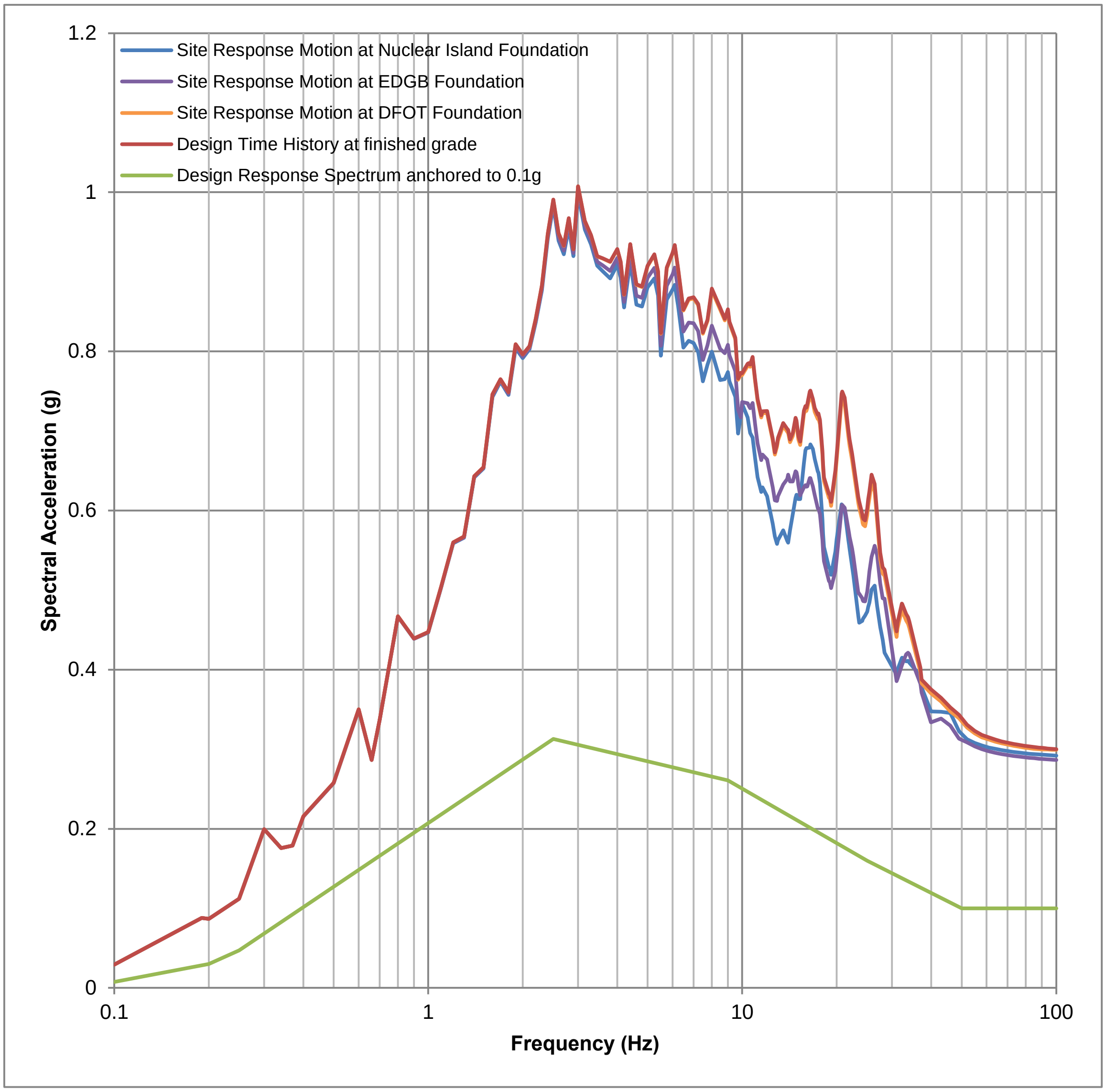

Figure 1 Comparison of between CSDRS and FIRS (in-layer motion), E-W direction, 5% damping

