3.7.2 Seismic System Analysis

This section provides seismic analysis details for Seismic Category I, II, Conventional Seismic (CS), and Radwaste Seismic (RS) structures that are considered in conjunction with the foundation and its supporting media as seismic systems. Other seismic structures, systems, equipment, and components that are not designated as seismic systems (i.e., heating, ventilation and air-conditioning systems; electrical cable trays; piping systems) are designated as seismic subsystems. The analysis of seismic subsystems other than piping is presented in Section 3.7.3. The analysis of piping subsystems is described in Section 3.9.2 and Section 3.12.

A three-dimensional rendering of the U.S. EPR is shown in Figure 1.2-1. Typical building locations are shown in the dimensional arrangement drawing of Figure 3B-1. The Nuclear Island (NI) Common Basemat Structures consist of ten buildings that share one common basemat. The NI common basemat is a heavily reinforced concrete slab which supports the Reactor Building (RB), Reactor Building Internal Structures, Safeguard Buildings (SB) 1 thru 4, Fuel Building (FB), SBs 2 and 3 shield structure, FB shield structure, RB shield structure, as well as the main steam valve stations (MSVS), the Vent Stack (VSTK), and the staircase towers (SCT) (see Figure 3B-1). Safeguard Building 2 and 3 are separate structures that share a common wall. An interior cutaway view of the U.S. EPR NI Common Basemat Structures is shown in Figure 3.7.2-1—Decoupling of the Nuclear Island Common Basemat Interior Structures from the Outer Shield Walls, which illustrates the hardened protection afforded by the aircraft protection shield structures and the decoupling between them and the remaining structures on the NI common basemat. The shield structures are discussed in more detail below.

The RB occupies the central portion of the NI common basemat and houses the reactor coolant system (RCS). The RB consists of three concrete structures:

- The inner Reactor Containment Building (RCB).
- The outer Reactor Shield Building (RSB).
- The RB Internal Structures (RBIS).

The RBIS are housed within the RCB. The main steam system (MSS) and main feedwater system valve stations are located within SBs 1 and 4. The SCTs are reinforced concrete structures located at the perimeter of the RSB. The SCTs are located in the areas where the footprints of the SBs and the FB overlap.

The primary function of the RSB is to protect the RCB from missiles and loads resulting from external design basis events such as hurricanes and tornados, as well as beyond design basis events such as extreme aircraft hazards and explosion pressure waves. The hardened cylindrical shell and dome are part of the monolithic protective shield that extends from the north wall of SBs 2 and 3, over the RCB, and to the south wall of the FB. The exterior walls and roof slab of the SCTs are part of this monolithic protective shield. The space between the interior surface of the RSB and the exterior surface of the RCB forms the RB Annulus. The approximately six-foot wide annulus serves as an access area for personnel and as a shelter for cables, piping, and heating, ventilation, air conditioning ducts, and it provides clearance to prevent structural interactions during design basis and beyond design basis events.

The common basemat provides assurance that overturning of the supported structures as a result of a seismic event or other hazards, such as aircraft impact, will not occur. To provide additional protection from external hazards and beyond design basis events, the containment interior structures are decoupled from the outer walls (see Figure 3.7.2-1). Because of the decoupling, containment interior structures are only connected by the common basemat foundation to the surrounding structure. In addition, except for electrical and mechanical system tie-ins, the NI Common Basemat Structures are structurally isolated from adjacent structures.

Two Emergency Power Generating Buildings (EPGB) and four Essential Service Water Buildings (ESWB) are situated in the vicinity of the NI Common Basemat Structures. The EPGB provides emergency power for the plant to allow safe shutdown and maintain safe shutdown, while the ESWB provides component cooling water for the safe operation and emergency shutdown of the plant. Key attributes of the two structures are:

- Each EPGB contains two diesel powered generators as well as two 120,000 gallon fuel storage tanks.
- Each ESWB includes a pumphouse and mechanical cooling towers with cells 60 feet square.

The U.S. EPR EUR-based and high frequency content certified seismic design response spectra (CSDRS), as described in Section 3.7.1, are associated with a variety of potential soil and rock conditions intended to encompass the majority of potential sites in the central and eastern United States. A soil-structure interaction (SSI) analysis is performed on the U.S. EPR NI Common Basemat structures, Nuclear Auxiliary Building (NAB), EPGB, and ESWB to compute the global seismic responses of the structures for the variety of soil conditions considered in Section 3.7.1.3. An embedded 3D finite element model (FEM) of the NI Common Basemat Structures and an embedded stick model of the NAB are used in the seismic SSI analysis. For the EPGB and ESWB, 3D FEM of the structures are used in the seismic SSI analysis. As described in Section 3.7.1, the input ground motion for the SSI analysis of the EPGB and ESWB is different from that for the NI and NAB.

The following sections describe the seismic analyses performed for the Seismic Category I, II, CS, and RS structures of the U.S. EPR. The seismic classification of U.S.

EPR structures is defined in Section 3.2. These seismic analyses meet the requirements of 10 CFR 50, GDC 2 and 10 CFR 50, Appendix S, with respect to the capability of the structures to withstand the effects of earthquakes. Application of the criteria in Section 3.7 to the seismic analysis and design of the U.S. EPR results in a robust design with significant seismic margin, as demonstrated in the seismic margin assessment of Section 19.1. A COL applicant that references the U.S. EPR design certification will confirm that the site-specific seismic response is within the parameters of Section 3.7 of the U.S. EPR standard design. The impact of changes to the standard design at the detailed design stage is evaluated using the following criteria.

- The effects of deviations are evaluated using methods that are consistent with those of Section 3.7 as used for the certified design.
- The evaluation considers the combined effect of such deviations.
- The combined deviations of the in-structure response spectra will be evaluated on a case-by-case basis.

3.7.2.1 Seismic Analysis Methods

The response of a multi degree-of-freedom system subjected to seismic excitation may be represented by the differential equations of motion in the following general form:

Equation 1

$$[M]\{\ddot{X}\}+[C]\{\dot{X}\}+[K]\{X\}=-[M]\{\ddot{u}_g\}$$

Where:

$[M]$ = mass matrix (n x n)

$[C]$ = viscous damping matrix (n x n)

$[K]$ = stiffness matrix (n x n)

$\{X\}$ = column vector of relative displacements (n x 1)

$\{\dot{X}\}$ = column vector of relative velocities (n x 1)

$\{\ddot{X}\}$ = column vector of relative accelerations (n x 1)

n = number of degrees of freedom

$\{\ddot{u}_g\}$ = column vector of input acceleration (n x 1)

Depending on the type of analysis and application, the following seismic analysis methods are used to solve the above equations of motion to determine the seismic responses of the U. S. EPR structures.

- Time history analysis method.
- Response spectrum method.
- Complex frequency response analysis method.
- Equivalent-static load method of analysis.

Seismic analysis is performed for the three orthogonal (two horizontal and one vertical) components of earthquake motion defined in Section 3.7.1. The orthogonal axes are aligned with the global axes of the seismic analysis models.

3.7.2.1.1 Time History Analysis Method

Equation 1 is solved using the time history analysis method in the time domain for the seismic response of the system using either the direct integration technique or the modal superposition technique. The choice of the technique depends on whether or not the system is a linear one.

When the system is linear elastic and the damping of the system in lieu of the damping matrix [C] may be explicitly specified as modal damping ratios associated with the normal modes of the system, the modal superposition technique is used to solve Equation 1 for the seismic response of the system. The modal time history analysis technique is used in the analysis of the fixed-base NI Common Basemat Structures to demonstrate dynamic compatibility between the dynamic 3D FEM used in the SSI analysis and the 3D FEM used in the static analysis. The modal time history analysis technique is also used in the (1) fixed-based RBIS analysis to demonstrate dynamic compatibility between the RBIS stick model used in the RCS structural analysis and the SSI analysis dynamic 3D FEM; and (2) the analysis of the fixed-base NAB structure to demonstrate dynamic compatibility between the stick model used in the SSI analysis and the static 3D FEM used in the static analysis. The modal time history analysis generates in-structure response spectra (ISRS) at representative locations of the structures for both the stick model and FEMs. The dynamic FEM and the NAB stick model used in the SSI analysis are considered compatible with the corresponding static FEMs when the ISRS of the SSI analysis model are similar to those at corresponding locations of the static FEM. For the NI Common Basemat Structures, ANSYS code, Version 11.0, is used in such modal time history analyses. For the NAB, the GTSTRUDL code, Version 29, is used in the modal time history analysis of both the stick model and FEM.

To solve Equation 1 numerically in the time domain using either the direct integration or modal superposition technique, the time step for numerical integration must be sufficiently small for stability and convergence of the solution. The time step is set to be no larger than one-tenth of the lowest natural period of interest. Normally, the lowest period of interest need not be less than the reciprocal of the zero period acceleration (ZPA) frequency. The general rule for solution convergence is that a time step must be small enough that use of one-half its duration does not change the response by more than ten percent. Section 3.7.2 describes each time history analysis case and the time step.

3.7.2.1.2 Response Spectrum Method

Response spectrum analyses are performed on flexible long span floors and roof of the NAB Non-Seismic Category I structure to obtain the amplified vertical accelerations of the floors. Input motion to the analysis is the vertical ISRS at the slab locations generated from the seismic SSI analysis of the NI Common Basemat Structures and NAB. This analysis technique is used for the Vent Stack, which is a Seismic Category I steel structure approximately 100 ft high located on top of the stair towercase structure between the FB and SB 4 (see Figure 3B-1).

Similar to the modal time history analysis method, when the response spectrum method is used it is assumed that the damping matrix [C] in Equation 1 may be explicitly represented by modal damping ratios so that the equation of motion given in Section 3.7.2.1 may be transformed to the equations of motion of the normal modes. The maximum seismic response of interest for each given mode is a function of the modal participation factor, mode shape and the input response spectrum acceleration at the corresponding modal frequency and damping ratio. The maximum modal responses are combined to determine the maximum response of interest in accordance with the combination method described in Section 3.7.2.7.

3.7.2.1.3 Complex Frequency Response Analysis Method

With this analysis method, the damping of the system is not represented by the viscous damping matrix, [C], but as the imaginary part of a complex stiffness matrix. Thus Equation 1 becomes complex and must be solved in the frequency domain. To facilitate the analysis, the time history of input ground motion is transferred to the frequency domain by Fast Fourier Transform (FFT). The seismic responses calculated in the frequency domain are then transferred back to the time domain as outputs by inverse FFT.

The complex frequency response analysis method is used in the seismic SSI analysis of all Seismic Category I structures. The computer code MTR/SASSI, Version 8.3, is used in the SSI analysis of the NI Common Basemat Structures and NAB, EPGBs, and

ESWBs. For the SSI analysis results to be sufficient, the following requirements are met:

- A sufficiently high cut-off frequency is selected to ensure all significant SSI frequencies are included.
- A sufficient number of frequency points is used to accurately define the transfer functions within the cut-off frequency.
- The time step size for the input ground motion time histories is sufficiently small to be compatible with the selected cutoff frequency.

The SSI analysis generates the maximum ZPA at various floor locations, the floor acceleration time histories at representative locations for ISRS generation, the maximum member or element forces and moments, and the maximum relative displacements at the structural basemats with respect to the free-field input motions.

The complex frequency response analysis method is also used in the soil column analysis using SHAKE91 to compute the free-field "in-column" motion at the foundation level of the NI Common Basemat Structures, EPGB, and ESWB for use as the input motion to the SSI analysis. This is because the SSI analysis of the NI Common Basemat Structures, EPGB, and ESWB considers structural embedment, and the input ground motion specified in Section 3.7.1 corresponds to a hypothetical free-field "outcrop" motion at the foundation level. MTR/SASSI, Version 8.3 requires that the input motion, when specified at the foundation level, be an "in-column" motion converted from the "outcrop" motion through a soil column analysis. Alternatively, a surface motion converted from the "outcrop" motion can also be used.

3.7.2.1.4 Equivalent Static Load Method of Analysis

This analysis method is used to determine the seismic induced element forces and moments in the 3D FEMs of the NI Common Basemat Structures, EPGB, ESWB and NAB. In the analysis, equivalent static loads corresponding to the ZPAs generated from the seismic SSI analyses are applied to the 3D FEMs of the structure and basemat for the applicable SSI analysis cases. Computer codes used in the analyses include ANSYS code Version 11.0 for the NI Common Basemat Structures, and GTSTRUDL code Version 29 for the EPGB, ESWB, and NAB.

Consideration of torsional loading induced by accidental eccentricities is presented in Section 3.7.2.11.

3.7.2.2 Natural Frequencies and Response Loads

In the SSI analysis, the NI Common Basemat Structures are represented by an embedded 3D FEM, and the RCS and NAB are represented by stick models. The EPGB and ESWB are each represented by a 3D FEM. Section 3.7.2.3 discusses the development of the structural models.

Table 3.7.2-1—Frequencies and Modal Mass Ratios for NI Common Basemat Structures with All Masses Included shows the frequencies and modal mass ratios of the dynamic 3D FEM of the NI Common Basemat Structures, and Table 3.7.2-4—Modal Frequencies of the Simplified Stick Model of Reactor Coolant Loop, shows the frequencies of the first 50 modes of the simplified stick model of the RCS. STICK-1T is the stick model for the RBIS and includes applicable masses in addition to the masses of the concrete. Frequencies and modal mass ratios of STICK-1T are shown in

- Table 3.7.2-3—Frequency and Modal Mass Ratios for Reactor Building Internal Structures STICK-1T with All Masses Included.

Table 3.7.2-6—Modal Frequencies of the Stick Model of NAB shows the frequencies and modal mass ratios computed by GTSTRUDL code for the first 25 modes of the NAB stick model. Table 3.7.2-7—Modal Frequencies of 3D FEM of Emergency Power Generating Building shows the frequencies of the 3D FEM of the EPGB. Table 3.7.2-8—Modal Frequencies of 3D FEM of Essentialmergency Service Water Building (EUR Motions) and Table 3.7.2-32—Modal Frequencies of 3D FEM of Essential Service Water Building (HF Motion) show the frequencies of the 3D FEMs of the ESWB used in SSI analysis based on the EUR motions and HF motion, respectively.

Since the SSI analysis is performed using the complex frequency response method where the equation of motion is solved in the frequency domain, the modal frequencies and mass ratios presented in the tables above are for reference information only.

3.7.2.3 Procedures Used for Analytical Modeling

Seismic SSI analysis of the Seismic Category I structures is performed following the guidance in ASCE 4-98 (Reference 1) and SRP 3.7.2 (Reference 2). Methodology for development of the structural models is discussed below. Methodology for development of the SSI analysis model is discussed in Section 3.7.2.4.

3.7.2.3.1 Seismic Category I Structures – Nuclear Island Common Basemat

The NI Common Basemat is approximately 10 feet thick and transitions to a thickened section where the cylindrical walls of the RSB and the RCB intersect with the basemat. The basemat then steps down at the outer edge of the tendon gallery wall and continues out under the SBs, FB, and the SCTs (see Figure 3.7.2-3).

The SBs basemat is approximately 10 feet thick from the intersection with the outer surface of the RSB wall to the internal wall dividing the radiological control area and nonradiological control area, where it thickens to approximately 13 feet and continues to the intersection with the exterior wall.

The FB basemat is approximately 10 feet thick throughout, with the exception of an area of the basemat that steps down to form a sump at the common wall with the RSB wall, and then steps up and continues out to the intersection with the exterior wall.

A total of eight SSI analyses are performed for the NI and NAB for eight soil and rock conditions. Five are encompassed by the EUR design spectra for the hard, medium, and soft soil conditions, and three are associated with the HF GMRS as described in Section 3.7.1. The purpose of the SSI analyses is to generate sets of global seismic response loads which can be used in the design of the Seismic Category I SSC. The seismic response loads generated include forces on the members and accelerations at nodal locations, ISRS at representative locations, and ISRS at representative flexible slabs.

In the SSI analysis, the NI Common Basemat Structures are represented by an embedded 3D FEM, and the RCS and NAB are represented by stick models. The 3D FEM is illustrated in Figure 3.7.2-113—Dynamic 3D Finite Element Model of Nuclear Island, Isometric View. Development of the 3D FEMs for the NI Common Basemat Structures is described in Sections 3.7.2.3.1.1 (static 3D FEM) and 3.7.2.3.1.2 (dynamic 3D FEM). The static FEM is used in the equivalent static analysis and provides the basis for the development of the dynamic FEM, which is used in SSI analysis of the NI Common Basemat Structures. The RCS is represented by a simplified stick model that is separately developed and coupled with the FEM of the RBIS for the SSI analysis of the NI Common Basemat Structures. The simplified RCS stick model is shown in Figure 3.7.2-56—Simplified Stick Model of Reactor Coolant Loop, and is compatible with a more detailed RCS model. The stick model for the RBIS is developed for RCS structural analysis and is dynamically compatible with the 3D FEM of the RBIS. The NAB is represented by a single embedded stick model supported on a separate basemat. The stick model for the NAB is developed in a manner similar to that used for the RBIS stick and is dynamically compatible with the 3D FEM of the NAB. Development of the stick models is described in Section 3.7.2.3.1.3. The SSI analysis is discussed in more detail in Section 3.7.2.4.

The stability check is performed considering the seismic time history response of the structure, and the factor of safety against sliding is calculated on a time history basis. The factor of safety against sliding is defined as the sliding resistance (or capacity) to demand ratio. The sliding resistance is determined by the frictional force, which is based on the dead weight of the structure minus the buoyancy forces and upward seismic loading multiplied by the coefficient of friction, passive soil pressure, and hydrostatic forces. The seismic demand includes driving forces based on soil reactions from the SASSI analysis, active soil pressure, surcharge loading, and hydrostatic pressure.

The passive soil capacity calculations determine the relationship between the displacement of a wall pushing into side soil/backfill and resistance to this displacement because of passive soil pressure mobilized behind the wall for the NI soil-retaining sidewalls. The passive soil capacity calculations are performed using the ADINA computer program. The analyses results estimate the coefficient of passive soil pressure (Kp) for seismic stability assessments. The time dependent Kp is used to determine passive pressures that resist the driving forces at each time step. The time history of seismic driving (demand) forces is determined from an SASSI analysis. The sliding factor of safety is determined at each time step. Full passive pressure is not required to meet a minimum factor of safety of 1.1 against sliding.

3.7.2.3.1.1 3D Finite Element Models for Static Analysis

The static 3D FEM is developed for the static and/or equivalent static analysis of the NI Common Basemat Structures. The static FEM is used to show dynamic compatibility between the static and dynamic FEMs as described in Section 3.7.2.3.1.2. Similarly, the 3D FEM developed for the static and/or equivalent static analysis of the NAB is used as the basis for adjusting or fine tuning the section properties of the NAB stick model to provide a reasonable dynamic compatibility between the two types of model. The static 3D FEM for the NI Common Basemat Structures consists of the following:

- A shell element 3D FEM of the seven balance-of-NI Common Basemat Structures consisting of the RSB, SB 2 and 3 shield structure, FB shield structure, SBs 1, 2/3 and 4, and FB. The FEM is developed for the ANSYS computer code. There is lateral structural coupling among the seven structures at some elevations above the top of the common basemat. Representations of the FEM are shown in Figure 3.7.2-5—Static 3D Finite Element Model of Balance of NI Common Basemat Structures Perspective View, Figure 3.7.2-6—Static 3D Finite Element Model of Balance of NI Common Basemat Structures Cutoff View on Y-Z Plane, and Figure 3.7.2-7—Static 3D Finite Element Model of Balance of NI Common Basemat Structures Cutoff View on X-Z Plane.

