

3.7 Seismic Design

The information in this section of the reference ABWR DCD, including all subsections, tables, and figures, is incorporated by reference with the following departure and supplements.

STD DEP 1.8-1

STD DEP T1 2.15-1 (Table 3.7-6 and Figure 3.7-34)

The Ultimate Heat Sink and Reactor Service Water Piping Tunnel are designed to the site-specific SSE. The additional information requested by Standard Review Plans 3.7.1 and 3.7.2 for these structures is provided in section 3H.6.

3.7.1 Seismic Design Parameters

Site-specific SSE design response spectra for damping ratios of 2%, 3%, 4%, 5%, and 7% used for the site-specific SSI analysis and site-specific seismic analysis and design of site-specific structures (Ultimate Heat Sink, Reactor Service Water (RSW) Pump House, and RSW Piping Tunnel) are shown in Figures 3.7-1a, 3.7-1b, 3.7-2a, and 3.7-2b. Development of the 5% design SSE spectra, shown in Figures 3.7-1a and 3.7-2a, is discussed in Section 3H.6.5.1.1 of the Appendix 3H, where it is called 'Input Spectrum'. The spectra for other damping values, shown in Figures 3.7-1b and 3.7-2b, were developed using the consistent time histories discussed in Section 3H.6.5.1.1. For the horizontal direction, the spectra generated from the X and Y direction time histories were enveloped.

The shear wave velocity at the STP 3 & 4 site does not meet the DCD Table 5.0 requirement for minimum shear wave velocity. STP DEP T1 5.0-1 describes this departure. The site-specific shear wave velocity data is provided in FSAR Table 2.5S.4-27. Shear wave velocities at the site vary both horizontally within a soil stratum, and vertically with depth.

A site-specific SSI analysis ~~has been~~will be performed, as discussed in Appendix 3A, to confirm that the standard plant results included in the DCD envelop the results of the site-specific SSI. ~~This analysis will use measured shear wave velocities, with appropriate variation to represent the variability at the site. There is a high degree of confidence that the results of this SSI analysis will be bounded by the results of the standard plant SSI analysis documented in the DCD for the following reasons:~~

- ~~The site specific SSE, as described in FSAR Section 2.5S.2, is enveloped by Regulatory Guide 1.60 spectrum anchored to 0.15g acceleration, which is only half the standard plant SSE of 0.30g.~~
- ~~The standard plant SSI results are based on an envelop of 22 different cases. The site specific SSI will be based on only the STP 3 & 4 site conditions.~~

~~A preliminary study of the potential impact of the site specific shear wave velocity and its degree of variability on the SSI has been performed. The purpose of this study was~~

~~to determine whether the site soil shear wave velocities below 305 meters/second (1,000 feet/second) could potentially result in site specific SSE response spectra which fall outside the design envelope of the DCD spectra. A sensitivity study was performed by developing free field ground surface spectra for the two following cases:~~

- ~~• Site specific SSE (RG 1.60 spectrum anchored at 0.15 g) using site specific shear wave velocity profiles.~~
- ~~• Standard plant SSE (RG 1.60 spectrum anchored at 0.30 g) using the shear wave velocities of the UB soil profile from the DCD. The UB soil profile was selected because it contains the lower bound shear wave velocity considered in the DCD (305 meters/second [1,000 feet /second] for the top 9m of soil) and therefore is most representative of the site specific shear wave velocities.~~

~~Two cases were compared to determine whether the site specific results are bounded by the DCD results. A similar comparison was repeated for the reactor and control building foundation levels. The soil column response to input ground motions utilized the equivalent linear analysis method as implemented in SHAKE2000.~~

~~The study considered two sources of variability: 1) the stochastic nature of earthquake ground motions and 2) variability in the site specific shear wave velocity profile. For the earthquake ground motion variability, eleven ground motion time histories compatible with RG 1.60 spectral shape were synthesized. Variability in the shear wave velocities was based on data obtained from FSAR Section 2.5S.4, Table 2.5S.4-27 and Figures 2.5S.4-39-44. For each ground motion time history, one hundred shear wave velocity profiles were developed by implementing the random generation option in SHAKE, resulting in 1,100 realizations for each of the horizontal and vertical ground motions.~~