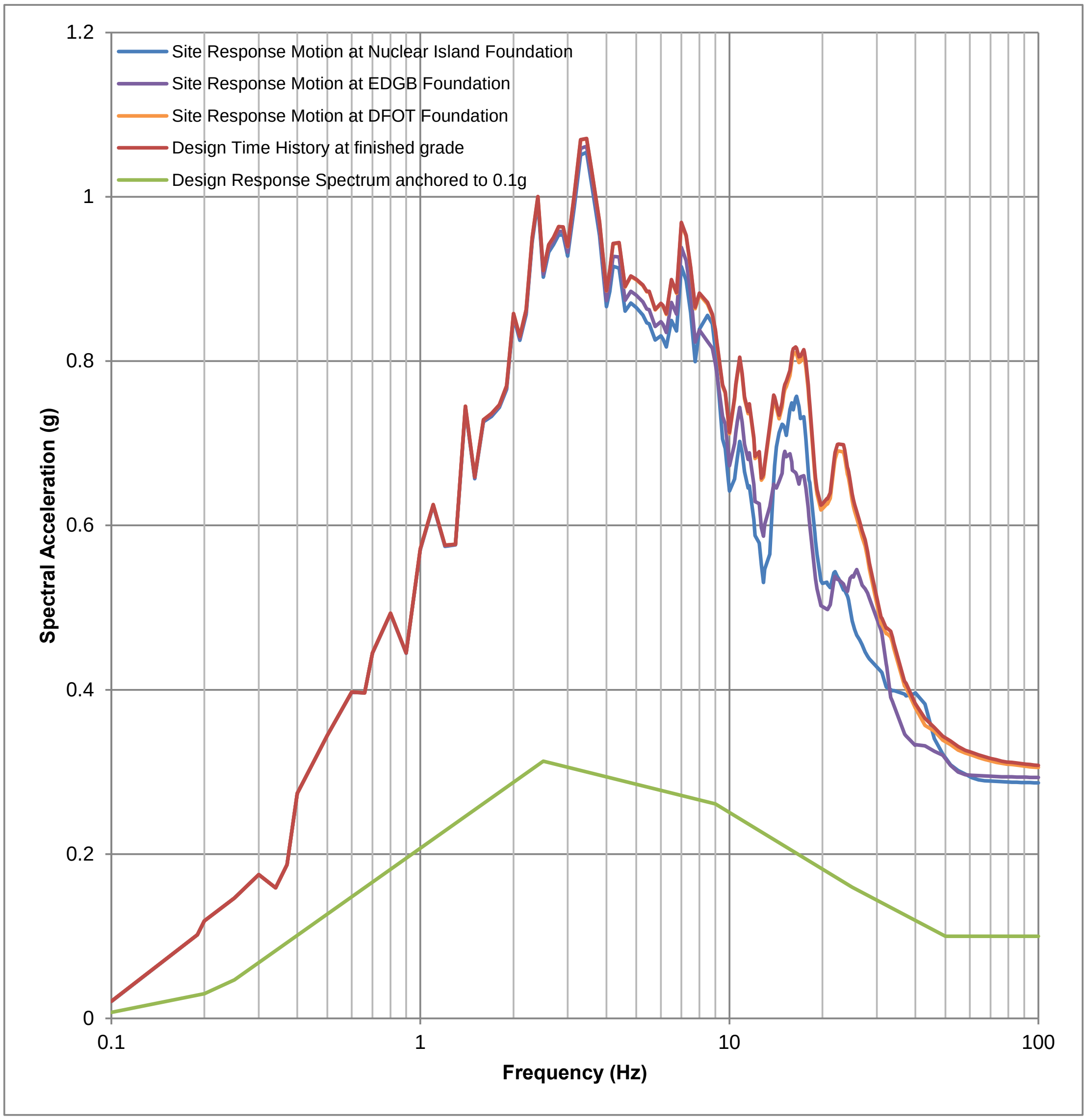

Figure 2 Comparison of between CSDRS and FIRS (in-layer motion), N-S direction, 5% damping

SEB Issue List Regarding APR1400 DC FSAR 3.7

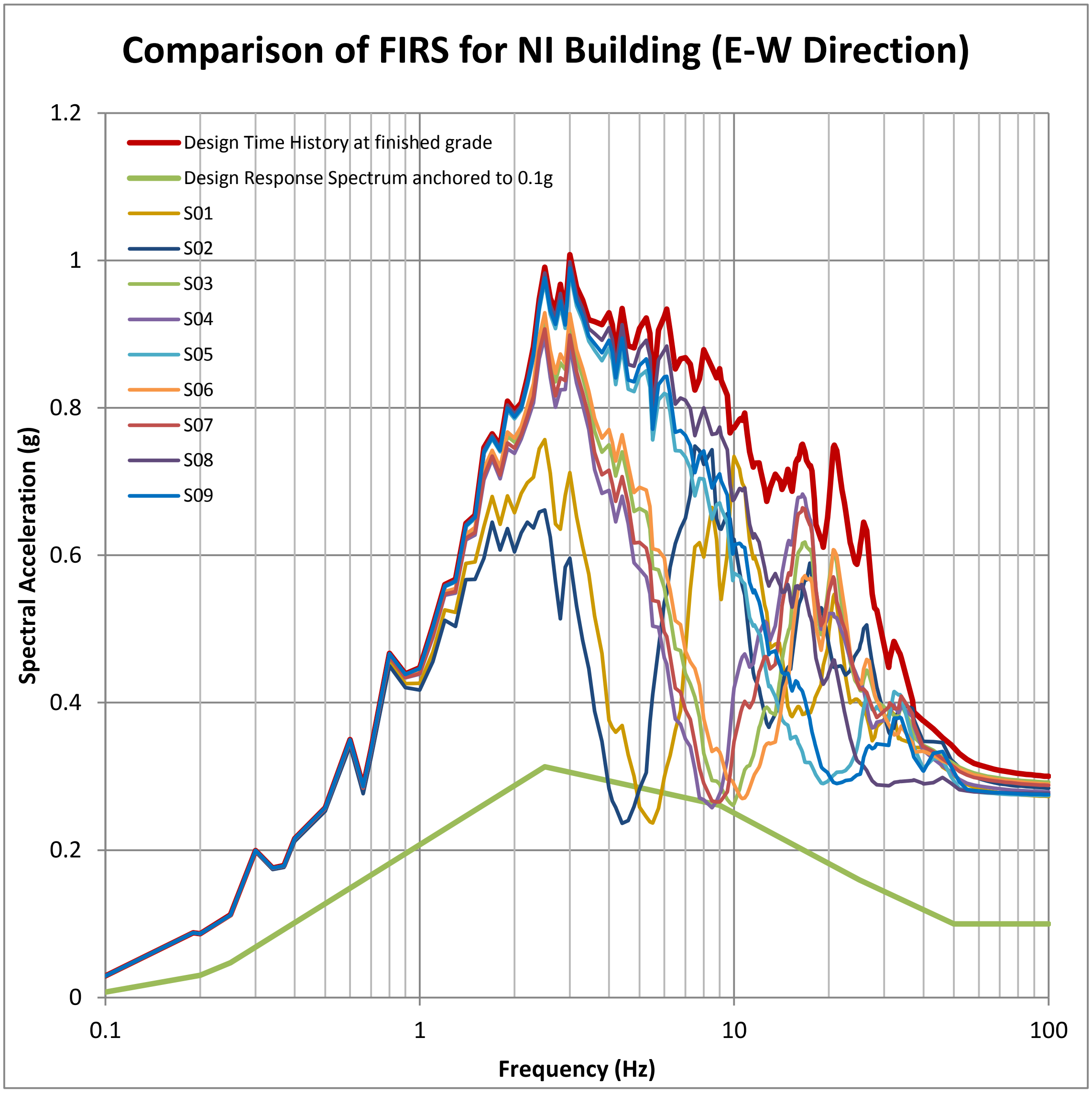

Figure 3 Comparison of between CSDRS and FIRS (in-layer motion) for NI Building, S01 through S09, E-W Direction, 5% Damping