- A solid element 3D FEM of the RCB is developed for the ANSYS computer code. This model is shown in Figure 3.7.2-8—Static 3D Finite Element Model of Reactor Containment Building.

- A shell element 3D FEM of the RBIS developed for the ANSYS code, as shown on Figure 3.7.2-9—Static 3D Finite Element Model of Reactor Building Internal Structures. The only exception is that solid elements are used to represent the lower portion of the Reactor Pressure Vessel (RPV) pedestal.

The static 3D FEMs of the NI Common Basemat Structures are connected to the top of the common basemat which is represented by solid elements of the ANSYS code. The particular elements of the ANSYS code used are listed below.

- SOLID45 – An eight-node solid element used to model the common basemat.

- SHELL43 – A four-node shell element used to model walls, slabs and the shell of the RB. This element is suitable for moderately thick shell structures and can also provide out of plane shear forces.

- BEAM44 – Used to model beams and columns.

The 3D FEM of the NAB consists of shell elements and is developed using the GTSTRUDL code, Version 29. It is used in the equivalent static analysis and serves as the basis for tuning the stick model of the NAB to ensure reasonable dynamic compatibility with the FEM.

3.7.2.3.1.2 3D Finite Element Models for Dynamic Analysis

The dynamic 3D FEM is developed for the SSI analysis of the U.S. EPR NI Common Basemat Structures. When the FEM and the degree of discretization are selected, it is ensured that the model can reliably be used to determine the structural response within the relevant frequency range. The stiffness of individual parts of the structure is represented by shell or beam finite elements, and only relevant structural elements to show a correct dynamic behavior of the NI buildings are considered. To facilitate development of a structured finite element mesh for the dynamic 3D FEM, a base grid is defined for each building except the RBIS. Each base grid consists of grid axes that are in the directions of the three orthogonal axes. The distance between adjacent grid axes as well as the size of typical shell finite elements is about 1.5 m. The following simplifications are made in the development of the model:

- Foundation level for all buildings is -38 ft, 10-1/2 inches (-11.85 m).

- Elements representing walls in the solid part of the basemat are considered to be rigid.

- Walls, ceilings and openings are moved to the nearest axes of the base grid.

- Openings smaller than about $1.5m^2$ are not considered.

- Walls and ceilings with a thickness less than 0.30m such as staircases, landings or channels are not considered.

For the dynamic FEM, shell elements are used to model walls and slabs, and the solid elements used to model the basemat in the static FEM are replaced with shell elements. Two removable walls, which enclose the inside faces of the SG towers above Elev. +63 feet, 11-3/4 inches, are also modeled by shell elements. The two side edges and bottom edge of each removable wall is attached to the SG using pinned boundary conditions at the wall supports. Most material properties of the dynamic FEM, with the exception of the walls inside the basemat that are assumed to be rigid, remain the same as the static FEM. The elements to model the tendons and steel liner plate in the static FEM are not included in the dynamic FEM. Beam elements are used to model internal columns, shield building buttresses, Polar Crane (PC) beams, and RCS beams. Lumped masses are included to model the PC and NSSS equipment.

To model structural loads, the dead and live loads are applied to the model and solved statically. The reactions at each node are found and then applied to the dynamic FEM as lumped masses, which include mass contributions from the following elements:

- Permanent equipment and distribution systems supported by slabs and platforms.
- Water in pools under normal operating conditions.
- Twenty-five percent of the live loads (variable loads) on floor slabs and platforms.
- Seventy-five percent of the maximum snow load on roof slabs.
- Miscellaneous dead loads of at least 50 psf.

In the dynamic FEM, the hydrodynamic loads are considered by adding the tributary water mass to the pool walls and slabs. For the static FEM, the hydrodynamic loads are developed using the method provided in TID-7024 and applied to the pool walls and slabs in the form of pressure distribution. The spent fuel racks are considered by lumping 100 percent of the spent fuel load at the bottom slab in the vertical direction and by distributing it along the height of the pool in the horizontal direction. Rack structure interaction is not considered in development of the FEM for the FB as far as global seismic response is concerned.

The sufficiency of the dynamic FEM is established by a comparison of the five percent damping ISRS envelopes between the static and dynamic fixed base FEMs at various locations within the models. The input ground motions are the three components of synthetic time histories for the EUR Hard motion. The ANSYS code, Version 11.0, is used in the modal time history analysis of the static FEM, whereas the MTR/SASSI code code Version 8.3, is used in the frequency response analysis of the dynamic FEM. The 0.0025 second time step is used in the modal time history analysis for the EUR Hard input motion, in which one-half the time step (0.00125 seconds) changes the ISRS by less than ten percent as indicated in Section 3.7.2.1.1. The figures listed show the spectrum comparison at the following locations:

- RSB
  - Apex of dome at elevation +200 ft, 5 inches. See Figure 3.7.2-14—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +200 ft, 5 in (+61.09m) (Dome Apex) of Reactor Shield Building, 5% Damping, X-Direction, Figure 3.7.2-15—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +200 ft, 5 in (+61.09m) (Dome Apex) of Reactor Shield Building, 5% Damping, Y-Direction, and Figure 3.7.2-16—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +200ft, 5 in (+61.09m) (Dome Apex) of Reactor Shield Building, 5% Damping, Z-Direction.

- SB 1
  - Roof at elevation +95 ft, 1-3/4 inches. See Figure 3.7.2-17—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +95 ft, 1-3/4 in (+29.00m) - Safeguard Building 1, 5% Damping, X-Direction, Figure 3.7.2-18—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +95 ft, 1-3/4 in (+29.00m) - Safeguard Building 1, 5% Damping, Y-Direction, and Figure 3.7.2-19—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +95 ft, 1-3/4 in (+29.00m) - Safeguard Building 1, 5% Damping, Z-Direction.
  - Floor at elevation +26 ft, 3 inches. See Figure 3.7.2-20—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +26 ft, 3 in (+8.00m) - Safeguard Building 1, 5% Damping, X-Direction, Figure 3.7.2-21—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +26 ft, 3 in (+8.00m) - Safeguard Building 1, 5% Damping, Y-Direction, and Figure 3.7.2-22—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +26 ft, 3 in (+8.00m) - Safeguard Building 1, 5% Damping, Z-Direction.
- SB 4
  - Roof at elevation +95 ft, 1-3/4 inches. See Figure 3.7.2-23—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +95 ft, 1-3/4 in (+29.00m) - Safeguard Building 4, 5% Damping, X-Direction, Figure 3.7.2-24—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +95 ft, 1-3/4 in (+29.00m) - Safeguard Building 4, 5% Damping, Y-Direction, and Figure 3.7.2-25—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +95 ft, 1-3/4 in (+29.00m) - Safeguard Building 4, 5% Damping, Z-Direction.
  - Floor at elevation +26 ft, 3 inches. See Figure 3.7.2-26—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +26 ft, 3 in (+8.00m) - Safeguard Building 4, 5% Damping, X-Direction, Figure 3.7.2-27—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +26 ft, 3 in (+8.00m) - Safeguard Building 4, 5% Damping, Y-Direction, and Figure 3.7.2-28—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +26 ft, 3 in (+8.00m) - Safeguard Building 4, 5% Damping, Z-Direction.
- SB 2 and 3
  - Floors at elevation +68 ft, 10-3/4 inches. See Figure 3.7.2-29—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +68 ft, 10-3/4 in (+21.00m) - Safeguard Building 2/3, 5% Damping, X-Direction, Figure 3.7.2-30—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +68 ft, 10-3/4 in (+21.00m) - Safeguard Building 2/3, 5% Damping, Y-Direction, and Figure 3.7.2-31—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +68 ft, 10-3/4 in (+21.00m) - Safeguard Building 2/3, 5% Damping, Z-Direction.
  - Floors at elevation +26 ft, 3 inches. See Figure 3.7.2-32—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +26 ft, 3 in (+8.00m) - Safeguard Building 2/3, 5% Damping, X-Direction, Figure 3.7.2-33—Static FEM vs.

Dynamic FEM Spectrum Comparison at Elev. +26 ft, 3 in (+8.00m) - Safeguard Building 2/3, 5% Damping, Y-Direction, and Figure 3.7.2-34—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +26 ft, 3 in (+8.00m) - Safeguard Building 2/3, 5% Damping, Z-Direction.

- FB
  - Floors at elevation +62 ft, 4-1/4 inches. See Figure 3.7.2-35—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +62 ft, 4-1/4 in (+19.00m) - Fuel Building, 5% Damping, X-Direction, Figure 3.7.2-36—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +62 ft, 4-1/4 in (+19.00m) - Fuel Building, 5% Damping Y-Direction, and Figure 3.7.2-37—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +62 ft, 4-1/4 in (+19.00m) - Fuel Building, 5% Damping, Z-Direction.
  - Floors at elevation +23 ft, 7-1/2 inches. See Figure 3.7.2-38—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +23 ft, 7-1/2 in (+7.20m) - Fuel Building, 5% Damping, X-Direction, Figure 3.7.2-39—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +23 ft, 7-1/2 in (+7.20m) - Fuel Building, 5% Damping, Y-Direction, and Figure 3.7.2-40—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +23 ft, 7-1/2 in (+7.20m) - Fuel Building, 5% Damping, Z-Direction.
- RCB
  - Apex of dome at elevation +190 ft, 3-1/2 inches. See Figure 3.7.2-41—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +190 ft, 3-1/2 in (+58.00m) - Containment Dome Apex, 5% Damping, X-Direction, Figure 3.7.2-42—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +190 ft, 3-1/2 in (+58.00m) - Containment Dome Apex, 5% Damping, Y-Direction, and Figure 3.7.2-43—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +190 ft, 3-1/2 in (+58.00m) - Containment Dome Apex, 5% Damping, Z-Direction.
  - Circular crane rail support at elevation +123 ft, 4-1/4 inches. See Figure 3.7.2-44—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +123 ft, 4-1/4 in (+37.60m) - Containment Building, 5% Damping, X-Direction, Figure 3.7.2-45—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +123 ft, 4-1/4 in (+37.60m) - Containment Building, 5% Damping, Y-Direction, and Figure 3.7.2-46—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +123 ft, 4-1/4 in (+37.60m) - Containment Building, 5% Damping, Z-Direction.
- RBIS
  - Upper lateral supports for the SGs at elevation +63 ft, 11-3/4 inches. See Figure 3.7.2-50—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +63 ft, 11-3/4 in (+19.50m) - Reactor Building Internal Structure, 5% Damping, X-Direction, Figure 3.7.2-51—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +63 ft, 11-3/4 in (+19.50m) - Reactor Building

Internal Structure, 5% Damping, Y-Direction, and Figure 3.7.2-52—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +63 ft, 11-3/4 in (+19.50m) - Reactor Building Internal Structure, 5% Damping, Z-Direction.

– Support for the RPV at elevation +16 ft, 10-3/4 inches. See Figure 3.7.2-53—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +16 ft, 10-3/4 in (+5.15m) - Reactor Building Internal Structure, 5% Damping, X-Direction, Figure 3.7.2-54—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +16 ft, 10-3/4 in (+5.15m) - Reactor Building Internal Structure, 5% Damping, Y-Direction, and Figure 3.7.2-55—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +16 ft, 10-3/4 in (+5.15m) - Reactor Building Internal Structure, 5% Damping, Z-Direction.

To bound the dynamic response in the SSI analysis considering the fully cracked and uncracked conditions for walls and slabs, an additional dynamic 3D FEM for the NI Common Basemat Structures is developed. The wall and slab thicknesses for this model are reduced to a value corresponding to 0.5I (where I = moment of inertia of uncracked section) to simulate cracked section properties in the out-of-plane direction.

3.7.2.3.1.3 Development of Stick Models for RBIS and NAB

The stick model for the RBIS is developed for RCS structural analysis. The NAB stick model and the simplified stick model for the RCS are developed for SSI analysis of the NI Common Basemat Structures. The stick models are developed by first locating key elevations (typically the major floor slab elevations) in the structure. Between two successive key elevations, two vertical massless sticks are developed. One stick is located at the center of shear area and the other at the center of axial area respectively, of the vertical structural elements between the two given key elevations. Section properties of the two sticks are determined by hand calculations based on the structural drawings. The total axial area of the vertical structural elements is assigned to the stick located at the center of axial area. The remaining five section properties, including the total shear areas along the two global axes and the total moments of inertia about the three global axes, are assigned to the stick located at the center of shear area. The two sticks are connected to each other at both their upper and lower ends with a horizontal rigid beam.

At the key elevations of the structure, a lumped mass is placed at the center of mass. The lumped mass is connected with horizontal rigid beams to the center of shear area and center of axial area located at the same elevation. It includes mass contributions from the following elements:

- Floor or roof slab(s), when applicable, at the particular elevation.
- Walls and miscellaneous floor slabs and platforms (including platform live load) within half height to the next key elevation below.

- Walls and miscellaneous floor slabs and platforms (including platform live load) within half height to the next key elevation above.
- Permanent equipment and distribution systems supported by slabs and platforms.
- Water in pools under normal operating conditions.
- Twenty-five percent of the live loads (variable loads) on floor slabs and platforms.
- Seventy-five percent of the maximum snow load on roof slabs, when applicable.
- Miscellaneous dead loads of at least 50 psf.

Floor/roof slabs and walls are assumed rigid when developing the stick model, except that out-of-plane flexibilities of the following RBIS walls are explicitly accounted for by SDOF oscillators in the stick model:

- The removable walls at the steam generator (SG) towers above elevation +63 ft, 11-1/2 inches of the RBIS.

At these locations, six SDOF oscillators simulating the local out-of-plane vibration along the height of the removable walls. Three for each tower are connected to the lumped masses at the proper elevations of the stick model to better represent the dynamic characteristics of the RBIS.

For the RBIS, the properties of the stick model developed by hand calculations are adjusted to provide a reasonable dynamic compatibility between the stick model and the corresponding dynamic 3D FEM of the structures when only the masses of concrete and other applicable permanent dead weights are considered. For the NAB, the adjustment is made considering the models that also account for 25% of live load and 75% of roof snow load. The adjustment is made on a trial and error basis so that the two models are reasonably similar to each other in not only the modal frequencies and mass ratios but also the ISRS at selected locations of the structure.

(1) Stick Model STICK-1T for Fixed Base Reactor Building Internal Structures

This stick model is developed using the GTSTRUDL code and is fixed at its base at elevation -21 ft., 4 inches. It is split into two sticks at and above elevation +63 ft, 11-3/4 inches because the two SG compartments are separated from each other except for a few miscellaneous walls and slabs that form a minor structural coupling between the two. The two split sticks are taken to be symmetrically located with respect to the Y-Z plane although they may have slightly different section properties and masses. As usual, rigid horizontal beams are used to link the lumped masses to the sticks where they are not coincidentally located. The only exception is taken at elevation +63 ft, 11-3/4 inches where the lumped mass is connected to the lower ends of the two split sticks of the SG compartments with horizontal flexible beams. In addition, a horizontal flexible beam is used to connect the lumped masses on the split sticks at each of the two higher elevations, +79 ft, 0-3/4 inches and +93 ft, 6 inches. Figure 3.7.2-13—Stick Model STICK-1T for Reactor Building Internal Structure - Perspective View and Figure 3.7.2-120—Dynamic 3D Finite Element Model of Reactor Building Internal Structures (RBIS) show the GTSTRUDL code stick model, STICK-1T, and the dynamic 3D FEM, respectively, of the fixed base RBIS.

The section properties of the vertical stick elements are adjusted and the flexible horizontal beams at and above elevation +63 ft, 11-3/4 inches are estimated, on a trial-and-error basis, to ensure a reasonable compatibility between the stick model and dynamic FEM. The sufficiency of the stick model is established by a comparison of the five percent damping ISRS envelopes between the concrete-only stick model and dynamic FEM at three representative elevations, +63 ft., 11-3/4 inches (at upper lateral supports for the SGs), +30 ft., 9-1/4 inches (at lower lateral supports for the SGs) and +16 ft, 10-3/4 inches (at support for the RPV). The input ground motions are the three components of synthetic time histories for the EUR Hard motion and HF motion.

Table 3.7.2-3 shows the frequencies and modal mass ratios of the first 30 modes of STICK-1T with all applicable masses included.

(2) Simplified Stick Model for Reactor Coolant System

Figure 3.6.3-1 shows a plan view of the configuration of the RCS. A simplified stick model of the RCS is developed for the purpose of the SSI analysis of the NI Common Basemat Structures. The simplified stick model is shown in Figure 3.7.2-56. The simplified stick model is coupled to appropriate nodal locations of the dynamic 3D FEM of the RBIS. The modal frequencies of the simplified RCS stick model are shown in Table 3.7.2-4.

(3) Stick Model for NAB

The stick model for the NAB is developed in a manner similar to that for the RBIS stick model. Dynamic compatibility between the stick model and 3D FEM is ensured by comparing the ISRS generated at selected locations for both models. Figure 3.7.2-67—Elevation View of NAB Stick Model in Y-Z Plane, shows elevation views of the stick model in the global X-Z and Y-Z plane.

3.7.2.3.1.4 Finite Element Model for NI Common Basemat Foundation

The 3D basemat FEM is used for the analysis and design of the NI Common Basemat foundation. The FE discretization is selected so that the elements representing elevations and varying thickness of the basemat are able to produce reliable forces and moments for design. The 3D basemat FEM consists of solid elements connected to the shell or beam element of the SASSI dynamic model described in Section 3.7.2.3.1.2 using the ANSYS code. Lumped masses representing the dead and live structural loads are applied to the model similar to the 3D FEMs for the Dynamic Analysis described in Section 3.7.2.3.1.2. Representations of the FEM are shown in Figure 3.7.2-151—Solid Element Basemat.

The model has soil spring dashpot elements in the three translational directions at the bottom to idealize the soil column behavior and sidewall spring elements for the active, at-rest and passive states of earth pressure caused by the movement of the NI sidewalls against embedded soil mass. A parametric comparison of different soil spring formulations was performed for the seismic model. The Gazetas formulation produced displacements and base reactions similar to SASSI and, therefore, was selected and used in the model. The distribution for seismic and static vertical soil springs is elliptical in nature as described by the equation in Section 3.8.5.4.2. The model represents the sliding interface between the foundation concrete basemat and the underlying soil using sliding elements, and allows for basemat uplift through compression only vertical springs. The ANSYS model is loaded statically by accelerating the lumped and distributed masses described in Section 3.7.2.3.1.2 before a nonlinear time-history analysis is performed. The input motions are in-column ground motions obtained from SHAKE91 analysis runs at the bottom of the NI Common Basemat foundation level in the three translational directions derived using the NEI approach in Section 2.5.2.6.

The SSI analysis, described in Section 3.7.2.4, is a frequency domain linear seismic analysis. The additional loads due to the nonlinearities of basemat uplift and sliding obtained in the 3D basemat FEM need to be considered for the design of the tendon gallery. The additional (delta) loads, generated on the tendon gallery walls due to sliding, are calculated by performing additional analyses without allowing for sliding and uplift behavior and comparing the results (sidewall pressures and design forces and moments) to the analysis that includes all the nonlinear effects. When nonlinear responses are observed in the model, the increase in loading is added to the SSI results described in Section 3.7.2.4 for the design of tendon gallery.