~~One set of results for a typical time history is presented in Figures 3.7-35, 36, and 37, which show the comparison of the DCD spectrum with the site specific spectra; results of other time histories are similar. The site specific spectra represent the envelope, mean+sigma, and mean of the one hundred simulated shear wave velocity profiles. The site specific response spectra are bounded by the comparable DCD spectra. A site specific SSI analysis will be performed to verify that the site specific seismic structural demands are bounded by the DCD standard plant seismic demands and the FSAR will be updated with the results in the next scheduled revision.~~

Other Analyses

The liquefaction evaluation described in FSAR Section 2.5S.4.8 uses the measured shear wave velocities at the site, and concludes that the site is acceptable from liquefaction potential point of view. It should be noted that the liquefaction evaluation was performed using three different methods, as described in Section 2.5S.4.8, and all three methods reached the same conclusion regarding no liquefaction potential at the site.

~~Other foundation evaluations, i.e. b~~Bearing capacity evaluations and lateral soil pressures, do not use shear wave velocities as an input for the calculations. Therefore, these calculations are not affected by variation in shear wave velocity. FSAR

Subsection 2.5S.4 describes the evaluation of bearing capacity and concludes that the Tier 1 requirement of Table 5.0-1 for allowable bearing capacity of 15 ksf is met.

At-rest lateral earth pressure in non-yielding walls of structures with deep foundations such as the Reactor and Control Buildings will be determined using the method described in Reference 2.5S.4-62. In this method, the at-rest seismic lateral earth pressure computation will utilize site-specific shear wave velocity. The impact of site-specific shear wave velocity on the design of exterior walls of these structures is expected to be insignificant because their designs are controlled by the combination of requirements for in-plane and out-of-plane loads. The at-rest seismic lateral pressure only affects the out-of-plane load. Also, the at-rest pressure includes effect of hydrostatic load, surcharge load etc., in addition to the dynamic pressure caused by the earthquake.

In the development of settlement estimates, the representative shear wave velocity value for intervals within a soil column is only one input used in the derivation of the elastic modulus for layers within that column. Since this derived elastic modulus value is first adjusted for strain and then weighted with estimated values derived from either SPT tests (for granular material) or undrained shear strength tests (for cohesive soils) the effect of variability of shear wave velocity upon settlement calculations is significantly attenuated. The foundation spring constants for mat design are based on settlement calculations and therefore the effect of shear wave velocity variation is similarly attenuated.

Based on above discussion, it is concluded that the shear wave velocities at the plant site do not impact the plant design.

3.7.1.4 Supporting Media for Seismic Category I Structures

STD DEP T1 2.15-1

The following ABWR Standard Plant Seismic Category I structures have concrete mat foundations supported on soil, rock or compacted backfill. The maximum value of the embedment depth below plant grade to the bottom of the base mat is given below for each structure:

- (1) *Reactor Building (including the enclosed primary containment vessel and reactor pedestal)—25.7m*
- (2) *Control Building—23.2m*
- ~~(3) *Radwaste Building Substructure—16m*~~

3.7.2.1.5.1.3 ~~Radwaste Building~~ Not Used

STD DEP T1 2.15-1

~~The Radwaste Building dynamic model is shown in Figure 3.7.34. The Radwaste Building is a box type shear wall system of reinforced concrete. The major walls between floor slabs are represented by beam elements of a box cross section. The~~

~~shear rigidity in the direction of excitation is provided by the parallel walls. The bending rigidity includes the cross walls contribution. In the vertical direction a single mass point is used for each slab and is connected to the walls by spring elements. The spring element stiffness is determined so that the fundamental frequency of the slab in the vertical direction is maintained.~~

3.7.2.2 Natural Frequencies and Response Loads

STD DEP T1 2.15-1

~~The natural frequencies up to 33 Hz for the Reactor, and Control and Radwaste Buildings are presented in Tables 3.7-2 through 3.7-65 for the fixed base condition.~~

~~Enveloped response loads at key locations in the Reactor Building complex and the control building due to SSE for the range of site conditions considered are presented in Appendix 3A. Response spectra at the major equipment elevations and support points are also given in Appendix 3A.~~