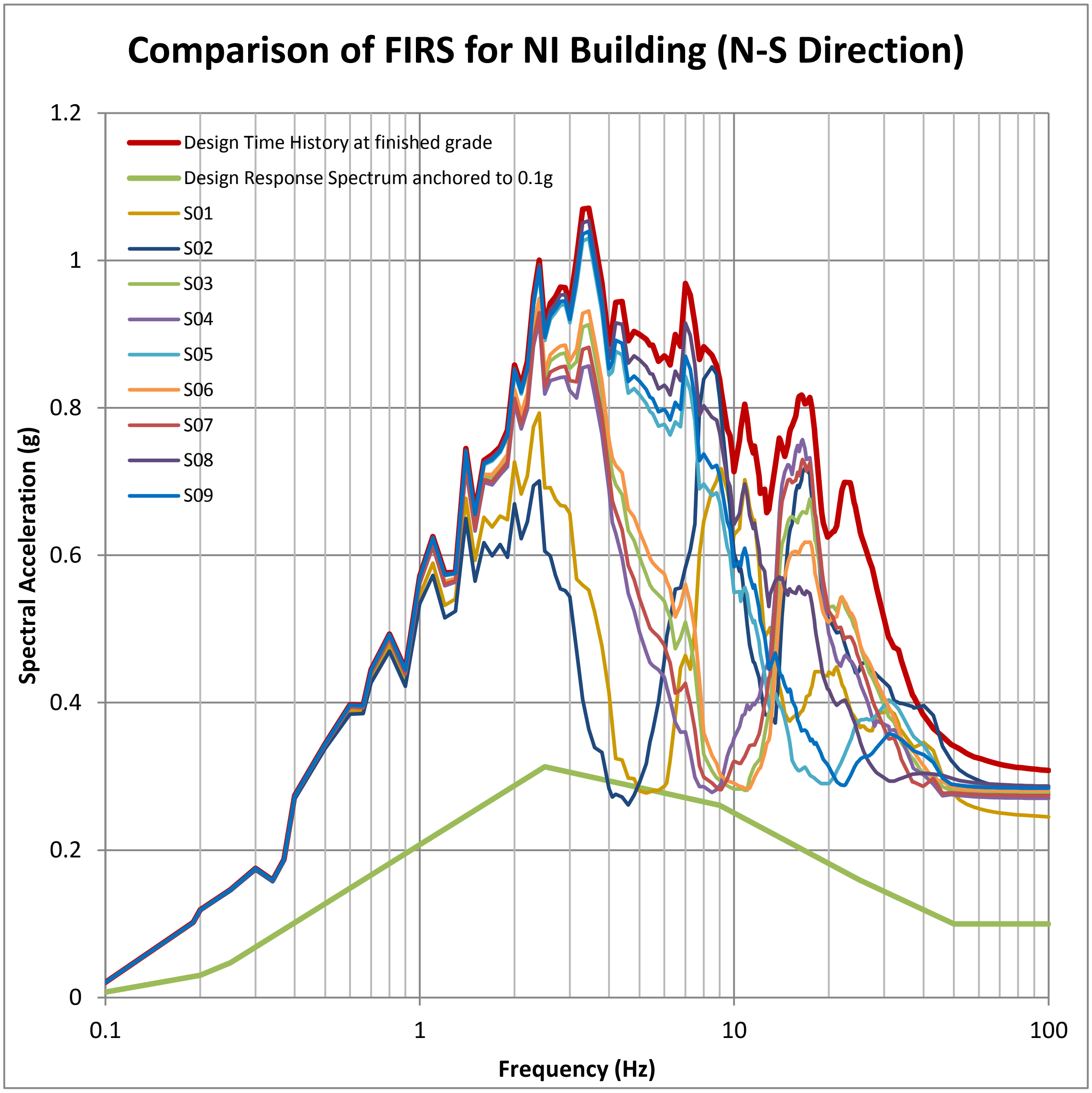

Figure 4 Comparison of between CSDRS and FIRS (in-layer motion) for NI Building, S01 through S09, N-S Direction, 5% Damping

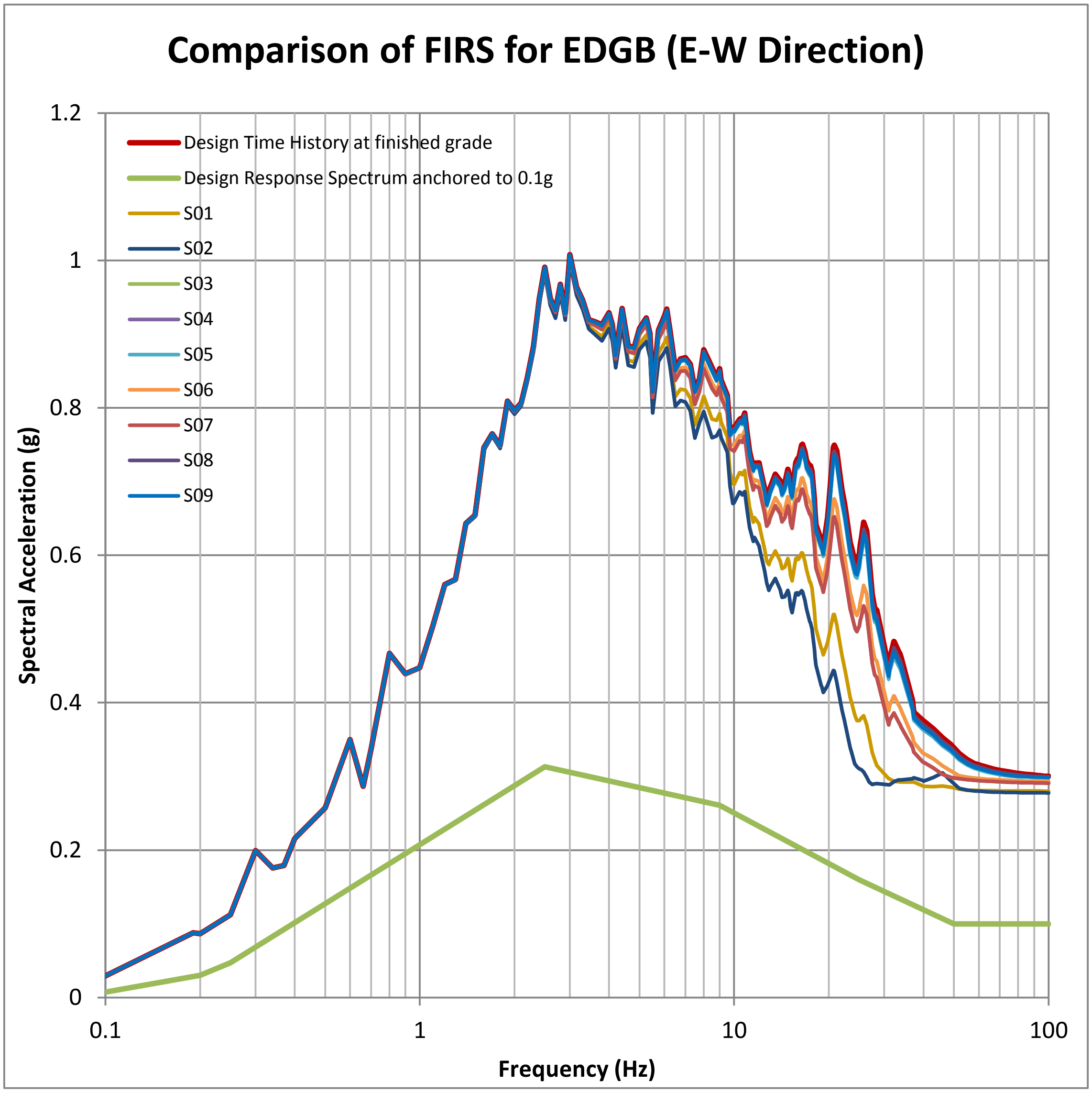

Figure 5 Comparison of between CSDRS and FIRS (in-layer motion) for EDGB, S01 through S09, E-W Direction, 5% Damping