3.7.2.3.2 Seismic Category I Structures – Not on Nuclear Island Common Basemat

3D FEM’s for the EPGB and ESWB are developed with GTSTRUDL code, Version 31, for use in both the equivalent static analysis and SSI analysis. For SSI analysis, the GTSTRUDL FEM’s are translated to a format suitable for the computer code MTR/SASSI, Version 8.3.

The reinforced concrete base mat, floor slabs, and walls of both structures are modeled in GTSTRUDL using shell elements, SBHQ6 and SBHT6, to accurately represent the structure and calculate both in-plane and out-of-plane effects from applied loads. For the EPGB, modifications are made to the slab stiffness at elevation +51 ft, 6 inches to accurately represent the stiffness of composite beams. For the ESWB, two additional modeling features are used:

- Space frame elements are used to simulate the fill support beams and the distribution header supports.
- In the lateral directions, the convective water mass is not included and only the rigid water mass, calculated in accordance with the procedure in ASCE 4-98, Reference 1 and ACI 350.3 (Reference 3), is lumped on the appropriate basin walls. The entire water mass is considered in the vertical direction. Both low water and high water level are separately considered.

Figure 3.7.2-57—Isometric View of GTSTRUDL FEM for Emergency Power Generating Building and Figure 3.7.2-58—Section View of GTSTRUDL FEM for Emergency Power Generating Building illustrate an isometric view and a section view of the 3D FEM of the EPGB. Figure 3.7.2-59—Isometric View of GTSTRUDL FEM for Essential Service Water Building (EUR Motions) and Figure 3.7.2-60—Section View of GTSTRUDL FEM for Essential Service Water Building (EUR Motions), depict the 3D FEM of the ESWB used in SSI analysis based on the EUR motions.

To bound the dynamic response in the SSI analysis considering the fully cracked and uncracked conditions for walls and slabs, and additional 3D FEM is developed for the EPGB and the ESWB. The wall and slab thicknesses for these models are reduced to a value corresponding to 0.5I (where I = moment of inertia of uncracked section) to simulate cracked section properties in the out-of-plane direction.

The EPGB is a surface mounted structure and its stability determination is analytically performed in the same manner as for the NI Common Basemat structure. The same analytical tools are used for Seismic Category I structures. To increase the margin due to overturning, the side wall friction for the embedded portions (i.e., the basemat and the shear keys are used). The sidewall friction forces are calculated using a coefficient of friction, μ = tan 20 deg = 0.36, with the at-rest soil pressure. The sliding and overturning safety factor of 1.1 is met.

The ESWB is an embedded structure and its stability determination will be analytically performed in the same manner as for the NI Common Basemat structure. The ESWB basemat includes a horizontal extension to add foundation mass and engage the weight of the soil above the extension to meet the sliding and overturning safety factor of 1.1.

3.7.2.3.3 Seismic Category II Structures

Non-Seismic Category I structures with potential to impair the design basis safety function of a Seismic Category I SSC will be classified as Seismic Category II in accordance with the criteria identified in Section 3.2.1.2. Seismic Category II structures that are included in the U.S. EPR design are analyzed to SSE load conditions and designed to the codes and standards associated with Seismic Category I structures so that the margin of safety is equivalent to that of a Category I structure with the exception of sliding and overturning criteria. Because Category II structures do not have a safety function, they may slide or uplift provided that the gap between the Category II structure and any Category I structure is adequate to prevent interaction. Procurement, quality control, and QA requirements for Category II structures will be performed according to the guidance provided in Section 3.2.1.2. Site-specific Seismic Category II structures are addressed in Section 3.7.2.8.

3.7.2.3.4 Conventional Seismic (CS) Structures

The analysis and design of Conventional Seismic building structures will be in accordance with the applicable requirements of the International Building Code (IBC) (Reference 4) and other codes, as appropriate (see Section 3.2.1.4 for description of CS structures).

3.7.2.4 Soil-Structure Interaction

The SSI analysis of the NI Common Basemat Structures and NAB is performed using MTR/SASSI, Version 8.3, for the soil cases specified in Table 3.7.1-6. The free-field input motion to the SSI analysis is the certified seismic design response spectra (CSDRS) previously described in Section 3.7.1.1.1 for the seismic design of NI Common Basemat Structures.

MTR/SASSI, Version 8.3, is also used in the seismic SSI analysis of the EPGB and ESWB. Soil cases specified in Table 3.7.1-8 and Table 3.7.1-9 are considered for EPGB and ESWB, respectively. The free-field input motion to the SSI analysis is the modified CSDRS described in Section 3.7.1.1.1. The modified CSDRS accounts for the approximate structure-soil-structure interaction (SSSI) effect of the NI Common Basemat Structures on the free-field motions at the locations of these structures, and is developed based on the results of the SSI analysis of the NI Common Basemat Structures and NAB.

Methodology for the SSI analysis of the NI Common Basemat Structures and NAB, EPGB and ESWB is discussed in the following.

3.7.2.4.1 Step 1 - Selection of Soil Profiles

The soil profiles previously specified in Table 3.7.1-6 are representative of potential sites in the central and eastern United States (CEUS). The soil profiles considered for SSI analysis of the NI Common Basemat Structures and NAB are Soil Cases 1n2ue, 2sn4ue, 4ue, 5ae, and 1n5ae, ranging from soft soil to medium soil to hard rock conditions, and hfub, hflb, and hfbe, representing soil conditions associated with high-frequency ground motion. Case 5ae simulates the hypothetical condition of a hard rock approaching a rigid foundation medium whereas Case 1n5ae simulates a soft backfill underlain by the same hard rock. Cases hfub, hflb and hfbe also contain a range of backfill soil layers. Table 3.7.2-9—Soil Properties Associated with Different

Shear Wave Velocities lists the soil properties associated with the various shear wave velocities considered in the soil profiles. For U.S. EPR design certification, the soil properties are taken to be strain-compatible values during seismic events. Column 2 of Table 3.7.1-6 shows the free-field input motion associated with each of the soil cases considered in the SSI analysis of the NI Common Basemat Structures and NAB. Each soil case is associated with one of the free-field input motions, giving rise to a total of eight SSI analysis cases for the NI Common Basemat Structures and NAB.
Figure 3.7.1-31 and Figure 3.7.1-32 illustrate the shear wave velocity profiles of the soil cases.

The soil cases considered in the SSI analysis of the EPGB and ESWB are specified in Table 3.7.1-8 and Table 3.7.1-9, respectively. Figure 3.7.1-60 through Figure 3.7.1-62 provide the shear wave velocity profiles of the soil cases. Soil cases 1n2u, 2sn4u, 4u, and 5a shown in Table 3.7.1-8 and Table 3.7.1-9 are the same as the soil cases 1n2ue, 2sn4ue, 4ue, and 5ae shown in Table 3.7.1-6, respectively, except that the ones in Table 3.7.1-6 have backfill layers above elevation -38 ft, 10-1/2 inches. The soil case 1n5a in Tables 3.7.1-8 and 3.7.1-9 is the same as the soil case 1n5ae in Table 3.7.1-6 except for the thickness of the backfill layer. The high frequency soil cases for the EPGB are hf_c and hf_s and are identified in Table 3.7.1-8. The seismic input for the EPGB and ESWB is the modified CSDRS that accounts for the effects of structure-soil-structure interaction between these structures and the Nuclear Island Common Basemat Structures, as described in Section 3.7.1.1.1. Two modified CSDRS are developed, one based on the EUR motions and the other based on the HF motion. As in the analysis of the NI Structures and NAB, soil cases considered in the analysis of the EPGB and ESWB are associated with SSSI, the EUR-based modified CSDRS and SSSIHF, the HF-based modified CSDRS.

3.7.2.4.2 Step 2 - Development of Models for Structures and Basemat

(1) NI Common Basemat Structures and NAB

Development of the dynamic 3D FEM for the NI Common Basemat Structures has previously been described in Section 3.7.2.3.1.3. The dynamic 3D FEM incorporates the NI Common Basemat Structures including the RBIS, RCB, RSB, FB, SBs 1, 2/3 and 4, SB 2/3 shield structure, FB shield structure, Polar Crane, and RCS. The ground surface is at elevation -9-3/4 inches (-0.25 m) and the bottom of the NI basemat is at elevation -38 ft, 10-1/2 inches (-11.85 m). A reinforced concrete tendon gallery extends down from the bottom of the RCB base to elevation -52 ft, 2 inches (-15.90 m). An isometric and elevation view of the dynamic 3D FEM is shown in Figure 3.7.2-113—Dynamic 3D Finite Element Model of Nuclear Island, Isometric View and Figure 3.7.2-114—Dynamic 3D Finite Element Model of Nuclear Island, Elevation View, respectively. The finite element models of FB, SB1, SB2/3, SB4, RCB and RBIS are shown in Figure 3.7.2-115 through Figure 3.7.2-120. The dynamic 3D FEM is a detailed finite element model that consists mainly of shell elements that represent the concrete floors, walls and basemat, as depicted in Figure 3.7.2-123—SSI Analysis Model – Nuclear Island Shell Elements. The excavated soil representing the region occupied by the subgrade portion of the NI foundation is modeled by solid elements as shown in Figure 3.7.2-121—SSI Analysis Model – Excavated Soil Solid Elements, Nuclear Island Foundation.

The RCS components are represented by the simplified stick model previously shown in Figure 3.7.2-56. The simplified stick model is coupled to the RBIS finite element model at the appropriate locations. The stick model of the RCS along with other beam elements of the NI Structures are shown in Figure 3.7.2-122—SSI Analysis Model – Nuclear Island Beam Elements.

Figure 3.7.2-128—SSI Analysis Model – Nuclear Auxiliary Building Stick Model shows the stick model of the NAB structure. The NAB foundation and side wall rigid beams and NAB foundation excavated soil are shown in Figure 3.7.2-126—SSI Analysis Model – Nuclear Auxiliary Building Foundation and Sidewall Rigid Beams and Figure 3.7.2-129—SSI Analysis Model – Nuclear Auxiliary Building Foundation Excavated Soil, respectively. For the excavated soil region of the NAB, only the south side wall rigid beams are provided because the other sides are closely adjacent to the surrounding buildings, as shown in Figure 3.7.2-132—Nuclear Island Foundation Layout Showing Basemat, Sidewalls, and Shear Key. Table 3.7.2-6 lists the frequencies and modal mass ratios calculated using the GTSTRUDL code for the first 25 modes of the fixed-base stick model of the NAB structure.

Structural damping values used in the SSI analysis are based on Table 3.7.1-1:

- Reinforced concrete (RBIS, balance-of-NI Common Basemat Structures and NAB) – 7 percent.
- Prestressed concrete (containment) – 5 percent.
- RCS components – 4 percent.

(2) EPGB and ESWB

Section 3.7.2.3.2 describes the development of the GTSTRUDL code 3D FEM of the structure, the translation of the FEM to that suitable for the MTR/SASSI code, and the development of the cracked FEM with reduced flexural stiffness in the out-of-plane direction of walls and slabs. Table 3.7.2-7, Table 3.7.2-8, and Table 3.7.2-32 show the frequencies computed by GTSTRUDL for the 3D FEM of the EPGB, ESWB (EUR motions), and ESWB (HF motion), respectively.

Both EPGB and ESWB are reinforced concrete structures. A structural damping equal to 4 percent is conservatively used in the SSI analysis.

3.7.2.4.3 Step 3 - Development of Soil Model

To develop the soil model for use in the SSI analysis with the SASSI code, each of the soil profiles is discretized into a sufficient number of sub-layers, followed by a uniform half space beneath the lowest sub-layer. The passing frequency f_p, which is the maximum frequency that can be represented by the soil model, is based on $f_p = V_s/(5L_e)$, where V_s is the soil shear wave velocity and L_e is the element size for discretizing the soil. Both the excavated soil element size and soil layer thickness are considered for L_e to assess the high-frequency transmission capability of the model in both the horizontal and vertical directions. The soil cases subjected to EUR soft input motions govern the design response spectra up to a frequency that is well below the calculated passing frequency of the subgrade. The medium and hard soil cases transmit frequencies up to the input motion frequency of interest. The upper bound HF (hfub) soil case bounds the ISRS responses in the high frequency range. The analysis models used in the seismic analyses, thus, adequately develop the seismic demand. The soil properties of the sub-layers corresponding to different generic shear wave velocities are shown in Table 3.7.2-9.

3.7.2.4.4 Step 4 - Development of SSI Analysis Model

(1) NI Common Basemat Structures and NAB

The NI Common Basemat Structures and NAB are embedded with the ground surface modeled at elevation -9-3/4 inches (-0.25 m) and the bottom of the basemat at elevation -38 ft, 10-1/2 inches (-11.85 m). The SSI analysis model is established by coupling the dynamic 3D FEM for the NI Common Basemat Structures and the stick model for the NAB with each of the soil models described in Step 3, at all interface nodes that represent the bottom faces of the NI Common Basemat Structures and NAB basemats and the lateral faces of the sidewalls. The interface nodes are shown in Figure 3.7.2-130—Nuclear Island and Nuclear Auxiliary Building Interface Nodes. The subtraction method provided by MTR/SASSI, Version 8.3, is used to account for the effects of seismic input and soil stiffness on the interface nodes. The surrounding Seismic Category I structures, EPGB and ESWB, are lighter than the NI Common Basemat Structures. It is expected that, through the soil, the SSI of the NI Common Basemat Structures will have some effects on the free-field seismic ground motions at these structures. To capture such effects, simple grids of massless rigid beams representing the footprints of these surrounding structures are placed at the respective plan locations on the soil surface of the SSI analysis model. Figure 3.7.2-124—SSI Analysis Model – Adjacent Structures Foundation Rigid Beam Elements, shows the layout of the rigid beam elements. The soil surface response motions at the footprints of the surrounding structure are extracted from the SSI analysis of the NI Common Basemat Structures and NAB to serve as the basis for developing the free-field input motion for the SSI analysis of the surrounding structures.

Exterior NI sidewalls below grade bear against soil except for those that are located next to the NAB and AB walls, as shown in Figure 3.7.2-132—Nuclear Island Foundation Layout Showing Basemat, Sidewalls, and Shear Key. The NAB and AB are embedded to approximately the same depth as the NI Common Basemat Structure. The NI sidewalls that are not bearing against soil are not connected to any soil interaction nodes except at the base of the wall and along the vertical edges common with other soil-bearing walls at which load transfer from soils onto those walls can occur.

Figure 3.7.2-130 shows an isometric view of the SSI model to illustrate (a) the interaction coupling between the soil model and NI Common Basemat Structures/NAB basemats, and (b) the interaction coupling between the soil and the other rigid grids representing the massless footprints of the surrounding structures.

(2) EPGB and ESWB

Similarly, the SSI analysis models for EPGB and ESWB are established by coupling the 3D FEM of the structure with each of the soil models for the soil profiles. The EPGB is embedded with the ground surface modeled at elevation -1 ft, 0 inches (-0.30 m) and the bottom of the basemat at elevation -6 ft, 0 inches (-1.83 m). For the ESWB, the exterior walls and basemat bottom of the 3D FEM are embedded in the soil model.

3.7.2.4.5 Step 5 - Performing SSI Analysis

The SSI analysis of the NI Common Basemat Structures and NAB is performed using MTR/SASSI, Version 8.3. MTR/SASSI code performs the analysis in the frequency domain using the complex frequency response analysis method and then outputs the seismic responses in the time domain. One analysis is performed for each of the eight SSI analysis cases resulting from the combination of the eight soil profiles and the four CSDRS design ground motions. The analysis cases combining each of the soil profiles with the corresponding ground motion are specified in Table 3.7.1-6.

Similarly, the SSI analysis of the EPGB and ESWB is performed using MTR/SASSI, Version 8.3. One SSI analysis is performed for each of the soil profiles, and the modified CSDRS is the input motion at the surface of the soil model for the EPGB and at the basemat elevation of the soil model for the ESWB. The analysis cases are specified in Table 3.7.1-8 and Table 3.7.1-9.

3.7.2.4.6 Step 6 - Extracting Global Seismic SSI Responses

(1) NI Common Basemat Structures and NAB

The SSI analyses of the NI Common Basemat Structures generate the global seismic responses of the NI Common Basemat Structures of all of the eight SSI analysis cases. In each analysis case, the analysis is performed for one component of the input motion at a time, and it outputs the time histories of the requested seismic responses (floor accelerations, member forces and moments, etc.) to the particular component of input motion. To account for the contributions from the three components of input motion to the floor acceleration response, the three output time histories for the floor acceleration in a given global direction and at a given location are algebraically summed to produce the total floor acceleration response time history in the corresponding global direction. The ZPA is the maximum amplitude of the total floor acceleration time history in the corresponding global direction. ZPAs at specified locations are computed using AREVA code SASSIEXT, Version 1.0. In addition, as discussed in Section 3.7.2.5 below, the in-structure response spectra (ISRS) for the floor acceleration time histories at specified locations are also computed using AREVA code SASSIEXT, Version 1.0.

At key elevations of the FEM for the individual structure, the envelope of ZPAs at the building corners is taken to be the ZPA representative of the particular SSI analysis case. The ZPAs are shown in Table 3.7.2-10—NI Common Basemat Structures ZPAs, which presents the individual envelope of ZPAs from the sixteen cases (eight SSI analysis cases times two uncracked and cracked analysis models) as well as the envelope of all sixteen cases.

The time history of the displacement at the NI Common Basemat relative to the input ground motion is determined by double integrating the acceleration response time history at the basemat, applying a linear baseline correction, and subtracting from it the displacement time history of the free field ground motion for each SSI analysis case. The maximum relative displacement at a given structural location in the NI Common Basemat Structures with respect to the basemat is conservatively taken from the equivalent static analysis of the FEM of the NI Common Basemat Structures described in Section 3.8.4.

(2) EPGB and ESWB

Similarly, the SSI analysis of the EPGB and ESWB generate total floor acceleration response time histories in the three global directions. ZPAs and ISRS at specified locations are computed using SASSIEXT, Version 1.0.

Table 3.7.2-28—Maximum Accelerations in EPGB and Table 3.7.2-29—Maximum Accelerations in ESWB show the maximum ZPAs at different elevations of the EPGB and ESWB, respectively.

As discussed in Section 3.8.4.4.3, subsequent analyses will incorporate certain design details for the EPGBs and ESWBs that are not reflected in the existing respective SASSI models used for the SSI analyses described in Section 3.7.2. The subsequent analyses will determine the impact of these design details on the seismic responses and ISRS presented in Section 3.7.2.

3.7.2.4.7 Step 7 – Determining Amplified Seismic Responses for Flexible Slabs and Walls

(1) NI Common Basemat Structures

The out-of-plane seismic responses of flexible slabs and walls are directly available from the SSI analysis because the meshing of the dynamic 3D FEM of the NI Common Basemat Structure is sufficient to represent the flexible slabs and walls. The seismic responses accounting for the fully cracked and uncracked conditions for walls and slabs are simulated, respectively, by the dynamic FEMs with cracked and uncracked section properties for the concrete walls and floors. Generation of response spectra for the flexible slabs and walls are discussed in Section 3.7.2.5.