~~The design SSE loads for the Radwaste Building are given in Table 3H.3-1.~~

3.7.2.12 Comparison of Responses

STD DEP T1 2.15-1

~~The time history method of analysis is used for the Reactor and Control Buildings. A comparison of responses with the response spectrum method is therefore not required. The Radwaste Building is analyzed using the response spectrum method, since the time history method needed for the generation of floor response spectra is not necessary because there are no safety related components inside the building.~~

3.7.3.16 Analysis Procedure for Non-Seismic Structures in Lieu of Dynamic Analysis

STD DEP 1.8-1

~~For the design of non-seismic Category I structures, the procedures described in the Uniform Building Code (UBC) International Building Code (IBC) seismic design criteria shall be followed.~~

~~Where a structure is required to be designed to withstand a SSE, the following limitations apply:~~

- ~~(1) The seismic zone shall be "Zone 3". The seismic acceleration shall be the SSE ground acceleration.~~
- ~~(2) The structure shall be classified as "Essential Facility"; thereby using appropriate importance factors for wind and seismic.~~
- ~~(3) For dual systems (i.e., shear wall with braced steel frame), one of the two systems must be designed to be capable of carrying all of the seismic or~~

wind loading without collapse. No credit will be given for the other for resisting lateral loads.

3.7.5 COL License Information

3.7.5.1 Seismic Design Parameters

The following site-specific supplement addresses COL License Information Item 3.19.

The site-specific assessment against the Tier 1 site requirements is provided in Subsection 2.5S.2. The site-specific soil structure interaction analysis for the Reactor Building and Control Building is provided in Appendix 3A.

3.7.5.2 Pre-Earthquake Planning and Post-Earthquake Actions

The following standard supplement addresses COL License Information Item 3.20.

The procedures for pre-earthquake planning and post-earthquake actions will be developed in accordance with Subsection 3.7.4 and Section 13.5 prior to fuel load. The procedures will implement the seismic instrumentation program specified in Subsection 3.7.4 and follow the guidelines recommended in EPRI Report NP-6695 (Reference 3.7-7), with the exceptions listed in Subsection 3.7.5.2 of the reference DCD. (COM 3.7-1)

3.7.5.3 Piping Analysis, Modeling of Piping Supports

The following standard supplement addresses COL License Information Item 3.21.

The method described in Subsection 3.7.3.3.1.6 will be used for determining pipe support stiffness. No other method will be used.

3.7.5.4 Assessment of Interaction Due to Seismic Effects

The following standard supplement addresses COL License Information Item 3.22.

Nonsafety-related SSCs that are located in the same room as safety-related SSCs will be reviewed to determine if their failure will impact the ability of the safety-related SSC to perform its safety function. Non-seismic Category 1 SSCs whose failure could jeopardize the function of a safety-related SSC will be analyzed to demonstrate that structural integrity will be maintained in an SSE.

A procedure to confirm that all nonsafety-related SSCs located in the same room as a safety-related SSC have been evaluated and correctly dispositioned for inspection of the as-built plant for II/I interactions will be developed in accordance with Section 13.5 and will be made available for inspection prior to fuel load. (COM 3.7-2)

This procedure will include the following elements as a minimum:

- The falling of a nonsafety-related SSE onto a safety-related SSC with particular emphasis on the adequate anchorage of the nonsafety-related SSC.

- The impact of a nonsafety-related SSC on a safety-related SSC with emphasis on seismic induced motion of an SSC on adjacent SSCs.

3.7.5.5 Response Spectra Amplification at Support Attachment Points

The following standard supplement addresses the COL License Information Item in Subsection 3.7.3.3.1.8.

The acceleration response spectra at piping attachment points are generated considering the drywell equipment and pipe support structure as part of the structure using the dynamic analysis methods described in Subsection 3.7.2.

3.7.5.6 Modeling of Special Engineered Pipe Supports

The following standard supplement addresses the COL License Information Item in Subsection 3.7.3.3.1.7.

STP 3 & 4 will not be using any special engineered pipe supports described in Subsection 3.9.3.4.1(6).