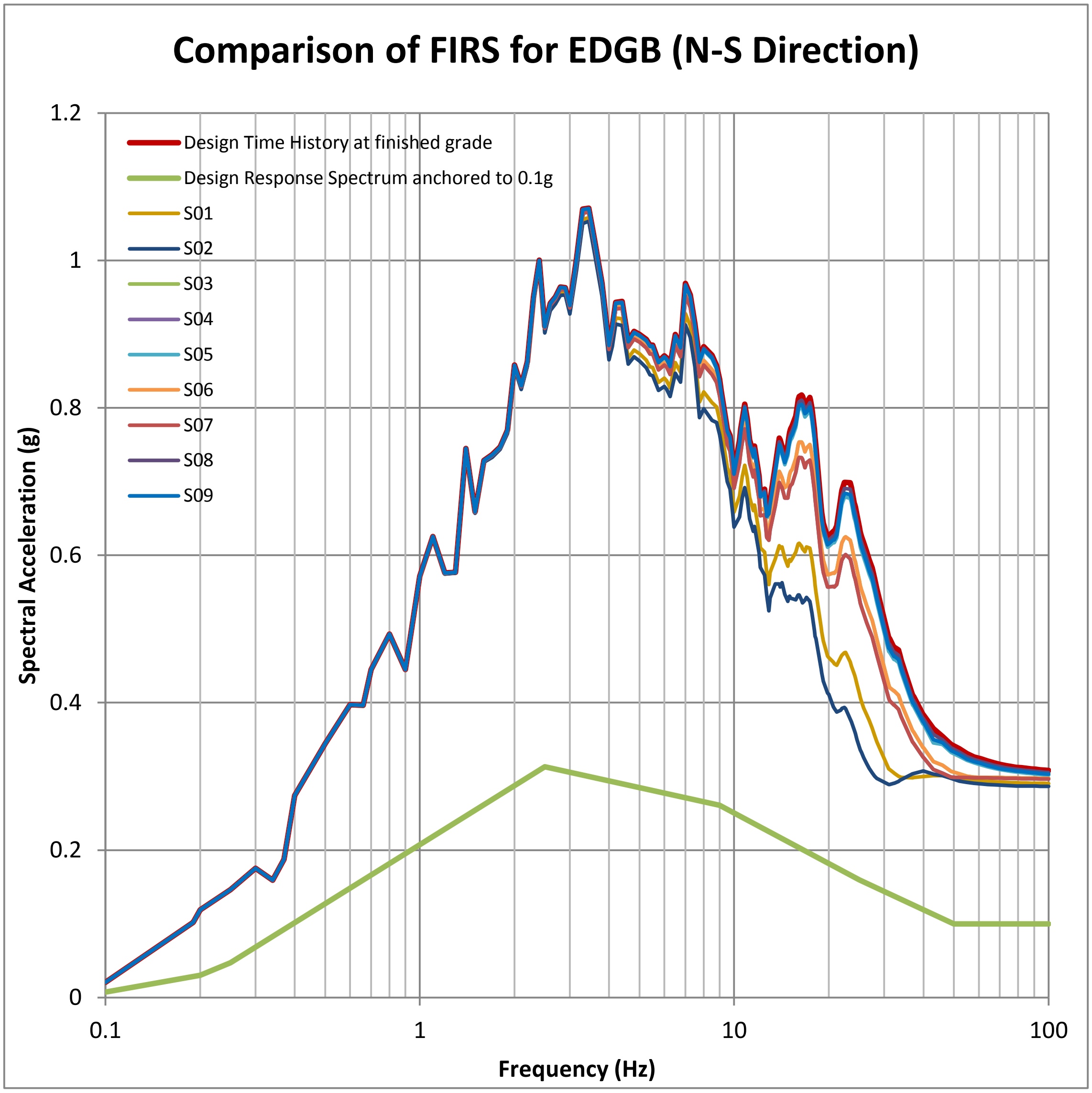

Figure 6 Comparison of between CSDRS and FIRS (in-layer motion) for EDGB, S01 through S09, N-S Direction, 5% Damping