(2) EPGB and ESWB

Similarly, the out-of-plane seismic responses of flexible slabs and walls are directly available from the 3D FEM of the EPGB and ESWB used in the SSI analyses. Generation of response spectra for the flexible slabs and walls are discussed in Section 3.7.2.5.

3.7.2.5 Development of Floor Response Spectra

The ISRS for the U.S. EPR Seismic Category I structures are developed following the guidance in RG 1.122, Revision 1. They are calculated for 2 percent, 3 percent, 4 percent, 5 percent, 7 percent and 10 percent damping.

(1) NI Common Basemat Structures and NAB

For NI Common Basemat Structures and NAB, the floor acceleration response time histories in a given direction due to the three components of input motion are combined algebraically to produce the combined floor acceleration time history in the same direction, from which the ISRS in the corresponding direction is then computed. The ISRS are calculated using AREVA code SASSIEXT, Version 1.0, at the following 98 frequencies:

Frequency Range (Hz)	Frequency Increment (Hz)
0.1 to 3.0	0.10
3.0 to 3.6	0.15
3.6 to 5.0	0.20
5.0 to 8.0	0.25
8.0 to 15.0	0.50
15.0 to 18.0	1.00
18.0 to 22.0	2.00
22.0 to 100	3.00

The above frequencies for ISRS generation comply with the guidelines set forth in Table 3.7.1-1 of SRP Section 3.7.1 in Reference 2. At each given structural elevation along the FEM for the individual building, ISRS at the key locations (nodes at wall-floor junctions) are calculated for each SSI analysis case. The key output nodes are shown in Figure 3.7.2-137—Location of Response Output Nodes – NI Common Basemat, Figure 3.7.2-138—Location of Response Output Nodes – Reactor Building Internal Structure – Elev. +16 ft, 10-3/4 in (+5.15 m), Figure 3.7.2-139—Location of Response Output Nodes – Reactor Building Internal Structure – Elev. +63 ft, 11-3/4 in (+19.50 m), Figure 3.7.2-140—Location of Response Output Nodes – Safeguard Building 1 – Elev. +26 ft, 3 in (+8.10 m), Figure 3.7.2-141—Location of Response Output Nodes – Safeguard Building 1 – Elev. +68 ft, 10-3/4 in (+21.00 m), Figure 3.7.2-142—Location of Response Output Nodes – Safeguard Building 2 and 3 – Elev. +26 ft, 7 in (+8.10 m), Figure 3.7.2-143—Location of Response Output Nodes – Safeguard Building 2 & 3 – Elev. +50 ft, 6-1/4 in (+15.40 m), Figure 3.7.2-144—Location of Response Output Nodes – Safeguard Building 4 – Elev. +68 ft, 10-3/4 in (+21.00 m), and Figure 3.7.2-147—Location of Response Output Nodes, Fuel Building at Elev. +12 ft, 1-2/3 in (3.7 m). The envelope of the ISRS at these locations represents the ISRS at the particular structural elevation for the particular SSI analysis case. The ISRS from the eight SSI analysis cases, with each case considering both FEMs simulating cracked and uncracked section properties, are enveloped, and the spectrum envelope is broadened by ±15 percent and smoothed to account for uncertainty anticipated in the structural modeling and SSI analysis techniques.

(2) EPGB and ESWB

The ISRS for the EPGB and ESWB are calculated similarly using SASSIEXT, Version 1.0 at the same set of 98 frequencies. The ISRS from the analyzed soil cases are then enveloped, and the ISRS envelope is broadened by ±15 percent and smoothed to account for uncertainty anticipated in the structural modeling and SSI analysis techniques.

Results of the Response Spectrum Development

The results of the response spectrum development are presented below for the NI Common Basemat Structures, EPGB and ESWB separately:

(1) NI Common Basemat Structures

Figure 3.7.2-68—Response Spectra at NI Common Basemat Bottom Node 274 - 5% Damping, X-Direction, Figure 3.7.2-69—Response Spectra at NI Common Basemat Bottom Node 274 - 5% Damping, Y-Direction, and Figure 3.7.2-70—Response Spectra at NI Common Basemat Bottom Node 274 - 5% Damping, Z-Direction show the ISRS at Node 274, the center bottom node of NI Common Basemat at elevation -38 ft, 10-1/2 inches, for five percent damping for the individual SSI analysis cases. No spectrum peak broadening and smoothing is applied.

Figure 3.7.2-71—Soil Model Surface Response Spectra at Centers of Footprint of EPGB - 5% Damping, X-Direction, Figure 3.7.2-72—Soil Model Surface Response

Spectra at Centers of Footprint of EPGB - 5% Damping, Y-Direction, and Figure 3.7.2-73—Soil Model Surface Response Spectra at Centers of Footprint of EPGB - 5% Damping, Z-Direction show the 5 percent damping response spectra of the response motions from all SSI analysis cases at the soil model surface (i.e., elevation -38 ft, 10-1/2 inches) at the center nodes of the footprints of EPGB 1 and 2 and ESWB 1 to 4. These response spectra are used as the basis for developing the modified CSDRS discussed in Section 3.7.2.1.1 for use as seismic input to the SSI analysis of the EPGB and ESWB.

The listed figures show the peak-broadened and smoothed ISRS envelopes at representative locations of the NI Common Basemat Structures.

– RBIS

  - Elevation +16 ft., 10-3/4 inches. See Figure 3.7.2-74—Spectrum Envelope of Reactor Building Internal Structure - Elev. +16 ft, 10-3/4 in (+5.15m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction, Figure 3.7.2-75—Spectrum Envelope of Reactor Building Internal Structure - Elev. +16 ft, 10-3/4 in (+5.15m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Y-Direction, and Figure 3.7.2-76—Spectrum Envelope of Reactor Building Internal Structure - Elev. +16 ft, 10-3/4 in (+5.15m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction.

  - Elevation +63 ft, 11-3/4 inches. See Figure 3.7.2-77—Spectrum Envelope of Reactor Building Internal Structure - Elev. +63 ft, 11-3/4 in (+19.50m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction, Figure 3.7.2-78—Spectrum Envelope of Reactor Building Internal Structure - Elev. +63 ft, 11-3/4 in (+19.50m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Y-Direction, and Figure 3.7.2-79—Spectrum Envelope of Reactor Building Internal Structure - Elev. +63 ft, 11-3/4 in (+19.50m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction.

– SB 1

  - Elevation +26 ft, 7 inches. See Figure 3.7.2-80—Spectrum Envelope of Safeguard Building 1 - Elev. +26 ft, 7 in (+8.10m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction, Figure 3.7.2-81—Spectrum Envelope of Safeguard Building 1 - Elev. +26 ft, 7 in (+8.10m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Y-Direction, and Figure 3.7.2-82—Spectrum Envelope of Safeguard Building 1 - Elev. +26 ft, 7 in (+8.10m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction.

  - Elevation +68 ft, 11 inches. See Figure 3.7.2-83—Spectrum Envelope of Safeguard Building 1 - Elev. +68 ft, 11 in (+21.00m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction, Figure 3.7.2-84—Spectrum Envelope of Safeguard Building 1 - Elev. +68 ft, 11 in (+21.00m) 2%, 3%, 4%, 5%, 7,% and 10% Damping, Y-Direction, and Figure 3.7.2-85—Spectrum Envelope of Safeguard Building 1 - Elev. +68 ft, 11 in (+21.00m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction.

- SBs 2 and 3

  - Elevation +26 ft, 7 inches. See Figure 3.7.2-86—Spectrum Envelope of Safeguard Building 2&3 - Elev. +26 ft, 7 in (+8.10m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction, Figure 3.7.2-87—Spectrum Envelope of Safeguard Building 2&3 - Elev. +26 ft, 7 in (+8.10m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Y-Direction, and Figure 3.7.2-88—Spectrum Envelope of Safeguard Building 2&3 - Elev. +26 ft, 7 in (+8.10m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction.

  - Elevation +53 ft, 6 inches. See Figure 3.7.2-89—Spectrum Envelope of Safeguard Building 2&3 - Elev. +53 ft, 6 in (+16.30m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction, Figure 3.7.2-90—Spectrum Envelope of Safeguard Building 2&3 - Elev. +53 ft, 6 in (+16.30m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Y-Direction, and Figure 3.7.2-91—Spectrum Envelope of Safeguard Building 2&3 - Elev. +53 ft, 6 in (+16.30m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction.

- SB 4

  - Elevation +68 ft, 11 inches. See Figure 3.7.2-92—Spectrum Envelope of Safeguard Building 4 - Elev. +68 ft, 11 in (+21.00m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction, Figure 3.7.2-93—Spectrum Envelope of Safeguard Building 4 - Elev. +68 ft, 11 in (+21.00m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Y-Direction, and Figure 3.7.2-94—Spectrum Envelope of Safeguard Building 4 - Elev. +68 ft, 11 in (+21.00m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction.

- RCB

  - Elevation +123 ft, 4-1/4 inches. See Figure 3.7.2-95—Spectrum Envelope of Containment Building - Elev. +123 ft, 4-1/4 in (+37.60m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction, Figure 3.7.2-96—Spectrum Envelope of Containment Building - Elev. +123 ft, 4-1/4 in (+37.60m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Y-Direction, and Figure 3.7.2-97—Spectrum Envelope of Containment Building - Elev. +123 ft, 4-1/4 in (+37.60m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction.

  - Elevation +190 ft, 3-1/2 inches. See Figure 3.7.2-98—Spectrum Envelope of Containment Building - Elev. +190 ft, 3-1/2 in (+58.00m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction, Figure 3.7.2-99—Spectrum Envelope of Containment Building - Elev. +190 ft, 3-1/2 in (+58.00m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Y-Direction, and Figure 3.7.2-100—Spectrum Envelope of Containment Building - Elev. +190 ft, 3-1/2 in (+58.00m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction.

- FB

  - Elevation +12 ft, 1-2/3 inches. See Figure 3.7.2-110—Spectrum Envelope of Fuel Building at Elev. +12 ft, 1-2/3 in (3.7 m) 2%, 3%, 4%, 5%, 7%, and

10% Damping, X-Direction, Figure 3.7.2-111—Spectrum Envelope of Fuel Building at Elev. +12 ft, 1-2/3 in (3.7 m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Y-Direction, and Figure 3.7.2-112—Spectrum Envelope of Fuel Building at Elev. +12 ft, 1-2/3 in (3.7 m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction.

(2) EPGB and ESWB

Figure 3.7.2-101—Spectrum Envelope of EPGB at the Center of Basemat - 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction, Figure 3.7.2-102—Spectrum Envelope of EPGB at the Center of Basemat - 2%, 3%, 4%, 5%, 7%, and 10% Damping, Y-Direction, and Figure 3.7.2-103—Spectrum Envelope of EPGB at the Center of Basemat - 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction show the peak-broadened and smoothed ISRS envelopes at elevation -6 ft, 0 inches of the EPGB.

Figure 3.7.2-148—Spectrum Envelope of EPGB at Elev. +51 ft, 6 in - 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction, Figure 3.7.2-149—Spectrum Envelope of EPGB at Elev. +51 ft, 6 in - 2%, 3%, 4%, 5%, 7%, and 10% Damping, Y-Direction, and Figure 3.7.2-150—Spectrum Envelope of EPGB at Elev. +51 ft, 6 in - 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction show the peak-broadened and smoothed ISRS envelopes on elevation +51 ft, 6 inches of the EPGB.

Figure 3.7.2-104—Spectrum Envelope of ESWB at Elev +63 ft, 0 in at Node 12733 - 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction, Figure 3.7.2-105—Spectrum Envelope of ESWB at Elev +63 ft, 0 in at Node 12733 - 2%, 3%, 4%, 5%, 7%, and 10% Damping, Y-Direction, Figure 3.7.2-106—Spectrum Envelope of ESWB at Elev +63 ft, 0 in at Node 12733 - 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction, Figure 3.7.2-107—Spectrum Envelope of ESWB at Elev +14 ft, 0 in at Node 10385 - 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction, Figure 3.7.2-108—Spectrum Envelope of ESWB at Elev +14 ft, 0 in at Node 10385 - 2%, 3%, 4%, 5%, 7%, and 10% Damping, Y-Direction, and Figure 3.7.2-109—Spectrum Envelope of ESWB at Elev +14 ft, 0 in at Node 10385 - 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction show the peak-broadened and smoothed ISRS envelopes at Node 12733 on elevation +63 ft, 0 inches and Node 10385 on elevation +14 ft, 0 inches of the ESWB.

As discussed in Section 3.8.4.4.3 and Section 3.8.4.4.4, subsequent analyses will incorporate certain design details for the EPGBs and ESWBs that are not reflected in the existing respective SASSI models used for the SSI analyses described in Section 3.7.2. The subsequent analyses will determine the impact of these design details on the seismic responses and ISRS presented in Section 3.7.2.

3.7.2.6 Three Components of Earthquake Motion

(1) NI Common Basemat Structures and NAB

As previously stated in Section 3.7.2.4.6, the floor acceleration time history in a given direction is obtained by algebraically combining the three corresponding time histories due to the three earthquake components. Therefore, both the floor ZPA and the ISRS for the floor acceleration time history properly account for the contributions from the three components of earthquake motion.

(2) EPGB and ESWB

Similarly, the floor acceleration time history in a given direction is obtained by algebraically combining the three corresponding time histories due to the three earthquake components. Therefore, both the ZPA and ISRS for the floor acceleration time history properly account for the contributions from the three components of earthquake motion.

3.7.2.7 Combination of Modal Responses

When the response spectrum method of analysis is used, the maximum modal responses are combined using one of the methods specified in RG 1.92, Section C, Revision 2. Such combination methods include the grouping method, ten percent method and double sum methods, and they consider the effects of closely spaced modes having frequencies differing from each other by 10 percent or less of the lower frequency.

The effect of missing mass for modes not included in the analysis is accounted for by calculating the residual seismic load in accordance with AREVA NP Topical Report ANP-10264NP-A (Reference 11) and RG 1.92, Appendix A, Revision 2.

3.7.2.8 Interaction of Non-Seismic Category I Structures with Seismic Category I Structures

Figure 1.2-1 and Figure 3B-1 show the layout of structures for a typical U.S. EPR standard plant. The Access Building and Turbine Building are site-specific structures. A COL applicant that references the U.S. EPR design certification will provide the site-specific separation distances for the Access Building and Turbine Building. The potential for seismic-induced interaction between Seismic Category I structures and non-seismic Category I structures is assessed to verify the ability of Seismic Category I SSC to perform their safety functions. The basis for the seismic interaction assessment guidelines given below is to prevent impairment of Category I structure design basis safety functions.

- The collapse of the non-Category I structure does not cause the non-Category I structure to strike a Category I SSC.
- The collapse of the non-Category I structure does not impair the integrity of seismic Category I SSC, nor result in incapacitating injury to control room occupants.
- The non-Category I structure will be analyzed and designed to prevent its failure under SSE conditions such that the margin of safety is equivalent to that of a Category I structure.

The seismic interaction criteria and assessment guidelines are summarized in Table 3.7.2-30—Seismic Structural Interaction Criteria for Building Structures. The NAB, Access Building (AB), and the Turbine Building (TB) have the potential to interact with the NI Common Basemat Structures and are categorized as Seismic Category II. Results of the seismic interaction assessment for those structures are presented below, with associated discussions of the Radioactive Waste Building (RWB) and Fire Protection Storage Tanks and Building.

The TB and AB are conceptual design structures, as stated in Section 1.8, and a seismic interaction analysis has not been performed.

Nuclear Auxiliary Building

Figure 3B-1 shows that the separation gap between the Nuclear Auxiliary Building and the NI Common Basemat Structures is 18 in.

The NAB is classified as an RS structure designed and analyzed to meet the commitments defined for RW-IIa structures in RG 1.143. The NAB is also classified as Seismic Category II due to its potential to interact with a Seismic Category I structure during an SSE. The NAB is analyzed to SSE load conditions and designed to the codes and standards associated with Seismic Category I structures so that the margin of safety is equivalent to that of a Category I structure with the exception of sliding and overturning criteria. Because the NAB does not have a safety function, it may slide or uplift provided that the gap between the NAB and any Category I structure is adequate to prevent interaction. The effects of sliding, overturning, and any other calculated building displacements (e.g., building deflections, settlement) are considered when demonstrating the gap adequacy between NAB and adjacent Seismic Category I structures.

The NAB (Seismic Category II) stability and interaction potential with the NI (Seismic Category I) is evaluated by time-history analysis performed on a 3D FEM of the structure using the ANSYS computer code. The 3D FEM represents the superstructure, foundation mat, and nonlinearity associated with the mat-to-soil interface. Nonlinearities explicitly considered are the compression only nature of the concrete/soil interface in the vertical direction and the sliding coefficient of friction between the foundation basemat and underlying soil.

Shell/beam elements are used to represent slabs, diaphragms, beams, and columns in the superstructure, as appropriate. Solid elements, typically four through the thickness, represent the mat.

The foundation is modeled using springs that allow compression-only load transfer at the concrete/soil interface in the vertical direction. The sliding interface between the concrete basemat and underlying soil is modeled using sliding/contact elements that incorporate a coefficient of friction. Soil springs are derived using Gazetas methodology presented in "Foundation Vibrations," Foundation Engineering Handbook (Reference 10). Springs are developed for each soil case in Table 3.7.1-6. Spring distributions are elliptical over the plan area of the basemat. The distribution methodology is the same as the NI and is described in Section 3.8.5.4.2.

The concrete-only mass of the structure is accounted for through the use of material weight density associated with each finite element that forms the structure. Additional masses representing added dead loads, 25 percent of the live loads, and 75 percent of the maximum precipitation loads are included in the analysis. The buoyant effects of the groundwater are also included. Seismic motions are applied at the base of the springs supporting the structure. Side wall, soil driving/resisting forces are modeled in the analysis.

Cracked concrete stiffness is used for analysis. The stiffnesses is approximated by setting Young's modulus to 50 percent of the code-based values for flexure and shear. However, the full value is retained for axial stiffness calculations.

For the purpose of NAB stability analysis, both the Certified Seismic Design Response Spectra (CSDRS), and a R.G. 1.60 based target spectra is used. The CSDRS include the EUR soft, medium and hard input motions, as well as, the high frequency lower bound (hflb), best estimate (hfbe), and upper bound (hfub) input motions, described in Section 3.7.1.1. The RG 1.60 target spectra (TS) input motions are anchored to a peak ground acceleration of 0.3g. Three independent motions (two horizontal and one vertical base line corrected for velocity and displacement) are created in accordance with SRP 3.7.1. The seed records are taken from the NRC CEUS database representing a magnitude seven earthquake rich in low frequency content. These transient results are developed in accordance with the requirements of Option 1, Approach 2 of the SRP 3.7.1.

NI displacement results are obtained and added to the NAB displacement results. The NI superstructure displacement results are obtained from the soil structure interaction (SSI) analysis and added to the displacement results from the 3D basemat FEM described in Section 3.7.2.3.1.4. Additionally the ½" in 50' tilt described in Section 2.5.4.10.2 is included for both structures. Absolute values of the results are summed to produce conservative reductions in the shake space between the two structures.

Sliding Analysis

The bounding soil case will produce the most displacement when the frictional resistance available is low, forcing more of the seismic motion energy into sliding the building.

A bilinear coefficient of friction of $\mu = 0.5$ static and $\mu = 0.25$ dynamic are analyzed.