Table 3.7-6 ~~Natural Frequencies of the Radwaste Building—Fixed Base Condition~~ Not Used

<i>Mode No.</i>	<i>Frequency (HZ)</i>	<i>Direction</i>
1	6.52	Y Horiz
2	7.19	X Horiz
3	11.98	Y Horiz
4	14.74	Z Vert
5	16.24	X Horiz
6	16.72	Y Horiz
7	21.49	X Horiz
8	26.28	Y Horiz
9	29.57	X Horiz
10	31.40	Z Vert

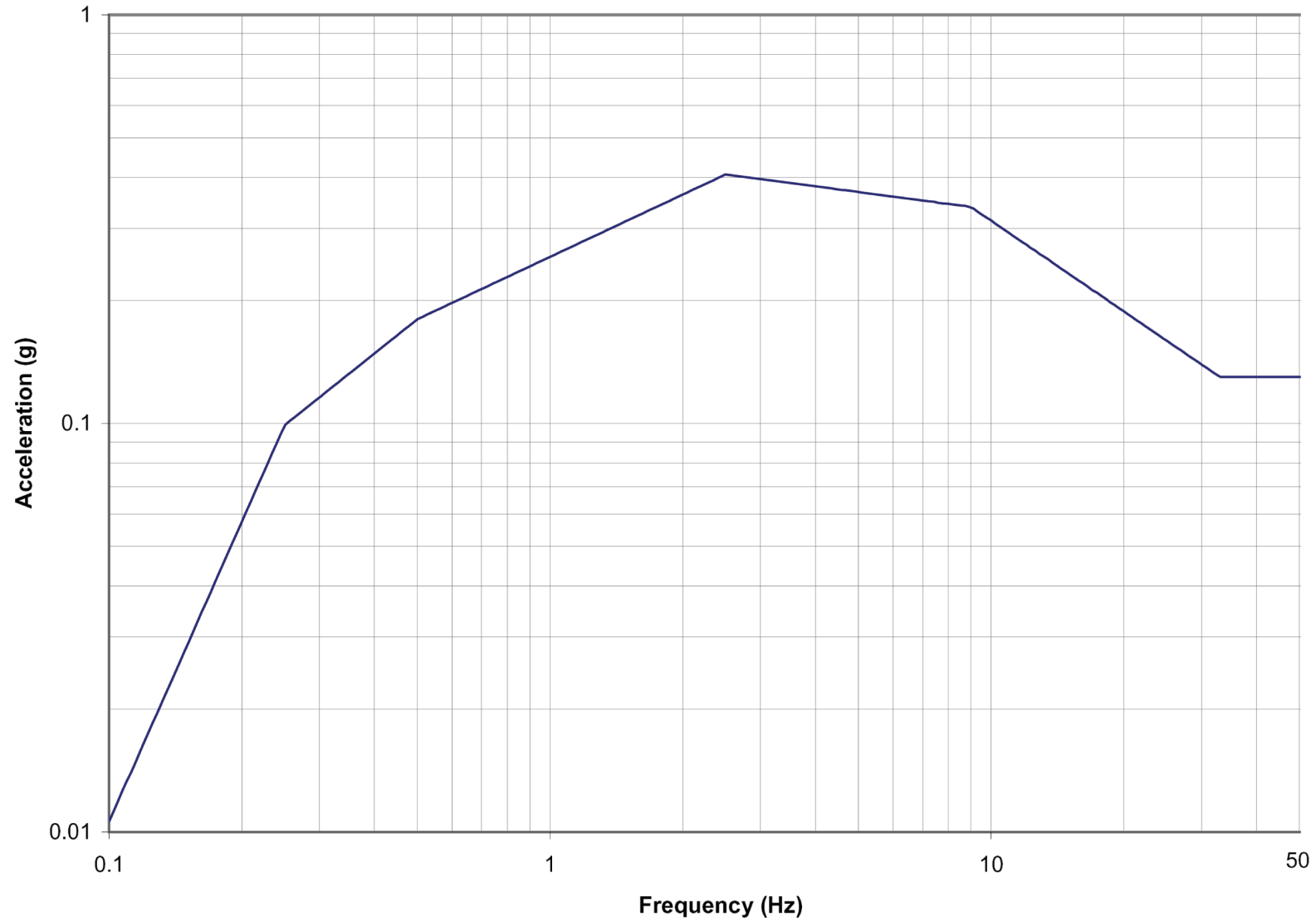


Figure 3.7-1a Site-Specific Design Response Spectrum for 5% Damping (Horizontal)