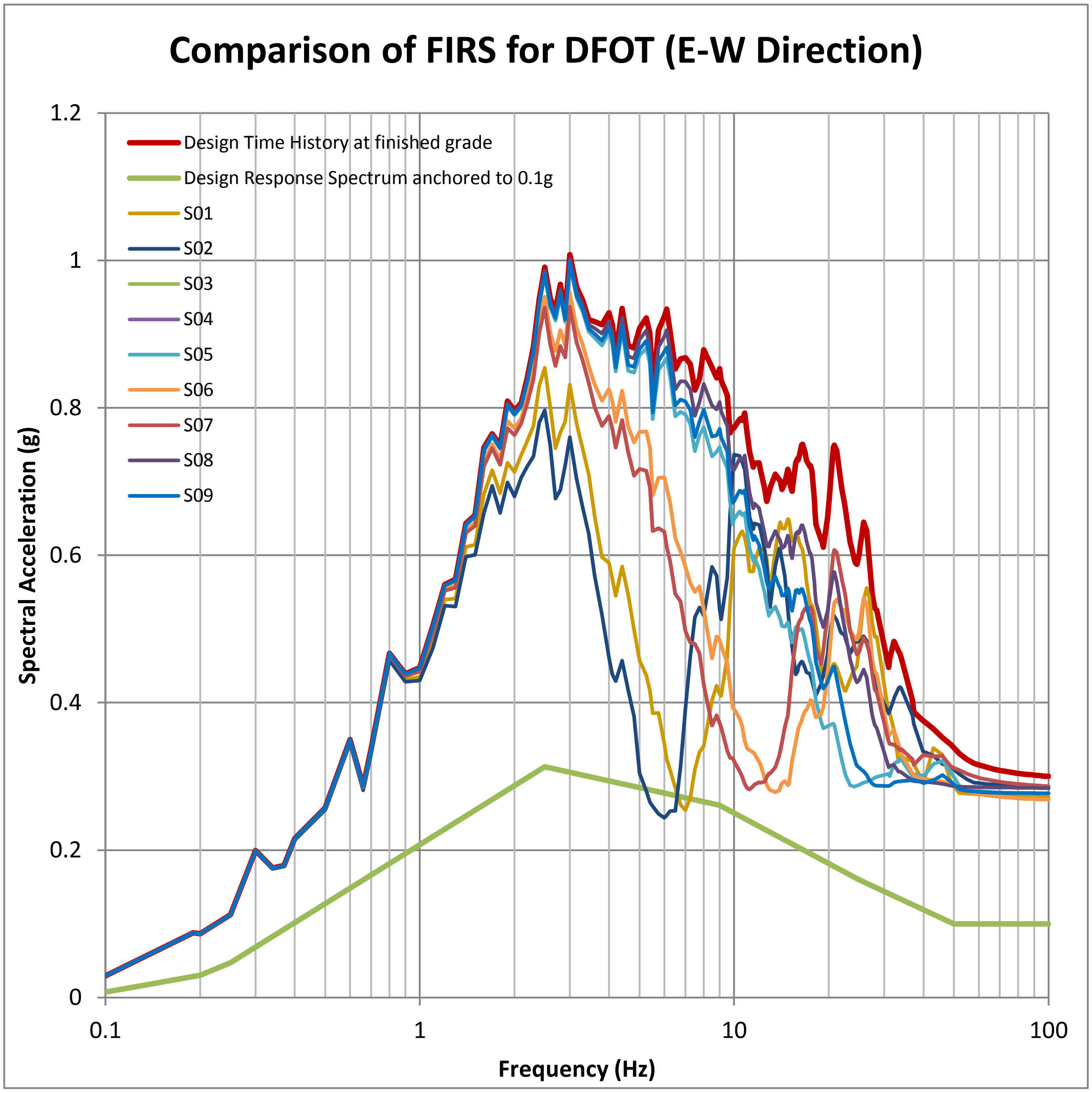

Figure 7 Comparison of between CSDRS and FIRS (in-layer motion) for DFOT, S01 through S09, E-W Direction, 5% Damping

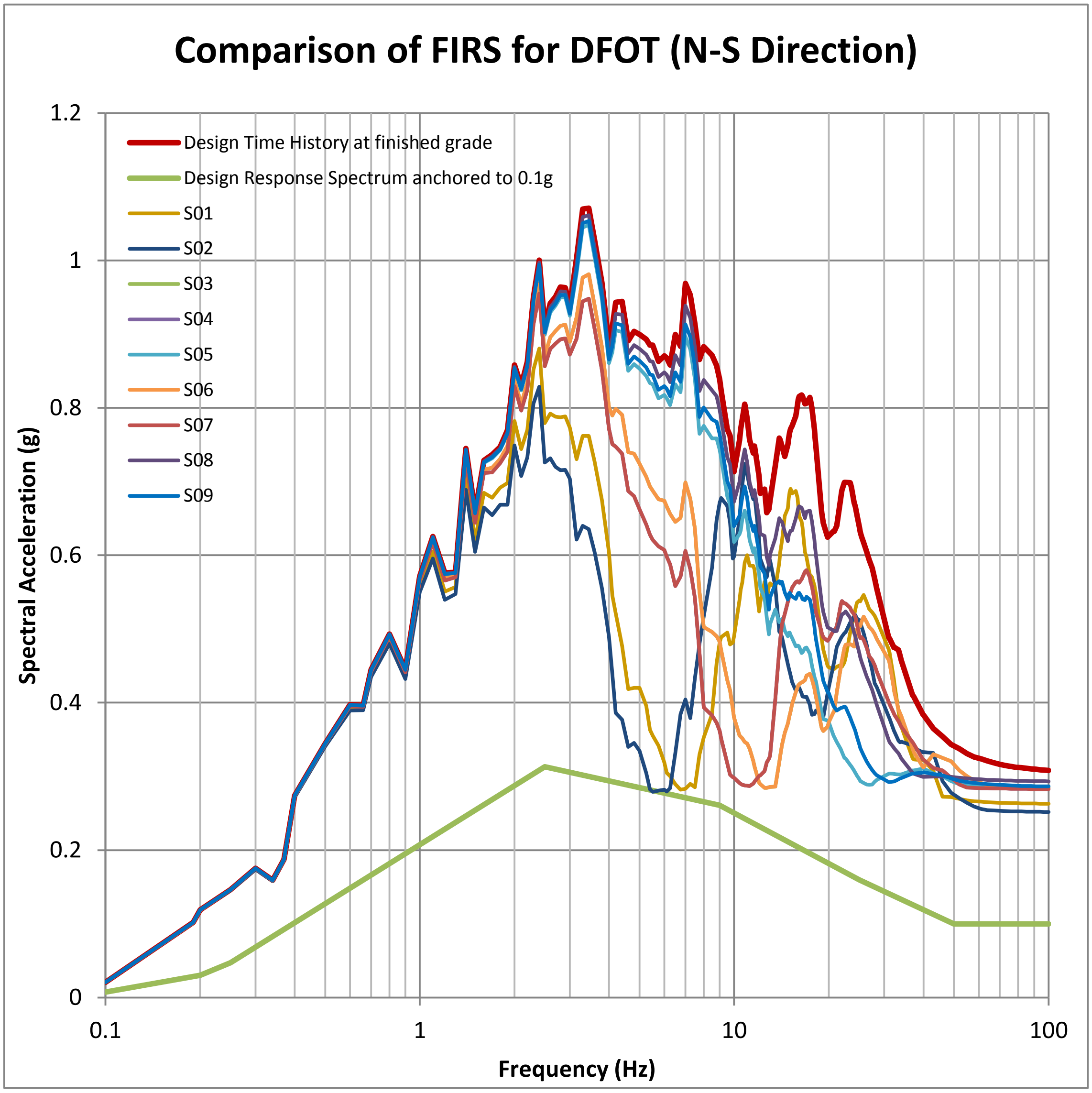

Figure 8 Comparison of between CSDRS and FIRS (in-layer motion) for DFOT, S01 through S09, N-S Direction, 5% Damping

Response to Action Item 3-74 Section 3.7

SEB Issue List Regarding APR1400 DC FSAR 3.7

Issue #5 (AI 3-74.5)

The last two paragraphs of Section 3.7.1.1.1 specify requirements for ground motion development on the combined license application (COLA): determination of site-specific SSE and OBE (COL 3.7(1)) and the horizontal foundation input response spectra (FIRS) satisfying the 0.1g minimum peak ground acceleration (PGA) requirement (COL 3.7(2)). The staff does not consider these two items as DC/COL interface items, because COL applicants will address these items as required by the regulation. As such, please explain why these two COL items are included in the APR1400 DCD.