Overturning Analysis

The bounding soil case will produce the most displacement when the frictional coefficient is high forcing more of the seismic motion energy into rocking the building.

A coefficient of friction of $\mu = 0.7$ is used to maximize the uplift.

Bounding analysis cases, using the Table 3.7.1-6 soil cases, are performed for sliding and overturning using the model previously described to demonstrate that:

- The combination of rotational and translational displacements does not close the NI to NAB shake space resulting in structure-to-structure contact. A safety factor of 2.0 is determined when the flexural stiffness of the NAB is reduced 50%. A safety factor of 1.8 is determined when flexural and shear stiffness of NAB is reduced 50%.
- Bearing pressure demands calculated at the concrete-to-soil interface are less than or equal to the calculated capacities using the principles of soil mechanics. Section 2.5.4.10.1 lists the safety factors to be used in the calculations.

Access Building

The Access Building is a non-Seismic Category I structure for which continued operation during an SSE event is not required. The Access Building is classified as Seismic Category II based on its proximity to the NI, a Seismic Category I structure. [[The Access Building is analyzed to site-specific SSE load conditions and designed to the codes and standards associated with Seismic Category I structures so that the margin of safety is equivalent to that of a Category I structure with the exception of sliding and overturning criteria. Because the Access Building does not have a safety function, it may slide or uplift provided that the gap between the Access Building and any Category I structure is adequate to prevent interaction. The effects of sliding, overturning, and any other calculated building displacements (e.g., building deflections, settlement) must be considered when demonstrating the gap adequacy between the Access Building and adjacent Category I structures. The separation gaps between the Access Building and SBs 3 and 4 are 0.98 ft and 1.31 ft, respectively (see Figure 3B-1).]] The walls of the Access Building are not physically connected to the SBs. SB 3 is protected by the aircraft hazard (ACH) shield wall which not only protects the structure, but also isolates control room personnel from adverse impact effects. SB 4 is not protected by the ACH shield wall

A COL applicant that references the U.S. EPR design certification will demonstrate that the response of the Access Building to an SSE event will not impair the ability of Seismic Category I systems, structures, or components to perform their design basis safety functions.

For COL applicants that incorporate the conceptual design for the Access Building presented in the U.S. EPR FSAR (i.e., [[the Access Building is analyzed to site-specific SSE load conditions and designed to the codes and standards associated with Seismic Category I structures so that the margin of safety is equivalent to that of a Category I structure with the exception of sliding and overturning criteria]]), this COL item is addressed by demonstrating that the gap between the Access Building and adjacent Category I structures is sufficient to prevent interaction. The effects of sliding, overturning, and any other calculated building displacements (e.g., building deflections, settlement) must be considered when demonstrating the gap adequacy between the Access Building and adjacent Category I structures.

Turbine Building

The TB (including Switchgear Building on the common basemat) is a non-Seismic Category I structure for which continued operation during an SSE event is not required. The TB is classified as Seismic Category II based on its proximity to the NI, a Seismic Category I structure. [[The TB is analyzed to site-specific SSE load conditions and designed to the codes and standards associated with Seismic Category I structures so that the margin of safety is equivalent to that of a Category I structure with the exception of sliding and overturning criteria. Because the TB does not have a safety function, it may slide or uplift provided that the gap between the TB and any Category I structure is adequate to prevent interaction. The effects of sliding, overturning, and any other calculated building displacements (e.g., building deflections, settlement) must be considered when demonstrating the gap adequacy between the TB and adjacent Category I structures. The separation between the TB and NI Common Basemat Structures is approximately 30 ft (see Figure 3B-1).]]

A COL applicant that references the U.S. EPR design certification will demonstrate that the response of the TB (including Switchgear Building on the common basemat) to an SSE event will not impair the ability of Seismic Category I systems, structures, or components to perform their design basis safety functions.

For COL applicants that incorporate the conceptual design for the TB presented in the U.S. EPR FSAR (i.e., [[the TB is analyzed to site-specific SSE load conditions and designed to the codes and standards associated with Seismic Category I structures so that the margin of safety is equivalent to that of a Category I structure with the exception of sliding and overturning criteria]]), this COL item is addressed by demonstrating that the gap between the TB and adjacent Category I structures is sufficient to prevent interaction. The effects of sliding, overturning, and any other calculated building displacements (e.g., building deflections, settlement) must be considered when demonstrating the gap adequacy between the TB and adjacent Category I structures.

Radioactive Waste Building

The RWB has no significant potential to seismically interact with either the NI Common Basemat Structures or with the nearest Seismic Category I structure not on the common basemat (i.e., the EPGB) therefore, the RWB is not evaluated for SSE. The RWB is a reinforced concrete shear wall structure with a low height-to-width ratio. It is designed according to RW-IIa criteria in RG 1.143; thus it is designed using the codes and standards, and load combinations associated with Category I structures (i.e., ACI-349, AISC N-690) and analyzed for 1/2 SSE. This provides significant lateral force resistance capacity, thus catastrophic collapse of the RWB during an SSE event is unlikely. The NAB is a reinforced concrete structure located between the RWB and the NI. The NAB is designed using the codes associated with Category I structures and analyzed to full SSE, resulting in an inherently robust design. If the RWB were to collapse and impact the NAB, the damage to the NAB would be limited to local areas. Therefore, there is no potential for indirect interaction between the RWB and the NI structures.

Potential interaction between the RWB and EPGB is precluded by separation and by design and site selection and foundation design criteria for the RWB. The RWB is embedded a significant distance below grade and has a clear height above grade of +52.5 ft, while the clearance between the RWB and EPGB is at least 49.5 ft (see Figure 3B-1). Therefore, the separation between the two is only a small distance less than the height above grade of the RWB. Failure of the RWB in such a manner as to strike the EPGB is not considered credible due to the separation distance and because of the seismic design for 1/2 SSE loading described above. In addition, site selection and foundation design criteria for the U.S. EPR standard plant ensure that the RWB is founded on competent soils, while the embedded section below grade provides additional stabilization against rotation.

[[Fire Protection Storage Tanks and Buildings]]

[[The Fire Protection Storage Tanks and Buildings are classified as Conventional Seismic Structures.]] RG 1.189 requires that a water supply be provided for manual firefighting in areas containing equipment for safe plant shutdown in the event of a SSE. [[The fire protection storage tanks and building are designed to provide system pressure integrity under SSE loading conditions. Seismic load combinations are developed in accordance with the requirements of ASCE 43-05 using a limiting acceptance condition for the structure characterized as essentially elastic behavior with no damage (i.e., Limit State D) as specified in the Standard.]]

The Fire Protection Storage Tanks and Buildings are site-specific structures. A COL applicant that references the U.S. EPR design certification will provide the seismic design basis for the sources of fire protection water supply for safe plant shutdown in the event of a SSE.

3.7.2.9 Effects of Parameter Variations on Floor Response Spectra

Uncertainties in seismic modeling, due to such items as uncertainties in material properties, mass properties, concrete cracking under normal loading, and structural and soil modeling techniques can affect the accuracy of floor response spectra calculated using any of the approaches for seismic analysis presented in Section 3.7.2.1. To compensate for the effect of these uncertainties, the ISRS for U.S. EPR Seismic Category I structures are broadened by ±15 percent. These broadened ISRS are used in the subsequent design of structural elements of those structures, including flexible floors and walls.

3.7.2.10 Use of Constant Vertical Static Factors

Vertical seismic loads are generated from the SSI analysis for use in the seismic design of U.S. EPR Seismic Category I structures and Seismic Category II structures. Therefore, there is no need for the use of constant vertical static factors in the design of those structures.

3.7.2.11 Method Used to Account for Torsional Effects

Torsional effects due to the eccentricity built into the stick models or 3D FEM of the structures are accounted for during the seismic SSI analysis. Additional seismic loads due to accidental torsion are accounted for as required by Standard Review Plan, Section 3.7.2, Seismic System Analysis, paragraph II.11 (Reference 2) and in ASCE 4-98, Reference 1. This is to account for uncertainties in material densities, member sizes, architectural variations, equipment loads, etc., from design assumptions. Due to these potential uncertainties, an additional torsional moment is introduced into the design and evaluation of structural members.

For the NI Common Basemat Structures, the additional torsional moment at a particular elevation is calculated as the story inertia force in each horizontal direction of interest times a moment arm equal to five percent of the building plan dimension in the perpendicular direction. Results due to the story inertia forces in both horizontal directions are summed to produce the total additional torsional moment at the particular elevation. For design purposes, this torsional moment is taken to be resisted by only selected major shear walls, and a simplified 3D FEM is developed for each of the NI Common Basemat Structures which includes only the selected shear walls. The additional torsional moment at each given elevation is applied to all wall nodes at the same elevation, constrained like a rigid diaphragm, of the simplified FEM to determine the additional design shear forces in the selected shear walls.

For the EPGB and ESWB, the additional torsional moment at a particular elevation is calculated as the story inertia force in each horizontal direction of interest times a moment arm equal to five percent of the building plan dimension in the perpendicular direction. This additional torsional moment due to the story inertia force in the given direction is converted into equivalent nodal inertial forces acting on the particular elevation where each equivalent nodal inertial force is proportional to the product of the nodal mass and the distances from the node to the shear center of the walls immediately below the elevation of interest. Equivalent nodal forces corresponding to the additional torsional moment due to the story inertia force in the other horizontal direction are calculated in the similar manner. The equivalent nodal forces at all applicable elevations are applied to the 3D FEM of the structure in the equivalent static analysis to determine the additional element forces and moments due to the accidental torsion.

3.7.2.12 Comparison of Responses

The response spectrum method is used only in the local seismic analysis of selected slabs in the NAB and the vent stack. Comparison of responses between the response spectrum method and a time history analysis method is not applicable.

3.7.2.13 Methods for Seismic Analysis of Category I Dams

See Section 3.7.3.13.

3.7.2.14 Determination of Dynamic Stability of Seismic Category I Structures

Section 3.8.5 describes specific details related to overturning analysis cases and factors of safety for the U.S. EPR structures.

3.7.2.15 Analysis Procedure for Damping

Section 3.7.1.3 describes the damping ratios used for seismic analysis of the SSC for the U.S. EPR. These damping values are summarized in Table 3.7.1-1 as a percentage of critical damping. For the SSI analysis of structures, the complex frequency response method does not require the computation of composite modal damping although the SSI analysis model consists of the 3D FEM and soil models having different damping values.

3.7.2.16 References

1. ASCE Standard 4-98, “Seismic Analysis of Safety-Related Nuclear Structures and Commentary,” American Society of Civil Engineers, 1999.

2. NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants,” Nuclear Regulatory Commission, March 2007.

3. ACI 350.3-06, “Seismic Design of Liquid-Containing Concrete Structures,” American Concrete Institute, 2006.

4. IBC-2009 International Code Council, International Building Code, 2009 Edition.

5. ASCE/SEI 43-05, “Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities,” American Society of Civil Engineers, 2005.

6. ACI 318-05, “Building Code Requirements for Structural Concrete and Commentary,” American Concrete Institute, 2005.

7. ANSI/AISC 341, “Seismic Provisions for Structural Steel Buildings,” American National Standards Institute/American Institute of Steel Construction, 2005.

8. ANSI/AISC 360, “Specifications for Structural Steel Buildings,” American National Standards Institute/American Institute of Steel Construction, 2005.

9. ASCE Standard 7-05, “Minimum Design Loads for Buildings and Other Structures,” Appendix 11A, “Quality Assurance Provisions,” American Society of Civil Engineers, January 1, 2006.

10. "Foundation Vibrations," Foundation Engineering Handbook, 2nd Edition, H.Y. Fang, Ed., Van Nostrand Reinholds, Chapter 15, pp.553-593, 1991.

11. ANP-10264NP-A, Revision 0, “U.S. EPR Piping Analysis and Support Design Topical Report,” AREVA NP Inc., November 2008.

Table 3.7.2-1—Frequencies and Modal Mass Ratios for NI Common Basemat Structures with All Masses Included
Sheet 1 of 5

Mode	Frequency	Modal Participating Mass Ratios		
No.	(Hz)	X	Y	Z
1	4.48	0.000	0.018	0.000
2	4.58	0.015	0.054	0.000
3	4.59	0.055	0.015	0.000
4	4.61	0.066	0.000	0.000
5	4.74	0.010	0.334	0.000
6	4.90	0.401	0.010	0.000
7	5.01	0.002	0.019	0.000
8	5.02	0.022	0.000	0.000
9	5.20	0.000	0.003	0.000
10	5.29	0.000	0.060	0.001
12	5.39	0.000	0.004	0.000
13	5.46	0.000	0.076	0.000
14	5.47	0.012	0.007	0.000
15	5.86	0.031	0.000	0.000
16	6.02	0.001	0.006	0.002
18	6.19	0.006	0.006	0.000
20	6.41	0.000	0.036	0.000
23	6.72	0.000	0.002	0.003
26	6.96	0.020	0.000	0.000
27	6.99	0.000	0.017	0.000
28	7.23	0.004	0.001	0.003
30	7.45	0.000	0.026	0.010
32	7.49	0.000	0.003	0.000
33	7.58	0.001	0.004	0.008
34	7.96	0.048	0.000	0.000
35	8.04	0.015	0.000	0.000
36	8.09	0.002	0.000	0.000
38	8.16	0.012	0.015	0.008

Mode	Frequency	Modal Participating Mass Ratios		
No.	(Hz)	X	Y	Z
39	8.23	0.008	0.003	0.002
40	8.33	0.001	0.000	0.000
41	8.34	0.000	0.002	0.000
42	8.36	0.013	0.003	0.002
43	8.39	0.006	0.001	0.000
44	8.49	0.001	0.000	0.000
46	8.62	0.000	0.017	0.001
49	8.97	0.001	0.001	0.001
50	9.08	0.000	0.003	0.009
52	9.40	0.001	0.003	0.004
53	9.40	0.005	0.000	0.000
54	9.41	0.012	0.000	0.000
55	9.58	0.000	0.000	0.077
56	9.75	0.000	0.002	0.006
57	9.86	0.001	0.000	0.000
58	9.98	0.001	0.002	0.023
61	10.20	0.000	0.007	0.038
79	10.47	0.000	0.000	0.024
83	10.54	0.001	0.002	0.002
86	10.87	0.000	0.001	0.000
91	11.08	0.000	0.000	0.003
92	11.13	0.000	0.001	0.001
93	11.15	0.000	0.000	0.004
94	11.17	0.003	0.001	0.000
95	11.24	0.002	0.000	0.002
96	11.43	0.000	0.002	0.001
97	11.47	0.000	0.002	0.001
98	11.49	0.000	0.000	0.007

Table 3.7.2-1—Frequencies and Modal Mass Ratios for NI Common Basemat Structures with All Masses Included
Sheet 2 of 5

Mode	Frequency	Modal Participating Mass Ratios		
99	11.62	0.000	0.001	0.004
100	11.65	0.001	0.000	0.016
102	11.75	0.000	0.001	0.000
103	11.80	0.000	0.001	0.000
104	11.82	0.000	0.000	0.001
105	11.86	0.001	0.000	0.000
107	11.94	0.000	0.001	0.000
108	12.00	0.001	0.000	0.000
109	12.08	0.001	0.000	0.001
111	12.11	0.000	0.000	0.026
112	12.12	0.001	0.000	0.000
114	12.17	0.000	0.001	0.000
115	12.18	0.000	0.000	0.038
117	12.21	0.000	0.000	0.002
130	12.27	0.000	0.000	0.001
145	12.31	0.001	0.000	0.001
147	12.35	0.000	0.000	0.009
148	12.41	0.001	0.000	0.010
150	12.50	0.000	0.000	0.001
151	12.50	0.000	0.000	0.001
152	12.51	0.000	0.001	0.000
153	12.57	0.001	0.000	0.000
157	12.72	0.001	0.000	0.001
158	12.74	0.000	0.003	0.000
162	12.90	0.000	0.004	0.001
164	12.97	0.000	0.000	0.018
165	13.02	0.000	0.001	0.000
167	13.07	0.002	0.002	0.001

Mode	Frequency	Modal Participating Mass Ratios		
169	13.22	0.000	0.000	0.009
170	13.31	0.000	0.000	0.003
171	13.35	0.004	0.011	0.000
172	13.36	0.000	0.000	0.040
173	13.39	0.000	0.000	0.018
174	13.39	0.011	0.004	0.000
175	13.40	0.001	0.000	0.004
176	13.42	0.007	0.001	0.001
177	13.45	0.000	0.004	0.007
178	13.53	0.002	0.002	0.000
179	13.53	0.000	0.000	0.001
180	13.60	0.000	0.000	0.001
181	13.66	0.008	0.000	0.002
185	13.89	0.004	0.003	0.000
186	13.90	0.000	0.002	0.000
187	13.98	0.002	0.000	0.004
188	14.06	0.000	0.000	0.021
189	14.06	0.001	0.000	0.003
190	14.07	0.001	0.000	0.000
191	14.09	0.000	0.000	0.017
192	14.11	0.004	0.000	0.000
193	14.14	0.001	0.000	0.000
194	14.24	0.001	0.000	0.005
196	14.27	0.000	0.000	0.001
197	14.31	0.000	0.005	0.000
198	14.37	0.005	0.000	0.014
199	14.40	0.003	0.001	0.000
200	14.52	0.000	0.002	0.000

Table 3.7.2-1—Frequencies and Modal Mass Ratios for NI Common Basemat Structures with All Masses Included
Sheet 3 of 5

Mode	Frequency	Modal Participating Mass Ratios		
201	14.53	0.000	0.001	0.000
202	14.57	0.003	0.000	0.003
203	14.61	0.000	0.000	0.001
205	14.68	0.000	0.000	0.005
207	14.71	0.000	0.000	0.006
208	14.77	0.000	0.000	0.018
209	14.81	0.002	0.000	0.002
212	14.97	0.000	0.003	0.003
213	15.01	0.000	0.001	0.001
214	15.03	0.000	0.000	0.001
215	15.09	0.000	0.001	0.001
216	15.10	0.001	0.001	0.000
221	15.30	0.000	0.000	0.002
223	15.36	0.000	0.000	0.005
224	15.39	0.000	0.000	0.005
226	15.46	0.001	0.000	0.000
227	15.47	0.000	0.000	0.002
228	15.49	0.002	0.001	0.003
230	15.58	0.000	0.000	0.002
232	15.65	0.006	0.003	0.000
233	15.68	0.001	0.000	0.000
234	15.78	0.000	0.000	0.001
237	15.92	0.001	0.003	0.007
238	15.97	0.000	0.000	0.004
239	15.99	0.000	0.001	0.001
240	16.07	0.001	0.000	0.001
242	16.10	0.000	0.003	0.000
243	16.11	0.000	0.001	0.000