3.7.1-8

Seismic Design Parameters

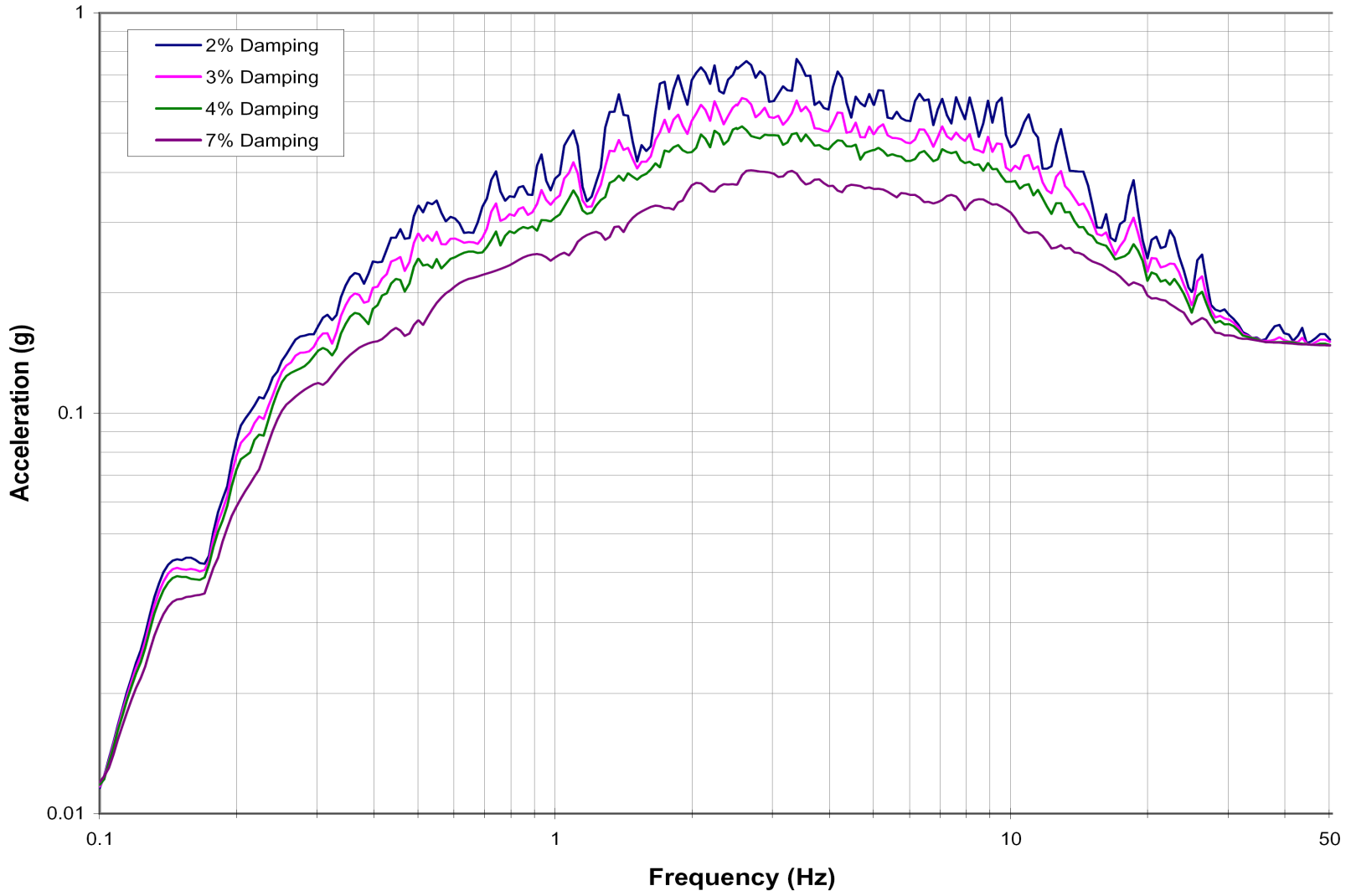


Figure 3.7-1b Site-Specific SSE Design Response Spectra (Horizontal)