Response

The two COL items (COL 3.7(1) and COL 3.7(2)) will be deleted from DCD Table 1.8-2, Section 3.7.1.1.1 and Section 3.7.5, as shown in the attachment associated with this response.

Impact on DCD

DCD Section 3.7.1.1.1 and 3.7.5 will be revised as indicated in the attached markup

Impact on PRA

There is no impact on the DCD

Impact on Technical Specifications

There is no impact on the Technical Specifications

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report

that the horizontal components of CSDRS in the free-field at the foundation level of the APR1400 standard plant seismic Category I structures satisfy the PGA of at least 0.1g. The vertical component of CSDRS in the free-field at the foundation level of the APR1400 standard plant seismic Category I structures is presented in Figure 3.7A-14 in Appendix 3.7A.

The site-specific seismic design can be developed for other seismic Category I and II SSCs, which are not included in the APR1400 standard plant design, at the combined license (COL) stage using the site-specific SSE derived from the ground motion response spectra (GMRS) in accordance with NRC RG 1.208 (Reference 4). ~~In this case, the COL applicant is to determine the site-specific SSE and OBE that are applied to the seismic design of the site-specific seismic Category I and II SSCs and to the basis for the plant shutdown and is to verify the appropriateness of the site-specific SSE and OBE (COL 3.7(1)).~~

to be deleted

~~The COL applicant is to confirm that the horizontal components of the site-specific SSE ground motion in the free-field at the foundation level of the structures that are not included in the APR1400 standard plant design satisfy a PGA of at least 0.1g (COL 3.7(2)).~~

to be deleted

3.7.1.1.2 Design Ground Motion Time History

The three design acceleration time histories composed of two horizontal (H1 and H2) and one vertical components (VT), which envelop the CSDRS, are applied in both soil-structure interaction analyses and fixed-base analyses of seismic Category I structures. The initial seed motions that were modified to create the design time histories are actual seed-recorded Northridge earthquake time histories.

The design time histories are generated with an increment of time size of 0.005 second to provide a Nyquist frequency of 100 Hz. Figures 3.7-3, 3.7-4, and 3.7-5 show the acceleration, velocity, and displacement time histories for H1, H2, and VT components for each time step, respectively. The design time histories, H1, H2, and VT, are applied in the east-west (E-W) direction, north-south (N-S) direction, and vertical direction, respectively. The absolute values of correlation coefficients for each pair of the design time histories are as follows:

Correlation coefficient for H1 and H2 = 0.032

2) The pre-shutdown inspection procedure supports determination of the effects of the earthquake on essential safe shutdown equipment. Following the earthquake, the equipment must be inspected for any needed resets or repairs, as well as for readiness prior to initiating shutdown activities.

3) The post-event inspection procedure supports determination of the degree of damage to equipment and equipment acceptability for continued operation.

3.7.5 Combined License Information

COL 3.7(1) ~~The COL applicant is to determine the site-specific SSE and OBE that are applied to the seismic design of the site-specific seismic Category I and II SSCs and the basis for the plant shutdown. The COL applicant is also to verify the appropriateness of the site-specific SSE and OBE.~~ [Deleted.]

COL 3.7(2) ~~The COL applicant is to confirm that the horizontal components of the site-specific SSE ground motion in the free-field at the foundation level of the structure satisfy a peak ground acceleration of at least 0.1g.~~ [Deleted.]

COL 3.7(3) The COL applicant is to provide the seismic design of the seismic Category I SSCs that are not part of the APR1400 standard plant design. The seismic Category I structures are as follows:

a. Seismic Category I essential service water building

b. Seismic Category I component cooling water heat exchanger building

COL 3.7(4) The COL applicant is to confirm that the any site-specific non-seismic Category I SSCs are designed not to degrade the function of a seismic Category I SSC to an unacceptable safety level due to their structural failure or interaction.

COL 3.7(5) The COL applicant is to perform any site-specific seismic design for dams that is required.

Table 1.8-2 (3 of 29)

Item No.	Description
COL 3.4(1)	The COL applicant is to provide site-specific information on protection measures for the design-basis flood, as required in Subsection 2.4.10.
COL 3.4(2)	The COL applicant is to provide flooding analysis with flood protection and mitigation features from internal flooding for the CCW Heat Exchanger Building and ESW Building.
COL 3.4(3)	The COL applicant is to confirm that the potential site-specific external flooding events are bounded by design-basis flood values or otherwise demonstrate that the design is acceptable.
COL 3.4(4)	The COL applicant is to identify any site-specific physical models that could be used to predict prototype performance of hydraulic structures and systems.
COL 3.5(1)	The COL applicant is to provide the procedure for heavy load transfer to strictly limit the transfer route inside and outside containment during plant maintenance and repair periods.
COL 3.5(2)	The COL applicant is to perform an assessment of the orientation of the turbine generator of this and other unit(s) at multi-unit sites for the probability of missile generation using the evaluation of Subsection 3.5.1.3.2 to verify that essential SSCs are outside the low-trajectory turbine missile strike zone.
COL 3.5(3)	The COL applicant is to evaluate site-specific hazards induced by external events that may produce more energetic missiles than tornado or hurricane missiles, and provide reasonable assurance that seismic Category I and II structures are designed to withstand these loads.
COL 3.5(4)	The COL applicant is to evaluate the potential for site proximity explosions and missiles due to train explosions (including rocket effects), truck explosions, ship or barge explosions, industrial facilities, pipeline explosions, or military facilities.
COL 3.5(5)	The COL applicant is to provide justification for the site-specific aircraft hazard and an aircraft hazard analysis in accordance with the requirements of NRC RG 1.206.
COL 3.6(1)	The COL applicant is to identify the site-specific SSCs that are safety related or required for safe shutdown that are located near high- and moderate-energy piping systems and that are susceptible to the consequences of piping failures.
COL 3.6(2)	The COL applicant is to provide a list of site-specific high- and moderate-energy piping systems including layout drawings and protection features and the failure modes and effects analysis for safe shutdown due to the postulated HELBs.
COL 3.6(3)	The COL applicant is to confirm that the bases for the LBB acceptance criteria are satisfied by the final as-built design and materials of the piping systems as site-specific evaluations, and is to provide the information including LBB evaluation report for the verification of LBB analyses.
COL 3.6(4)	The COL applicant is to provide the procedure for initial filling and venting to avoid the known causes for water hammer in DVI line.
COL 3.7(1)	~~The COL applicant is to determine the site-specific SSE and OBE that are applied to the seismic design of the site-specific seismic Category I and II SSCs and the basis for the plant shutdown. The COL applicant is also to verify the appropriateness of the site-specific SSE and OBE.~~ [Deleted.]
COL 3.7(2)	~~The COL applicant is to confirm that the horizontal components of the SSE site-specific ground motion in the free-field at the foundation level of the structure satisfy a peak ground acceleration of at least 0.1 g.~~ [Deleted.]