Mode	Frequency	Modal Participating Mass Ratios		
244	16.13	0.000	0.001	0.001
246	16.19	0.000	0.003	0.000
247	16.22	0.001	0.000	0.000
248	16.33	0.002	0.001	0.001
249	16.40	0.000	0.000	0.001
250	16.41	0.000	0.000	0.003
251	16.45	0.000	0.001	0.000
252	16.55	0.001	0.000	0.001
254	16.65	0.001	0.006	0.002
255	16.70	0.000	0.000	0.001
257	16.82	0.000	0.001	0.000
260	16.91	0.001	0.004	0.003
261	16.95	0.000	0.001	0.000
262	16.96	0.000	0.000	0.001
264	17.08	0.001	0.000	0.000
266	17.11	0.002	0.001	0.001
267	17.12	0.002	0.000	0.001
269	17.18	0.001	0.000	0.001
271	17.29	0.000	0.000	0.010
272	17.29	0.000	0.002	0.000
273	17.30	0.001	0.001	0.001
274	17.32	0.000	0.000	0.001
276	17.40	0.000	0.001	0.000
280	17.51	0.001	0.000	0.001
282	17.55	0.000	0.000	0.004
283	17.57	0.000	0.000	0.003
285	17.60	0.000	0.000	0.001
288	17.71	0.000	0.000	0.006

Table 3.7.2-1—Frequencies and Modal Mass Ratios for NI Common Basemat Structures with All Masses Included
Sheet 4 of 5

Mode	Frequency	Modal Participating Mass Ratios		
290	17.78	0.000	0.000	0.001
291	17.84	0.000	0.001	0.003
292	17.86	0.000	0.000	0.001
293	17.89	0.000	0.000	0.001
294	18.01	0.000	0.003	0.001
300	18.14	0.000	0.001	0.001
301	18.20	0.000	0.001	0.001
303	18.22	0.001	0.000	0.000
305	18.27	0.000	0.001	0.000
306	18.34	0.000	0.001	0.027
308	18.39	0.002	0.000	0.001
309	18.49	0.000	0.000	0.004
311	18.54	0.000	0.001	0.002
313	18.65	0.000	0.001	0.000
315	18.76	0.000	0.001	0.003
317	18.84	0.000	0.000	0.001
320	18.91	0.001	0.001	0.017
321	18.93	0.000	0.000	0.001
322	19.01	0.000	0.000	0.001
325	19.07	0.000	0.000	0.010
326	19.13	0.002	0.000	0.000
329	19.27	0.000	0.000	0.003
331	19.31	0.001	0.000	0.001
334	19.38	0.000	0.003	0.003
335	19.49	0.000	0.001	0.000
339	19.64	0.000	0.000	0.002
341	19.66	0.001	0.000	0.000
345	19.70	0.000	0.000	0.001

Mode	Frequency	Modal Participating Mass Ratios		
348	19.79	0.002	0.000	0.000
349	19.81	0.001	0.000	0.000
352	19.87	0.000	0.000	0.001
356	19.99	0.000	0.001	0.001
357	20.02	0.000	0.001	0.000
359	20.09	0.001	0.000	0.000
367	20.24	0.001	0.000	0.000
368	20.25	0.000	0.001	0.001
372	20.40	0.000	0.001	0.000
374	20.51	0.000	0.000	0.001
377	20.63	0.000	0.000	0.001
378	20.63	0.000	0.001	0.000
379	20.64	0.001	0.000	0.000
381	20.73	0.000	0.000	0.001
383	20.77	0.000	0.000	0.001
385	20.82	0.000	0.000	0.002
386	20.84	0.000	0.000	0.006
389	20.93	0.000	0.001	0.000
390	20.96	0.000	0.000	0.003
391	20.99	0.000	0.000	0.001
392	21.02	0.000	0.000	0.002
397	21.12	0.000	0.001	0.000
398	21.14	0.002	0.000	0.000
399	21.14	0.000	0.000	0.015
400	21.19	0.000	0.000	0.001
401	21.20	0.000	0.001	0.000
402	21.23	0.001	0.000	0.000
403	21.27	0.000	0.000	0.001

Table 3.7.2-1—Frequencies and Modal Mass Ratios for NI Common Basemat Structures with All Masses Included
Sheet 5 of 5

Mode	Frequency	Modal Participating Mass Ratios		
405	21.35	0.000	0.000	0.001
406	21.39	0.000	0.001	0.000
407	21.40	0.000	0.000	0.002
409	21.43	0.000	0.000	0.001
411	21.51	0.000	0.000	0.001
413	21.56	0.000	0.002	0.000
415	21.57	0.000	0.000	0.001
417	21.64	0.000	0.000	0.001
423	21.81	0.000	0.000	0.001
424	21.86	0.001	0.000	0.001
427	21.95	0.000	0.000	0.002
428	22.04	0.000	0.001	0.000
431	22.16	0.001	0.000	0.001
437	22.27	0.001	0.000	0.001
451	22.56	0.000	0.001	0.000
452	22.58	0.001	0.000	0.000
457	22.68	0.000	0.000	0.002
462	22.84	0.000	0.000	0.001
469	22.97	0.000	0.000	0.001
478	23.16	0.000	0.000	0.001
487	23.37	0.000	0.000	0.001
493	23.58	0.000	0.000	0.001
494	23.62	0.000	0.001	0.000
497	23.66	0.000	0.000	0.001
516	24.06	0.000	0.000	0.001
522	24.16	0.000	0.000	0.001
526	24.25	0.000	0.001	0.000
527	24.25	0.000	0.000	0.002

Mode	Frequency	Modal Participating Mass Ratios		
541	24.45	0.001	0.000	0.000
557	24.95	0.000	0.002	0.000
561	25.01	0.000	0.000	0.001
565	25.09	0.000	0.001	0.000
589	25.60	0.000	0.000	0.001
623	26.32	0.000	0.000	0.001
631	26.52	0.000	0.001	0.000
637	26.60	0.000	0.001	0.000
643	26.80	0.000	0.000	0.001
647	26.89	0.000	0.000	0.001
669	27.40	0.000	0.000	0.001
673	27.51	0.001	0.000	0.000
685	27.84	0.000	0.000	0.001
775	29.46	0.000	0.000	0.001
783	29.57	0.000	0.000	0.001
786	29.63	0.000	0.000	0.001
805	30.01	0.000	0.000	0.001
809	30.08	0.000	0.001	0.000
987	33.22	0.000	0.000	0.001
1154	35.81	0.000	0.000	0.001
1205	36.66	0.000	0.000	0.001
1345	38.92	0.000	0.000	0.002
1444	40.44	0.000	0.000	0.001
1661	43.70	0.000	0.000	0.001
1690	44.07	0.000	0.000	0.001
1967	47.97	0.000	0.000	0.001
1978	48.10	0.000	0.000	0.001
2010	48.48	0.000	0.000	0.001

Table 3.7.2-2—Deleted

Table 3.7.2-3—Frequency and Modal Mass Ratios for Reactor Building Internal Structures STICK-1T with All Masses Included Sheet 1 of 2

Mode No.	Frequency (Hz)	Modal Participating Mass Ratios		
		X	Y	Z
1	4.79	0.343	0.000	0.000
2	5.61	0.152	0.006	0.000
3	5.86	0.002	0.426	0.002
4	6.06	0.000	0.126	0.000
5	8.50	0.024	0.000	0.000
6	8.94	0.004	0.000	0.005
7	9.16	0.083	0.000	0.000
8	9.37	0.000	0.000	0.000
9	9.38	0.000	0.000	0.000
10	9.38	0.000	0.000	0.000
11	9.45	0.025	0.000	0.000
12	9.83	0.070	0.000	0.001
13	10.31	0.003	0.001	0.026
14	12.50	0.000	0.099	0.331
15	13.91	0.000	0.063	0.238
16	14.12	0.000	0.030	0.042
17	14.47	0.000	0.002	0.020
18	15.21	0.003	0.001	0.001
19	16.14	0.004	0.000	0.005
20	17.22	0.104	0.000	0.000
21	19.84	0.000	0.007	0.034
22	21.10	0.000	0.001	0.049
23	22.61	0.002	0.025	0.006
24	22.84	0.002	0.021	0.003
25	22.90	0.000	0.010	0.001
26	23.07	0.000	0.013	0.001
27	25.07	0.002	0.001	0.019
28	25.47	0.010	0.000	0.003
29	26.09	0.000	0.000	0.006
30	27.01	0.000	0.000	0.026

Table 3.7.2-3—Frequency and Modal Mass Ratios for Reactor Building Internal Structures STICK-1T with All Masses Included Sheet 2 of 2

Mode No.	Frequency (Hz)	Modal Participating Mass Ratios		
		X	Y	Z
31	28.13	0.000	0.000	0.000
32	31.27	0.000	0.013	0.000
33	31.39	0.000	0.001	0.000
34	34.67	0.035	0.000	0.000
35	38.38	0.000	0.005	0.000
36	39.04	0.000	0.009	0.000
37	39.72	0.000	0.033	0.000
38	41.11	0.000	0.000	0.000
39	43.49	0.000	0.000	0.000
40	44.49	0.013	0.000	0.000
41	45.80	0.001	0.000	0.000
42	47.90	0.000	0.000	0.000
43	49.09	0.000	0.000	0.000

Table 3.7.2-4—Modal Frequencies of the Simplified Stick Model of Reactor Coolant Loop
Sheet 1 of 2

Mode Number	Frequency (Hz)	Mode Characterization
1	5.5562	SG
2	5.6042	SG
3	5.6103	SG
4	5.6106	SG
5	6.5902	SG
6	6.5907	SG
7	6.5913	SG
8	6.5914	SG
9	11.804	RC Pump
10	11.807	RC Pump
11	11.818	RC Pump
12	11.819	RC Pump
13	12.300	Piping (Crossover Leg)
14	13.383	RC Pump
15	13.428	RC Pump
16	13.428	RC Pump
17	13.481	RC Pump
18	13.534	RC Pump
19	13.541	RC Pump
20	13.542	RC Pump
21	13.752	RC Pump
22	14.006	RC Pump
23	14.028	RC Pump
24	14.030	RC Pump
25	14.231	RC Pump
26	14.496	Pressurizer
27	14.496	Pressurizer
28	15.280	RV
29	15.468	Piping (Crossover Leg)
30	15.469	Piping (Crossover Leg)
31	15.499	Piping (Crossover Leg)

Table 3.7.2-4—Modal Frequencies of the Simplified Stick Model of Reactor Coolant Loop
Sheet 2 of 2

Mode Number	Frequency (Hz)	Mode Characterization
32	15.531	SG
33	16.554	SG
34	16.601	SG
35	16.739	RV
36	17.063	RV
37	19.965	Piping (Crossover Leg)
38	20.798	Piping (Crossover Leg)
39	20.803	Piping (Crossover Leg)
40	20.807	Piping (Crossover Leg)
41	22.076	RV
42	22.611	Piping (Crossover Leg)
43	24.993	Piping (Crossover Leg)
44	24.997	Piping (Crossover Leg)
45	25.042	Piping (Crossover Leg)
46	25.164	Pressurizer
47	25.164	Pressurizer
48	25.454	Piping (Crossover Leg)
49	28.756	RC Pump
50	28.757	RC Pump

Table 3.7.2-5—Deleted

Table 3.7.2-6—Modal Frequencies of the Stick Model of NAB

Mode No.	Frequency (Hz)	Modal Mass Ratios		
		X	Y	Z
1	4.24	0.000	0.636	0.002
2	4.96	0.601	0.000	0.000
3	7.54	0.044	0.002	0.000
4	10.65	0.001	0.201	0.051
5	12.90	0.207	0.002	0.018
6	14.33	0.009	0.009	0.582
7	19.06	0.001	0.034	0.042
8	19.33	0.003	0.003	0.036
9	19.50	0.000	0.026	0.057
10	20.58	0.019	0.000	0.001
11	23.89	0.046	0.003	0.000
12	24.47	0.003	0.024	0.001
13	29.48	0.006	0.003	0.000
14	30.49	0.002	0.018	0.000
15	31.58	0.009	0.001	0.000
16	34.25	0.000	0.000	0.041
17	35.92	0.013	0.002	0.001
18	36.29	0.009	0.006	0.001
19	37.19	0.003	0.001	0.000
20	40.41	0.001	0.000	0.010
21	42.11	0.000	0.000	0.053
22	43.05	0.004	0.000	0.001
23	43.58	0.001	0.000	0.001
24	44.95	0.000	0.015	0.000
25	49.54	0.000	0.004	0.000

Table 3.7.2-7—Modal Frequencies of 3D FEM of Emergency Power Generating Building
Sheet 1 of 6

Mode No.	Frequency (Hz)	Modal Participating Mass Ratios		
		X	Y	Z
1	10.23	7.57E-14	7.35E+01	2.16E-15
2	10.77	6.88E+01	3.24E-14	1.74E-02
3	11.19	7.26E-12	6.50E-02	5.54E-17
4	11.67	3.35E-14	1.97E-02	8.92E-16
5	12.29	1.80E+00	3.31E-16	3.44E-01
6	12.93	4.13E-13	3.24E-03	2.87E-16
7	12.95	7.03E-01	1.39E-15	1.53E-04
8	13.24	3.25E+00	2.78E-15	1.69E-01
9	13.87	5.98E-14	3.20E-01	8.78E-14
10	14.08	1.92E-09	5.72E-14	3.95E+00
11	14.17	1.35E-15	2.28E-01	3.07E-15
12	14.57	1.09E-05	1.09E-13	4.25E-01
13	14.80	1.08E-13	4.82E-02	1.56E-13
14	14.94	3.71E-01	3.76E-15	8.21E-03
15	15.96	2.91E-13	3.76E+00	3.93E-11
16	16.59	1.37E-12	3.14E-01	3.93E-10
17	16.90	8.24E-02	3.30E-12	3.49E+01
18	17.34	3.67E-13	1.26E-01	1.13E-09
19	17.76	4.89E-13	1.75E-02	1.02E-10
20	18.45	3.09E-03	4.46E-14	3.45E-01
21	18.46	1.53E-13	1.09E-02	4.44E-13
22	18.89	1.93E+00	3.31E-14	2.80E+00
23	20.73	6.34E-15	1.25E-01	1.84E-13
24	21.12	8.29E-12	1.51E-03	5.59E-12
25	21.87	3.11E-01	2.55E-10	1.04E-01
26	22.00	1.70E-11	4.52E+00	5.71E-12
27	22.52	1.63E-13	1.41E-02	1.77E-12
28	22.58	1.73E-03	1.44E-12	3.95E-01
29	23.30	8.78E-16	1.59E-01	5.02E-14
30	23.35	3.47E-01	7.49E-15	4.22E-02
31	23.55	1.56E-13	4.88E-02	8.52E-13
32	23.93	1.00E-01	2.26E-15	6.83E-03
33	24.31	1.17E-14	4.27E-06	2.77E-12
34	24.90	1.57E-13	4.20E-02	2.60E-12
35	24.98	5.78E-13	1.82E-02	7.90E-12

Table 3.7.2-7—Modal Frequencies of 3D FEM of Emergency Power Generating Building
Sheet 2 of 6

Mode No.	Frequency (Hz)	Modal Participating Mass Ratios		
		X	Y	Z
36	24.99	1.38E-02	1.07E-11	1.45E-01
37	25.16	1.84E-01	3.27E-13	8.14E-02
38	25.34	3.23E-12	1.43E-01	2.74E-12
39	25.56	2.98E-02	3.15E-09	7.01E-02
40	25.59	2.03E-09	1.78E-01	3.62E-09
41	25.64	8.66E-02	9.45E-10	1.65E-01
42	26.04	1.43E-12	1.03E-02	5.90E-15
43	26.23	1.60E-12	2.27E-01	6.69E-12
44	26.36	3.75E-02	9.28E-11	1.20E-01
45	26.79	2.21E-03	1.43E-12	6.73E-02
46	27.03	5.98E-12	2.48E-02	8.79E-13
47	27.07	2.76E-01	3.42E-12	1.66E-04
48	27.23	3.77E-13	1.48E-01	2.90E-13
49	27.46	7.94E-01	9.71E-17	2.04E-03
50	27.82	2.08E-13	2.00E+00	1.69E-14
51	28.52	4.20E-14	5.72E-02	1.66E-11
52	28.54	1.85E-03	1.65E-11	4.65E-03
53	29.47	2.20E-01	4.11E-15	8.28E-01
54	29.71	6.00E-01	1.78E-15	1.85E-01
55	30.00	4.39E-14	1.32E-02	3.32E-12
56	30.12	1.26E-03	3.22E-15	8.21E-03
57	30.68	6.03E-14	8.55E-03	8.91E-11
58	31.08	2.53E-01	3.34E-11	8.03E-01
59	31.30	4.51E-10	2.17E-02	2.88E-10
60	31.54	1.19E-01	8.46E-13	2.26E+00
61	31.67	3.85E-12	5.56E-02	3.25E-11
62	31.97	7.45E-10	1.32E-02	1.59E-12
63	32.04	3.82E-01	5.36E-12	2.25E-02
64	32.09	2.49E-11	3.33E-02	1.29E-11
65	32.30	1.85E-04	1.39E-10	2.88E-02
66	32.42	6.24E-11	1.32E-02	1.15E-11
67	32.70	2.08E-01	2.49E-11	2.30E+00
68	32.89	6.10E-11	2.16E-05	2.91E-09
69	33.12	4.35E-02	2.95E-13	7.33E-02
70	33.65	2.24E-11	1.11E-01	1.12E-10

Table 3.7.2-7—Modal Frequencies of 3D FEM of Emergency Power Generating Building
Sheet 3 of 6

Mode No.	Frequency (Hz)	Modal Participating Mass Ratios		
		X	Y	Z
71	33.88	5.45E-01	7.42E-14	2.26E-01
72	34.27	5.55E-10	5.41E-02	1.68E-10
73	34.29	6.03E-01	6.57E-11	1.52E-03
74	34.84	3.87E-01	2.60E-12	3.97E-01
75	35.19	3.15E-12	6.22E-02	1.61E-11
76	35.65	1.89E-12	1.12E-01	2.33E-11
77	35.99	1.19E-02	9.58E-13	3.15E-02
78	36.12	9.04E-13	2.17E-03	1.22E-11
79	36.25	3.84E-02	7.10E-15	2.36E-03
80	36.26	8.50E-11	2.28E-05	3.07E-11
81	36.62	1.40E-11	4.43E-02	4.38E-14
82	37.17	5.35E-02	4.09E-09	1.54E-01
83	37.22	7.74E-10	3.26E-01	2.38E-09
84	37.48	2.15E-02	4.17E-11	2.47E-02
85	37.58	2.45E-12	3.02E-02	2.18E-11
86	37.66	3.14E-02	4.61E-10	1.98E-01
87	37.82	3.42E-01	1.56E-10	1.97E-01
88	37.92	3.42E-10	5.41E-02	1.78E-12
89	38.34	2.09E-12	1.80E-01	1.37E-12
90	38.53	1.01E-10	2.75E-02	5.35E-10
91	38.58	4.29E-02	1.11E-10	3.03E-01
92	38.87	1.78E-08	1.12E-01	2.18E-07
93	38.88	1.50E-01	1.84E-08	2.03E+00
94	38.97	5.47E-02	1.33E-09	2.15E+00
95	39.27	5.51E-12	1.43E-01	9.84E-10
96	39.50	9.25E-02	4.12E-11	5.49E+00
97	39.52	2.01E-10	2.93E-02	1.34E-08
98	39.89	8.71E-13	1.70E-02	1.87E-12
99	40.41	6.00E-03	1.86E-11	1.28E+00
100	40.59	4.00E-12	2.24E-01	3.84E-11
101	40.86	6.58E-12	6.15E-02	4.01E-10
102	41.06	1.53E-02	4.86E-12	2.18E+00
103	41.23	2.68E-12	4.61E-03	2.77E-10
104	41.63	1.21E-12	3.31E-02	4.37E-11
105	41.80	1.28E-02	3.69E-14	3.01E-03