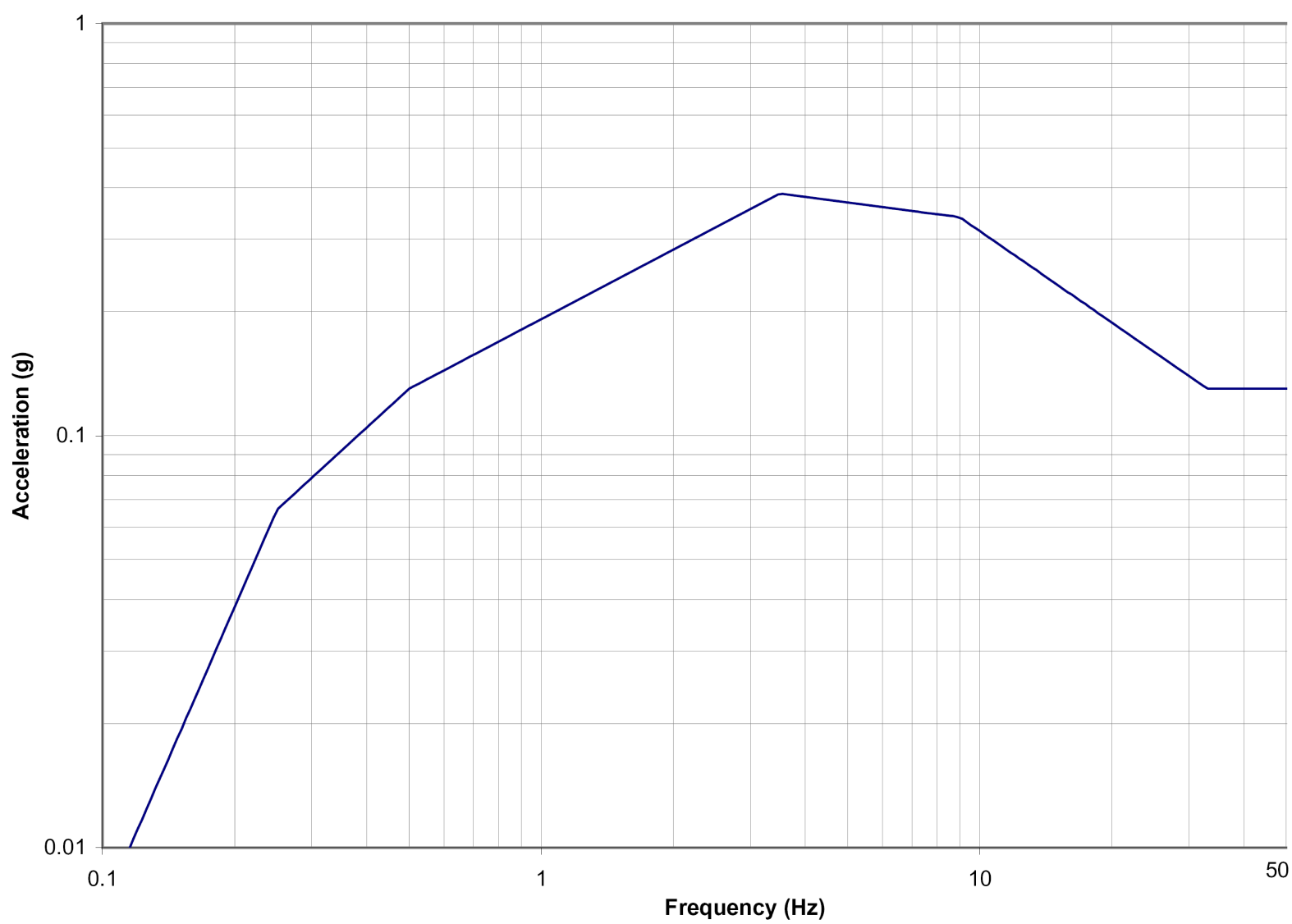


Figure 3.7-2a Site-Specific Design Response Spectrum for 5% Damping (Vertical)