Response to Action Item 3-74 Section 3.7

SEB Issue List Regarding APR1400 DC FSAR 3.7

Issue #6 (AI 3-74.6)

Section 3.5.1 of APR1400-E-S-NR-14004-P, Rev. 1, “Evaluation of Effects of [hard rock high frequency] HRHF Response Spectra on SSCs,” compares the APR1400 HRHF horizontal target PSD with the target PSD curves presented in Appendix B of the SRP 3.7.1 Draft Rev. 4, as shown in Figure 3-24 of this report. The PSD tables in Appendix B of the SRP 3.7.1 Draft Rev. 4 were determined to have typos and those target PSDs are generally not compatible with the bin average response spectra. Appendix B of SRP 3.7.1 has been revised in Rev. 4 to address these issues and the guidance in SRP 3.7.1 has been updated. Therefore, comparison to the data in those tables in Appendix B of the SRP 3.7.1 Draft Rev. 4 is not considered to be appropriate and the HRHF report should be revised, as appropriate.

Response

The PSDs presented in Appendix B of SRP 3.7.1 Draft Rev. 4 used for comparison with the APR1400 horizontal target PSD compatible with the HRHF horizontal DRS will be revised to the PSDs presented in Appendix B of SRP 3.7.1 Rev. 4, as shown in Figure 1. This revised figure of comparison will replace the corresponding figure in Section 3.5.1 of APR1400-E-S-NR-14004-P, Rev. 1.

Impact on DCD

There is no impact on the DCD

Impact on PRA

There is no impact on the PRA

Impact on Technical Specifications

There is no impact on the Technical Specifications

Impact on Technical/Topical/Environmental Reports

Technical report, APR1400-E-S-NR-14004-P, Rev.1 Figure 3-24 will be revised as indicated in the attached markup

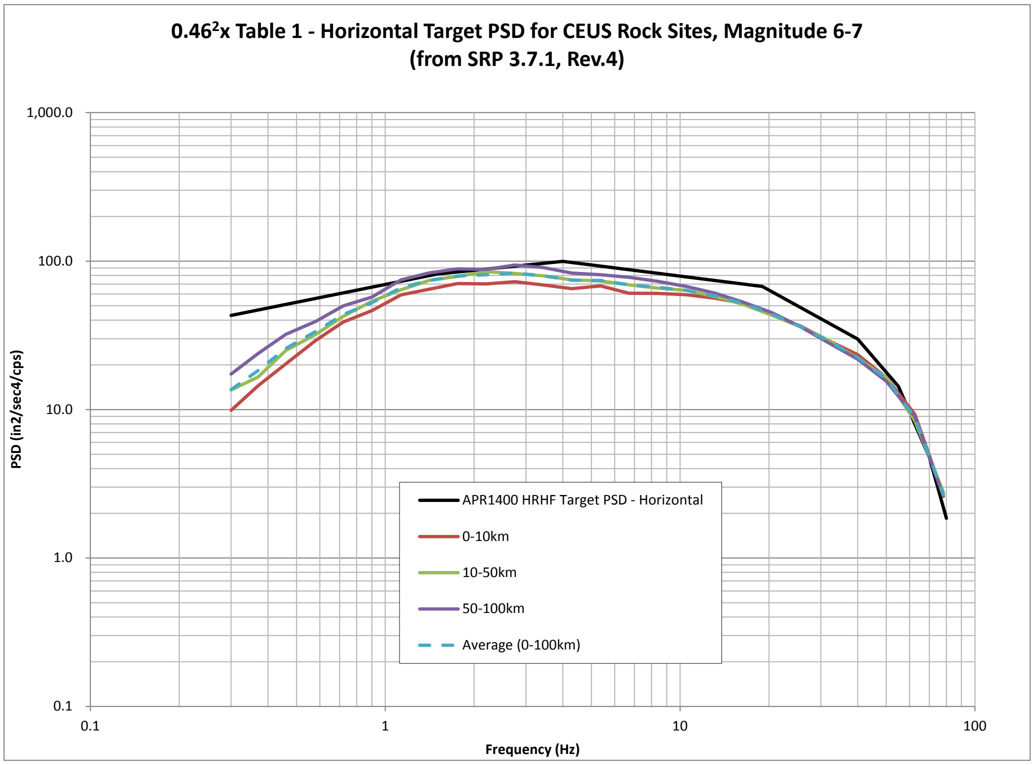

Figure 1 Comparison of the Horizontal Target PSD Compatible with APR1400 HRHF Horizontal Response Spectra with the SRP 3.7.1PSDs for CEUS Rock Sites