Table 3.7.2-7—Modal Frequencies of 3D FEM of Emergency Power Generating Building
Sheet 4 of 6

Mode No.	Frequency (Hz)	Modal Participating Mass Ratios		
		X	Y	Z
106	42.16	6.40E-02	2.59E-10	2.07E-03
107	42.22	5.72E-11	3.00E-01	8.07E-12
108	42.32	3.08E-14	1.62E-01	1.92E-11
109	43.06	1.55E-02	3.63E-12	1.58E-04
110	44.19	3.34E-13	4.76E-02	3.38E-11
111	44.46	5.75E-03	4.16E-13	4.31E+00
112	44.95	2.12E-11	1.12E-01	1.55E-11
113	45.05	1.51E+00	1.05E-11	3.84E-01
114	45.28	3.43E-01	9.42E-11	1.93E-01
115	45.33	1.72E-09	6.88E-02	8.91E-10
116	45.70	6.77E-01	2.65E-12	1.29E+00
117	45.75	1.31E-11	8.29E-02	3.47E-11
118	46.31	2.71E-01	1.39E-12	1.02E-01
119	46.40	1.29E-10	3.91E-04	9.10E-13
120	46.43	2.31E-03	1.91E-12	1.13E-01
121	46.48	2.90E-13	3.41E-02	1.05E-15
122	46.60	4.90E-01	3.05E-13	2.55E-01
123	46.70	1.06E-11	2.09E-01	6.43E-11
124	46.84	7.89E-10	6.22E-03	3.08E-09
125	46.94	8.77E-02	5.89E-11	3.68E-01
126	47.48	2.69E-01	1.64E-10	9.11E-01
127	47.61	1.54E-09	3.47E-02	5.23E-09
128	48.03	2.76E-01	4.05E-15	6.64E-01
129	48.06	2.07E-01	1.87E-11	1.37E-01
130	48.32	3.99E-13	1.07E-01	8.01E-13
131	48.41	1.24E-02	1.66E-12	1.08E-01
132	48.53	2.01E-16	3.00E-02	7.75E-11
133	48.74	1.21E-01	1.86E-13	1.26E-02
134	48.85	1.88E-11	1.69E-05	1.85E-12
135	48.91	3.28E-01	9.71E-13	2.19E-02
136	48.98	1.23E-12	7.41E-03	2.01E-12
137	49.30	1.50E-11	4.59E-02	2.96E-12
138	49.39	5.93E-02	6.14E-13	3.70E-01
139	49.50	1.81E-03	2.71E-11	2.96E-02
140	49.51	7.61E-11	5.70E-03	7.16E-10

Table 3.7.2-7—Modal Frequencies of 3D FEM of Emergency Power Generating Building
Sheet 5 of 6

Mode No.	Frequency (Hz)	Modal Participating Mass Ratios		
		X	Y	Z
141	49.67	7.98E-12	2.15E-02	1.54E-11
142	49.72	1.63E-10	1.60E-01	2.21E-10
143	49.83	6.37E-02	2.83E-10	1.83E-02
144	49.98	1.19E-11	2.56E-01	3.51E-15
145	50.09	7.39E-03	1.09E-11	7.57E-01
146	50.14	5.88E-03	5.55E-12	8.00E-03
147	50.40	6.09E-11	1.90E-01	1.21E-08
148	50.42	2.73E-05	1.00E-08	2.11E-01
149	51.21	1.45E-09	6.44E-02	1.12E-08
150	51.27	7.97E-02	2.00E-09	7.48E-01
151	51.40	4.72E-12	2.81E-01	2.85E-11
152	51.55	1.84E-11	3.59E-01	3.92E-10
153	52.13	1.54E-02	7.65E-14	3.26E-02
154	52.36	6.26E-13	2.76E-01	8.23E-11
155	52.87	6.31E-02	9.20E-11	1.78E-01
156	52.92	2.39E-02	6.28E-10	6.17E-01
157	53.01	6.29E-11	6.76E-02	4.91E-09
158	53.38	7.41E-13	6.42E-02	8.75E-11
159	53.56	1.67E-01	9.01E-13	2.40E-01
160	53.89	4.17E-13	1.56E-02	1.04E-13
161	54.18	6.66E-01	8.24E-12	7.28E-02
162	54.45	5.83E-09	1.62E-02	5.38E-10
163	54.55	1.04E-11	7.45E-03	1.06E-14
164	54.60	8.03E-01	1.44E-11	1.26E-02
165	54.72	2.54E-01	2.67E-11	4.84E-02
166	55.29	7.86E-10	1.90E-02	1.99E-10
167	55.37	1.08E+00	2.39E-11	7.76E-02
168	55.45	1.93E-11	9.39E-03	8.15E-13
169	55.65	1.66E-10	8.19E-03	5.87E-11
170	55.73	1.98E-02	5.96E-12	9.20E-02
171	56.22	1.12E-01	8.00E-11	3.48E-02
172	56.27	8.83E-10	2.27E-02	1.13E-10
173	56.40	4.16E-11	7.98E-02	4.83E-13
174	56.95	1.46E-01	2.24E-11	3.64E-03
175	56.96	1.95E-11	3.91E-01	2.19E-11

Table 3.7.2-7—Modal Frequencies of 3D FEM of Emergency Power Generating Building
Sheet 6 of 6

Mode No.	Frequency (Hz)	Modal Participating Mass Ratios		
		X	Y	Z
176	57.16	3.60E-02	7.44E-11	8.89E-03
177	57.31	4.60E-11	4.47E-02	1.48E-11
178	57.62	3.57E-11	4.55E-01	6.74E-11
179	57.79	1.44E-11	1.74E-01	2.44E-11
180	58.12	5.99E-02	9.23E-11	1.47E-01
181	58.37	1.81E-02	1.09E-10	2.79E-02
182	58.70	1.93E-01	9.51E-11	2.89E-03
183	58.81	3.47E-10	8.73E-02	1.18E-10
184	58.96	1.99E-11	1.53E-01	9.97E-10
185	59.08	4.74E-02	2.82E-11	2.76E-01
186	59.52	4.11E-08	2.44E-01	2.15E-08
187	59.54	2.22E-01	5.28E-08	1.19E-01
188	59.85	2.47E-09	5.75E-03	2.53E-09
189	59.93	3.39E-04	8.72E-14	4.48E-01
190	60.38	1.30E-11	7.73E-02	1.44E-10
191	60.86	1.36E-11	1.82E-04	4.57E-12
192	60.87	8.14E-03	8.16E-13	8.83E-02
193	60.99	3.89E-03	2.30E-12	4.17E-02
194	61.26	4.17E-10	8.14E-04	5.00E-08
195	61.26	2.62E-03	4.57E-09	1.75E-01
196	61.36	9.81E-12	2.65E-03	1.96E-09
197	61.63	9.16E-12	2.06E-04	2.70E-09
198	61.80	7.36E-10	3.14E-02	1.39E-09
199	61.90	2.06E-02	2.95E-07	2.82E-01
200	61.94	2.11E-04	4.18E-09	6.24E-01
Total MPF's in Each Direction:		92.222	92.789	80.029

Note:

1. Y is in the vertical direction for GTSTRUDL FEM of EPGB.

Table 3.7.2-8—Modal Frequencies of 3D FEM of Essential Service Water Building (EUR Motions)
Sheet 1 of 10

Mode No.	Frequency (Hz)	X % Participating Mass	Y % Participating Mass	Z % Participating Mass
1	6.670	0.00	0.00	25.22
2	6.855	0.00	0.00	0.84
3	7.209	39.61	0.06	0.00
4	7.597	0.00	0.00	0.00
5	7.605	0.00	0.00	0.00
6	7.646	0.00	0.00	0.00
7	7.653	0.00	0.00	0.00
8	7.717	0.00	0.00	0.00
9	7.723	0.00	0.00	0.02
10	7.796	0.00	0.00	10.92
11	7.797	0.00	0.00	0.00
12	7.803	0.00	0.00	0.00
13	7.876	0.00	0.00	0.00
14	7.882	0.00	0.00	0.02
15	7.945	0.01	0.00	0.00
16	7.951	0.00	0.00	0.00
17	8.002	0.00	0.00	0.00
18	8.008	0.00	0.00	0.00
19	8.039	0.25	0.00	0.00
20	8.043	0.00	0.00	0.00
21	8.078	0.00	0.00	0.00
22	8.083	0.00	0.00	0.03
23	9.151	0.09	0.00	0.00
24	9.190	0.00	0.00	0.02
25	9.228	0.00	0.00	0.09
26	9.288	0.00	0.00	0.14
27	9.294	0.00	0.00	0.00
28	9.296	0.01	0.00	0.00
29	9.335	0.00	0.00	0.00
30	9.337	0.00	0.00	0.00
31	9.341	0.00	0.00	0.00

Table 3.7.2-8—Modal Frequencies of 3D FEM of Essential Service Water Building (EUR Motions)
Sheet 2 of 10

Mode No.	Frequency (Hz)	X % Participating Mass	Y % Participating Mass	Z % Participating Mass
32	9.344	0.00	0.00	0.00
33	9.346	0.00	0.00	0.00
34	9.347	0.00	0.00	0.00
35	9.355	0.00	0.00	0.00
36	9.357	0.00	0.00	0.00
37	9.362	0.00	0.00	0.00
38	9.364	0.00	0.00	0.00
39	9.368	0.00	0.00	0.00
40	9.368	0.00	0.00	0.00
41	9.373	0.00	0.00	0.01
42	9.391	0.00	0.00	0.05
43	9.473	0.06	0.00	0.00
44	9.649	0.03	0.85	0.00
45	9.723	4.83	0.00	0.00
46	9.763	0.02	1.07	0.00
47	9.824	0.00	0.00	0.00
48	9.963	0.00	0.00	0.01
49	10.454	0.00	0.38	0.00
50	10.519	0.08	0.00	0.00
51	10.578	1.89	0.10	0.00
52	11.068	2.49	0.01	0.00
53	11.430	0.00	0.00	0.01
54	11.674	0.00	0.00	0.00
55	11.733	0.15	0.03	0.00
56	11.981	0.04	0.37	0.00
57	12.141	0.00	0.01	6.17
58	12.171	0.05	9.37	0.00
59	12.318	0.00	0.00	6.03
60	12.952	0.00	1.75	0.00
61	13.066	0.01	8.25	0.00
62	13.127	0.00	0.00	0.01

Table 3.7.2-8—Modal Frequencies of 3D FEM of Essential Service Water Building (EUR Motions)
Sheet 3 of 10

Mode No.	Frequency (Hz)	X % Participating Mass	Y % Participating Mass	Z % Participating Mass
63	13.184	0.06	0.13	0.00
64	13.210	0.00	0.00	0.11
65	13.288	0.00	0.00	0.00
66	13.456	0.00	0.00	0.15
67	13.553	0.06	0.03	0.00
68	13.607	0.00	0.00	0.72
69	13.656	0.25	0.01	0.00
70	13.704	0.00	0.00	6.84
71	13.849	0.09	0.00	0.00
72	14.002	1.29	0.01	0.00
73	14.126	0.00	0.00	0.16
74	14.180	0.16	0.00	0.00
75	14.347	0.00	0.00	0.01
76	14.501	0.00	0.00	0.26
77	14.629	0.00	0.00	0.02
78	14.781	2.38	0.03	0.00
79	14.946	0.00	0.00	0.00
80	15.135	0.02	0.02	0.00
81	15.161	0.00	0.00	0.15
82	15.220	0.00	0.00	0.00
83	15.261	0.02	0.00	0.00
84	15.349	0.00	0.01	0.00
85	15.426	0.00	0.02	0.00
86	15.933	0.00	0.00	0.16
87	16.098	0.01	0.04	0.00
88	16.137	0.00	1.92	0.00
89	16.204	0.00	0.07	0.00
90	16.417	0.01	1.29	0.00
91	16.521	0.00	0.00	0.25
92	16.645	0.00	0.00	0.01
93	16.902	0.00	0.00	0.00

Table 3.7.2-8—Modal Frequencies of 3D FEM of Essential Service Water Building (EUR Motions)
Sheet 4 of 10

Mode No.	Frequency (Hz)	X % Participating Mass	Y % Participating Mass	Z % Participating Mass
94	16.905	0.00	0.00	0.00
95	16.963	0.00	0.00	0.00
96	16.966	0.00	0.00	0.00
97	17.048	0.00	0.00	0.00
98	17.050	0.00	0.00	0.00
99	17.050	0.00	0.12	0.00
100	17.052	0.00	0.00	0.00
101	17.137	0.01	0.02	0.00
102	17.148	0.00	0.00	0.00
103	17.170	0.02	0.02	0.00
104	17.187	0.03	0.11	0.00
105	17.212	0.00	0.00	0.03
106	17.219	0.00	0.00	0.02
107	17.250	0.00	0.00	0.01
108	17.253	0.00	0.00	0.00
109	17.274	0.00	0.00	0.03
110	17.274	0.00	0.01	0.00
111	17.328	0.00	0.00	0.02
112	17.374	0.00	0.07	0.00
113	17.393	0.05	0.03	0.01
114	17.405	0.01	0.00	0.12
115	17.757	0.00	0.00	0.00
116	18.027	0.00	0.00	0.06
117	18.456	0.01	0.50	0.00
118	18.524	0.00	0.00	0.11
119	18.599	0.00	0.00	0.00
120	18.657	0.00	0.00	0.00
121	18.727	0.01	0.01	0.00
122	18.737	0.00	0.00	0.00
123	18.791	0.00	0.00	0.00
124	18.804	0.00	0.00	0.00

Table 3.7.2-8—Modal Frequencies of 3D FEM of Essential Service Water Building (EUR Motions)
Sheet 5 of 10

Mode No.	Frequency (Hz)	X % Participating Mass	Y % Participating Mass	Z % Participating Mass
125	18.826	0.00	0.00	0.00
126	18.837	0.00	0.00	0.06
127	18.845	0.00	0.00	0.01
128	18.852	0.02	0.01	0.00
129	18.854	0.00	0.00	0.00
130	18.891	0.00	0.05	0.00
131	18.908	0.00	0.00	0.00
132	18.930	0.00	0.00	0.00
133	18.938	0.00	0.00	0.00
134	19.022	0.00	0.00	0.00
135	19.044	0.00	0.01	0.00
136	19.095	0.01	5.23	0.00
137	19.152	0.00	0.00	0.00
138	19.190	0.00	0.01	0.00
139	19.337	0.00	0.00	0.61
140	19.473	0.00	0.00	0.02
141	19.739	0.03	12.19	0.00
142	19.844	0.00	0.01	0.00
143	19.876	0.00	0.00	0.31
144	19.974	0.00	0.00	0.08
145	20.013	0.00	0.32	0.00
146	20.016	0.00	0.09	0.01
147	20.169	0.00	0.00	0.00
148	20.204	0.00	0.00	0.00
149	20.447	0.00	0.00	1.12
150	20.580	0.00	0.00	0.01
151	20.673	0.00	0.00	0.71
152	20.904	0.14	0.00	0.00
153	20.926	0.59	0.01	0.00
154	21.109	0.00	0.00	0.12
155	21.275	1.28	0.01	0.00

Table 3.7.2-8—Modal Frequencies of 3D FEM of Essential Service Water Building (EUR Motions)
Sheet 6 of 10

Mode No.	Frequency (Hz)	X % Participating Mass	Y % Participating Mass	Z % Participating Mass
156	21.383	0.00	0.00	0.01
157	21.388	0.93	0.02	0.00
158	21.407	0.05	0.00	0.00
159	21.418	0.00	0.00	0.04
160	21.504	0.05	0.01	0.00
161	21.599	0.00	0.00	0.00
162	21.686	0.00	0.00	0.00
163	21.909	0.63	0.00	0.00
164	22.081	0.08	0.32	0.00
165	22.094	0.00	0.00	0.00
166	22.231	0.05	0.00	0.00
167	22.274	0.00	0.00	0.00
168	22.408	0.00	0.00	0.64
169	22.435	0.00	0.00	0.00
170	22.480	0.00	0.00	0.11
171	22.552	0.00	0.00	0.28
172	22.588	0.03	0.44	0.00
173	22.797	0.65	0.09	0.00
174	22.830	0.34	0.04	0.00
175	23.010	0.00	0.00	0.39
176	23.034	0.00	0.02	0.00
177	23.148	0.00	0.00	0.85
178	23.325	0.06	1.59	0.00
179	23.376	0.50	0.02	0.00
180	23.425	0.06	1.32	0.00
181	23.540	0.04	0.00	0.24
182	23.549	0.69	0.03	0.01
183	23.692	0.00	0.00	0.00
184	24.149	0.00	0.00	0.06
185	24.297	0.14	0.00	0.00
186	24.470	0.60	0.01	0.00

Table 3.7.2-8—Modal Frequencies of 3D FEM of Essential Service Water Building (EUR Motions)
Sheet 7 of 10

Mode No.	Frequency (Hz)	X % Participating Mass	Y % Participating Mass	Z % Participating Mass
187	24.579	0.55	0.00	0.00
188	24.816	0.00	0.01	0.00
189	24.845	0.01	0.19	0.00
190	24.874	0.10	0.03	0.00
191	25.195	1.31	0.14	0.00
192	25.209	0.43	0.08	0.00
193	25.358	0.00	0.00	0.00
194	25.496	0.01	0.00	0.00
195	25.501	0.00	0.00	0.00
196	25.577	0.00	0.00	0.00
197	25.595	0.46	0.98	0.00
198	25.626	0.00	0.01	0.00
199	25.660	0.00	0.00	0.00
200	25.681	0.00	0.00	0.00
201	25.711	0.01	0.01	0.01
202	25.755	0.01	0.01	0.00
203	25.851	0.32	5.11	0.00
204	25.907	0.10	0.84	0.00
205	25.982	0.00	0.00	0.00
206	26.058	0.00	0.00	0.00
207	26.107	0.00	0.05	0.00
208	26.126	0.26	4.15	0.00
209	26.151	0.01	0.07	0.00
210	26.173	0.01	0.12	0.00
211	26.228	0.00	0.00	0.00
212	26.262	9.74	0.03	0.00
213	26.274	0.02	0.02	0.00
214	26.282	0.03	0.01	0.02
215	26.516	0.00	0.00	0.01
216	26.680	0.00	0.00	0.00
217	26.691	0.00	0.00	0.00

Table 3.7.2-8—Modal Frequencies of 3D FEM of Essential Service Water Building (EUR Motions)
Sheet 8 of 10