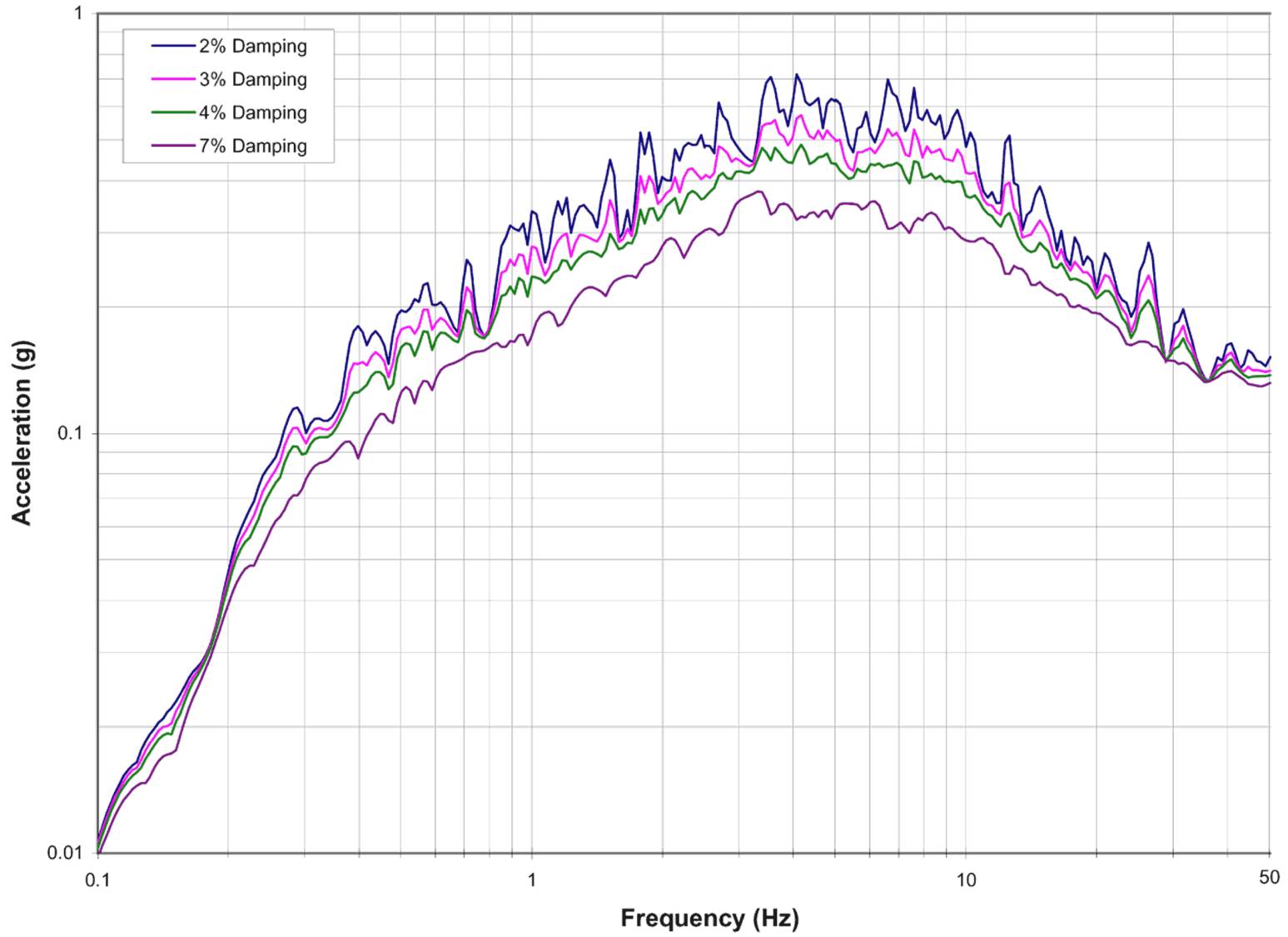


Figure 3.7-2b Site-Specific SSE Design Response Spectra (Vertical)

Figure 3.7-34 ~~Radwaste Building Seismic Mode~~ Not Used

Figure 3.7-35 ~~Comparison of Ground Surface Spectra for DCD UB Soil Profile and Site Specific Soil Profiles for a Typical Time History~~

Figure 3.7-36 Comparison of Reactor Building Foundation Level Spectra for DCD-UB Soil Profile and Site Specific Soil Profiles for a Typical Time History

Figure 3.7-37 ~~Comparison of Control Building Foundation Level Spectra for DCD-UB Soil Profile and Site Specific Soil Profiles for a Typical Time History~~