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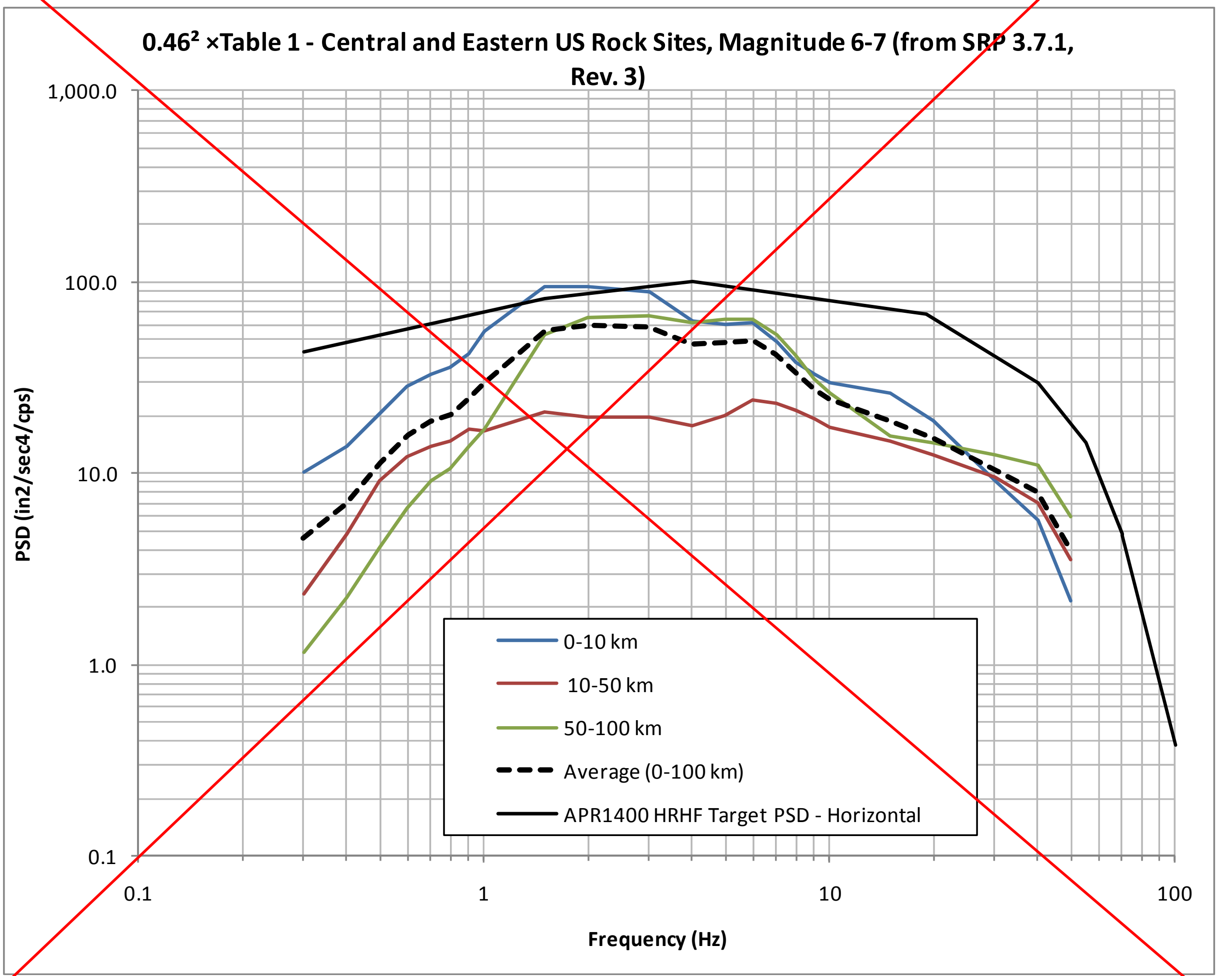

Figure 3-24 Comparison of the Horizontal Target PSD Compatible with APR1400 HRHF Horizontal Response Spectra with the SRP 3.7.1 PSDs for CEUS Rock Sites

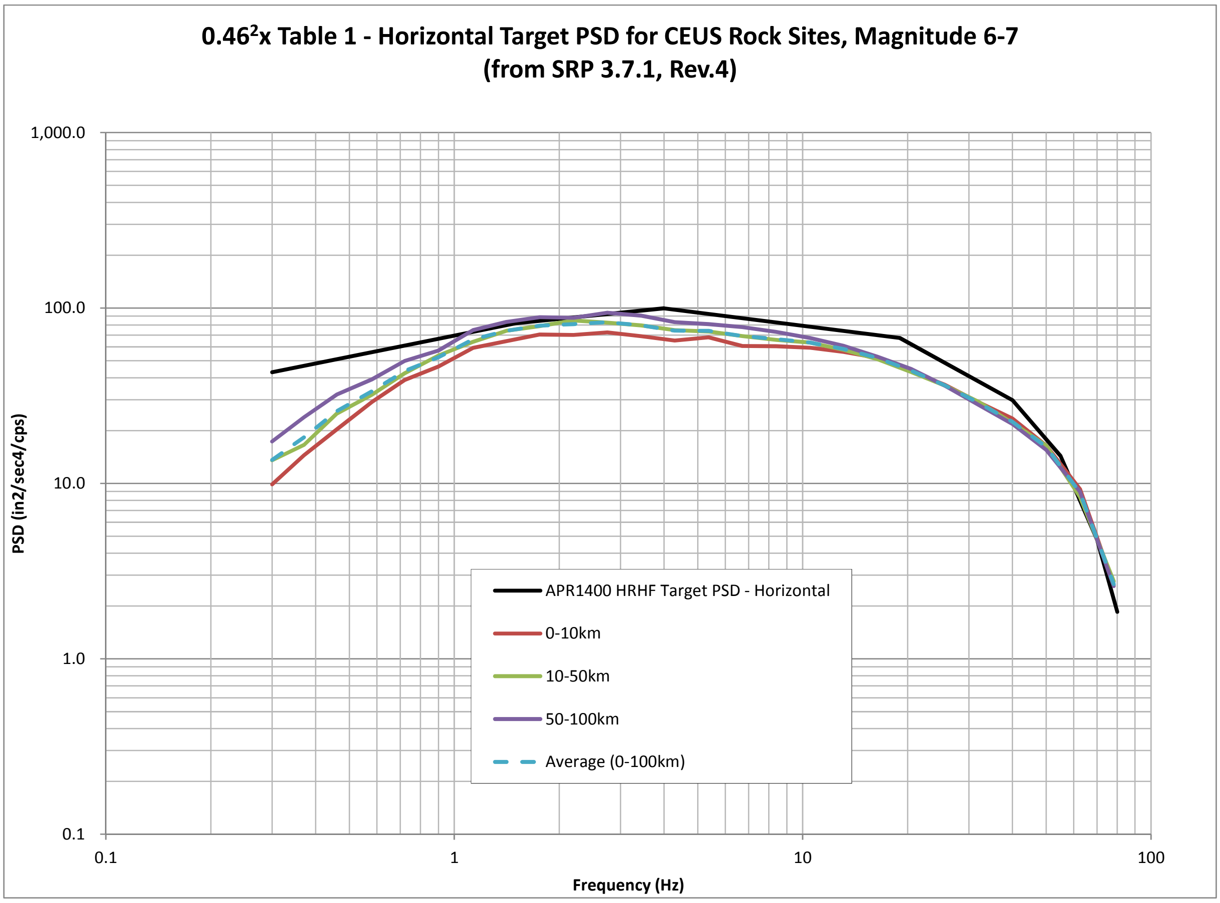

Figure 3-24 Comparison of the Horizontal Target PSD Compatible with APR1400 HRHF Horizontal Response Spectra with the SRP 3.7.1 PSDs for CEUS Rock Sites