Mode No.	Frequency (Hz)	X % Participating Mass	Y % Participating Mass	Z % Participating Mass
218	26.740	0.22	0.41	0.00
219	26.744	0.16	0.21	0.01
220	26.794	0.00	0.00	0.03
221	26.805	0.09	0.01	0.00
222	26.816	0.00	0.03	0.00
223	27.010	0.00	0.00	0.00
224	27.025	0.00	0.00	0.00
225	27.036	0.97	0.01	0.00
226	27.084	0.02	0.01	0.00
227	27.117	0.03	0.17	0.00
228	27.156	0.17	0.01	0.00
229	27.191	0.00	0.00	0.02
230	27.227	0.01	0.00	0.00
231	27.323	0.00	0.00	0.00
232	27.329	0.01	0.00	0.02
233	27.359	0.54	0.00	0.00
234	27.366	0.00	0.00	0.00
235	27.381	0.00	0.00	0.00
236	27.519	0.00	0.00	0.25
237	27.551	0.00	0.06	0.00
238	27.673	0.00	0.00	0.01
239	27.798	0.68	0.05	0.00
240	27.980	1.89	0.31	0.00
241	28.347	0.01	0.01	0.00
242	28.489	0.00	0.00	0.16
243	28.668	0.00	0.00	0.85
244	28.908	0.00	0.00	0.05
245	29.103	0.00	0.00	0.00
246	29.163	0.08	0.02	0.00
247	29.348	0.00	0.00	0.62
248	29.544	0.15	0.09	0.00

Table 3.7.2-8—Modal Frequencies of 3D FEM of Essential Service Water Building (EUR Motions)
Sheet 9 of 10

Mode No.	Frequency (Hz)	X % Participating Mass	Y % Participating Mass	Z % Participating Mass
249	29.945	0.03	0.18	0.00
250	29.965	0.00	0.01	0.02
251	30.023	0.00	0.00	0.18
252	30.097	0.03	0.47	0.00
253	30.399	0.00	0.00	0.09
254	30.678	0.04	0.22	0.00
255	30.752	0.00	0.00	0.01
256	30.876	0.26	0.31	0.00
257	30.982	0.00	0.00	0.05
258	31.095	0.20	0.63	0.00
259	31.128	0.00	0.00	0.04
260	31.375	0.00	0.00	0.04
261	31.425	0.00	0.23	0.00
262	31.625	0.05	0.08	0.04
263	31.640	0.05	0.08	0.04
264	31.822	0.02	0.46	0.00
265	31.914	0.00	0.12	0.00
266	32.062	0.29	0.09	0.00
267	32.146	0.00	0.00	1.95
268	32.293	0.02	0.54	0.00
269	32.406	0.30	0.00	0.00
270	32.585	0.00	0.01	0.00
271	32.713	0.00	0.01	0.00
272	32.850	0.04	0.62	0.00
273	32.999	0.00	0.00	0.11
274	33.179	0.00	0.07	0.00
275	33.235	0.00	0.00	0.01
276	33.402	0.00	0.00	0.16
277	33.589	0.00	0.00	0.01
278	33.614	0.01	0.03	0.00
279	33.670	0.06	0.05	0.00

Table 3.7.2-8—Modal Frequencies of 3D FEM of Essential Service Water Building (EUR Motions)
Sheet 10 of 10

Mode No.	Frequency (Hz)	X % Participating Mass	Y % Participating Mass	Z % Participating Mass
280	33.770	0.01	0.02	0.00
281	33.853	0.01	0.01	0.00
282	33.954	0.00	0.00	0.00
283	33.960	0.00	0.00	0.00
284	33.982	0.06	0.03	0.00
285	33.997	0.00	0.00	0.00
286	34.008	0.04	0.03	0.00
287	34.017	0.00	0.00	0.00
288	34.019	0.02	0.01	0.00
289	34.024	0.00	0.00	0.00
290	34.064	0.01	0.01	0.00

Note:

1. Y is in vertical direction for GTSTRUDL FEM of ESWB.

Table 3.7.2-9—Soil Properties Associated with Different Shear Wave Velocities

Applicable Soil Profiles	Shear Wave Velocity (ft/s)	Shear Wave Velocity (m/s)	Poisson's Ratio μ	Weight Density (pcf)	Weight Density (kN/m^3)	Shear Wave Damping Ratio (%)	Dynamic Shear Modulus (ksf)	Static Shear Modulus (ksf)
EUR	700	213	0.40	110	17.28	4.00 - 7.00	1,675	838
	820	250	0.40	110	17.28	7.00	2,299	1,150
	1,640	500	0.40	110	17.28	4.00	9,197	4,599
	3,937	1,200	0.40	120	18.85	1.00	57,790	28,900
	6,601	2,012	0.35	156	24.51	1.00	211,200	105,600
	13,123	4,000	0.35	156	24.51	1.00	834,900	417,500
HF	470	143	0.35	140	21.98	4.78	961	480
	578	176	0.35	140	21.98	3.58 - 4.65	1,454	727
	708	216	0.35	140	21.98	2.50	2,181	1,091
	719	219	0.48	140	21.98	4.49	2,251	1,125
	720	220	0.35	140	21.98	2.10	2,257	1,128
	908	277	0.48	140	21.98	3.35	3,585	1,793
	1,408	429	0.37	126	19.80	1.00	7,769	3,884
	2,817	859	0.44	126	19.80	1.00	31,080	15,540
	5,427	1,654	0.31	170	26.70	1.00	155,500	77,760
	6,647	2,026	0.31	170	26.70	0.75	233,300	116,700
	7,838	2,389	0.26	170	26.70	1.10	324,400	162,200
	8,143	2,482	0.31	170	26.70	0.51	350,200	175,100
	9,600	2,926	0.26	170	26.70	0.70	486,700	243,300
	10,960	3,341	0.26 - 0.31	170	26.70	0.50	634,400	317,200
	11,759	3,584	0.26	170	26.70	0.47	730,200	365,100

Notes:

1. P-wave damping is taken to be 1/3*S-wave damping.
2. When shear wave velocity varies linearly in a layer, other properties vary accordingly.
3. P-wave velocity = S-wave velocity*$[2(1-\mu)/(1-2\mu)]^{1/2}$.
4. Shear-wave velocities and S-wave damping values are strain compatible. Damping values do not exceed 15 percent.
5. Dynamic (best-estimate) shear modulus = mass density*(S-wave velocity)^2.
6. Static shear modulus is taken as half of the dynamic shear modulus.

Table 3.7.2-10—NI Common Basemat Structures ZPAs
Sheet 1 of 2

Nuclear Island Key Locations																			
Zero Period Accelerations at Each Floor Level [g]																			
		Motion =>	EURS	EURH	EURM	EURM	EURH	HF	HF	HF	EURS	EURH	EURM	EURM	EURH	HF	HF	HF	
			Uncracked								Cracked								
Designation	Elevation [m]	Direction	Case 1n2ue	Case 1n5ae	Case 2sn4ue	Case 4ue	Case 5ae	Case hflb	Case hfbe	Case hfub	Case 1n2ue	Case 1n5ae	Case 2sn4ue	Case 4ue	Case 5ae	Case hflb	Case hfbe	Case hfub	Envelope All Cases
Containment Building		X	0.33	0.74	0.65	0.84	0.88	0.20	0.33	0.37	0.32	0.68	0.65	0.76	0.76	0.19	0.31	0.35	0.88
	37.60	Y	0.28	0.70	0.67	0.91	0.86	0.18	0.25	0.34	0.31	0.74	0.72	0.95	0.92	0.21	0.22	0.37	0.95
		Z	0.33	0.72	0.50	0.67	0.91	0.22	0.29	0.32	0.35	0.69	0.50	0.65	0.89	0.24	0.25	0.33	0.91
		X	0.39	1.08	0.83	1.03	1.11	0.29	0.34	0.37	0.41	1.05	0.83	0.95	1.02	0.28	0.32	0.38	1.11
	58.00	Y	0.35	0.97	0.90	1.26	1.06	0.35	0.44	0.48	0.38	0.91	0.93	1.27	1.00	0.36	0.40	0.47	1.27
		Z	0.37	1.12	0.57	0.95	1.38	0.56	0.83	0.80	0.34	1.11	0.58	0.95	1.35	0.49	0.69	1.04	1.38
Reactor Building Internal Structure		X	0.17	0.38	0.36	0.46	0.38	0.17	0.22	0.21	0.20	0.36	0.36	0.45	0.37	0.16	0.24	0.21	0.46
	5.15	Y	0.21	0.33	0.32	0.35	0.38	0.13	0.19	0.20	0.22	0.37	0.32	0.40	0.40	0.14	0.17	0.19	0.40
		Z	0.28	0.46	0.45	0.53	0.50	0.17	0.30	0.25	0.29	0.49	0.46	0.50	0.54	0.18	0.23	0.25	0.54
		X	0.20	0.55	0.52	0.61	0.60	0.24	0.24	0.22	0.22	0.55	0.57	0.66	0.61	0.23	0.24	0.23	0.66
	19.50	Y	0.24	0.54	0.44	0.51	0.61	0.17	0.20	0.22	0.26	0.53	0.44	0.54	0.60	0.16	0.18	0.22	0.61
		Z	0.29	0.55	0.50	0.59	0.62	0.23	0.28	0.26	0.30	0.58	0.50	0.55	0.61	0.23	0.22	0.25	0.62
Safeguard Building 1		X	0.20	0.37	0.37	0.36	0.37	0.16	0.20	0.33	0.22	0.41	0.34	0.37	0.45	0.14	0.18	0.40	0.45
	8.10	Y	0.20	0.40	0.27	0.40	0.38	0.15	0.20	0.50	0.22	0.40	0.31	0.42	0.37	0.17	0.19	0.46	0.50
		Z	0.33	0.55	0.41	0.51	0.45	0.16	0.17	0.30	0.32	0.49	0.40	0.50	0.42	0.16	0.17	0.25	0.55
		X	0.23	0.49	0.45	0.50	0.54	0.18	0.23	0.37	0.24	0.49	0.44	0.51	0.60	0.18	0.22	0.29	0.60
	21.00	Y	0.25	0.49	0.31	0.51	0.55	0.19	0.25	0.33	0.26	0.44	0.37	0.51	0.59	0.19	0.21	0.32	0.59
		Z	0.34	0.68	0.45	0.61	0.70	0.23	0.27	0.38	0.35	0.73	0.44	0.59	0.78	0.25	0.30	0.39	0.78

Table 3.7.2-10—NI Common Basemat Structures ZPAs
Sheet 2 of 2

Nuclear Island Key Locations																		
Zero Period Accelerations at Each Floor Level [g]																		
		Motion =>	EURS	EURH	EURM	EURM	EURH	HF	HF	HF	EURS	EURH	EURM	EURM	EURH	HF	HF	HF	
			Uncracked								Cracked								
Designation	Elevation [m]	Direction	Case 1n2ue	Case 1n5ae	Case 2sn4ue	Case 4ue	Case 5ae	Case hflb	Case hfbe	Case hfub	Case 1n2ue	Case 1n5ae	Case 2sn4ue	Case 4ue	Case 5ae	Case hflb	Case hfbe	Case hfub	Envelope All Cases
Safeguard Building 2 & 3	8.10	X	0.24	0.71	0.36	0.60	0.89	0.30	0.41	0.40	0.23	0.74	0.37	0.59	0.92	0.31	0.40	0.38	0.92
		Y	0.24	0.52	0.31	0.62	0.59	0.24	0.28	0.27	0.23	0.51	0.34	0.59	0.62	0.22	0.27	0.26	0.62
		Z	0.37	0.47	0.46	0.51	0.50	0.19	0.19	0.23	0.37	0.48	0.43	0.49	0.52	0.18	0.20	0.24	0.52
	16.30	X	0.28	0.70	0.43	0.75	1.07	0.24	0.24	0.33	0.24	0.71	0.42	0.77	1.08	0.25	0.26	0.34	1.08
		Y	0.28	0.67	0.48	0.74	0.82	0.28	0.29	0.34	0.25	0.68	0.43	0.69	0.81	0.28	0.27	0.32	0.82
		Z	0.38	0.56	0.48	0.54	0.68	0.20	0.25	0.34	0.39	0.52	0.44	0.57	0.62	0.19	0.22	0.27	0.68
Safeguard Building 4	21.00	X	0.21	0.48	0.37	0.51	0.45	0.22	0.23	0.27	0.22	0.49	0.35	0.47	0.51	0.20	0.20	0.27	0.51
		Y	0.26	0.44	0.34	0.48	0.52	0.22	0.24	0.27	0.27	0.41	0.37	0.53	0.56	0.17	0.19	0.25	0.56
		Z	0.33	0.58	0.48	0.46	0.52	0.29	0.33	0.35	0.33	0.55	0.47	0.44	0.51	0.26	0.31	0.39	0.58
Fuel Building Shield Structure	3.70	X	0.17	0.38	0.31	0.32	0.43	0.19	0.22	0.17	0.17	0.39	0.30	0.34	0.45	0.19	0.19	0.25	0.45
		Y	0.22	0.47	0.30	0.41	0.44	0.16	0.22	0.21	0.22	0.40	0.35	0.39	0.46	0.18	0.19	0.23	0.47
		Z	0.32	0.47	0.49	0.44	0.48	0.20	0.26	0.25	0.32	0.47	0.50	0.44	0.46	0.21	0.23	0.25	0.50

Table 3.7.2-11—Deleted

Table 3.7.2-12—Deleted

Table 3.7.2-13—Deleted

Table 3.7.2-14—Deleted

Table 3.7.2-15—Deleted

Table 3.7.2-16—Deleted

Table 3.7.2-17—Deleted

Table 3.7.2-18—Deleted

Table 3.7.2-19—Deleted

Table 3.7.2-20—Deleted

Table 3.7.2-21—Deleted

Table 3.7.2-22—Deleted

Table 3.7.2-23—Deleted

Table 3.7.2-24—Deleted

Table 3.7.2-25—Deleted

Table 3.7.2-26—Deleted

Table 3.7.2-27—Deleted

Table 3.7.2-28—Maximum Accelerations in EPGB

Slab Elevation	X-Direction	Y-Direction	Z-Direction
+68 ft, 0 in	1.37 g	1.58 g	2.63 g
+51 ft, 6 in	1.16 g	1.22 g	1.84 g
+19 ft, 3 in	0.65 g	1.00 g	0.61 g
0 ft, 0 in	0.46 g	0.44 g	0.58 g

Table 3.7.2-29—Maximum Accelerations in ESWB

Will be provided later.

Table 3.7.2-30—Seismic Structural Interaction Criteria for Building Structures

Basis: Control Interaction through Prevention of Structure-to-Structure Impact[4]				
Structure	**Seismic Category**	**Design Code**	**Seismic Interaction Criteria**	**Seismic Interaction Evaluation**
Turbine / SBO	II	[[AISC N690]] [[ACI 349]]	Site-specific SSE	[[COL applicant will demonstrate that there is not interaction potential]]
Access	II	[[AISC N690]] [[ACI 349]]	Site-specific SSE	[[COL applicant will demonstrate that there is not interaction potential]]
NAB	II RS	AISC N690 ACI 349	SSE	No Interaction Potential
RWB	RS	AISC N690[3] ACI 349[3]	None[1]	No Interaction Potential

Notes:

1. The RWB, as a radwaste structure, is designed for the ½ SSE in accordance with the guidance for RW-IIa structures in RG 1.143.
2. Deleted.
3. ACI 349 and AISC N690 required due to Radwaste Seismic classification.
4. This table is not applicable to equipment and subsystems qualification criteria.

Table 3.7.2-31—Deleted

Table 3.7.2-32—Modal Frequencies of 3D FEM of Essential Service Water Building (HF Motion)

Will be provided later.

Figure 3.7.2-1—Decoupling of the Nuclear Island Common Basemat Interior Structures from the Outer Shield Walls

Figure 3.7.2-2—Deleted

Figure 3.7.2-3—Schematic Elevation View of Stick Model for Reactor Building Internal Structures in Global Y-Z Plane

Figure 3.7.2-4—Deleted

Figure 3.7.2-5—Static 3D Finite Element Model of Balance of NI Common Basemat Structures Perspective View

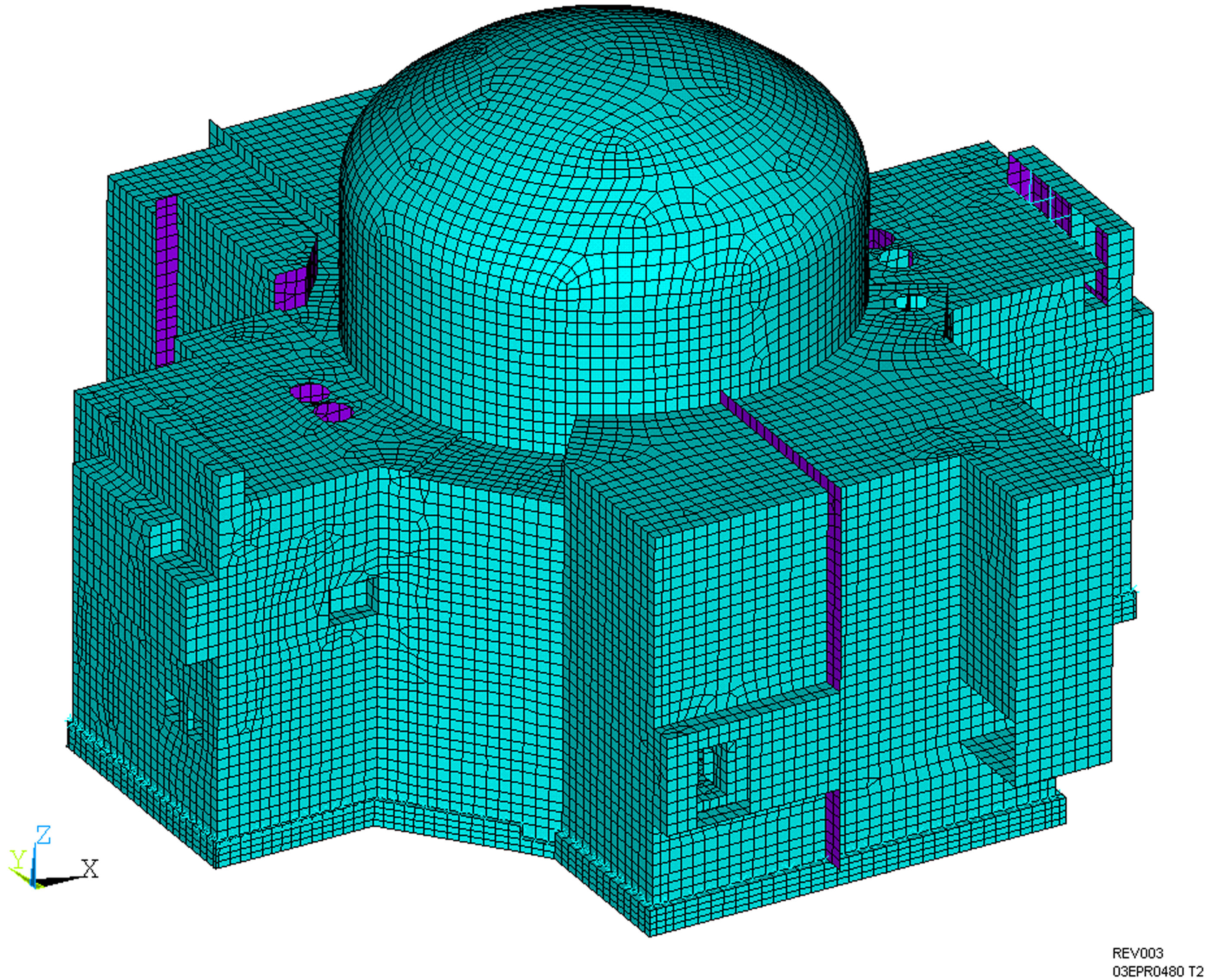

Figure 3.7.2-6—Static 3D Finite Element Model of Balance of NI Common Basemat Structures Cutoff View on Y-Z Plane

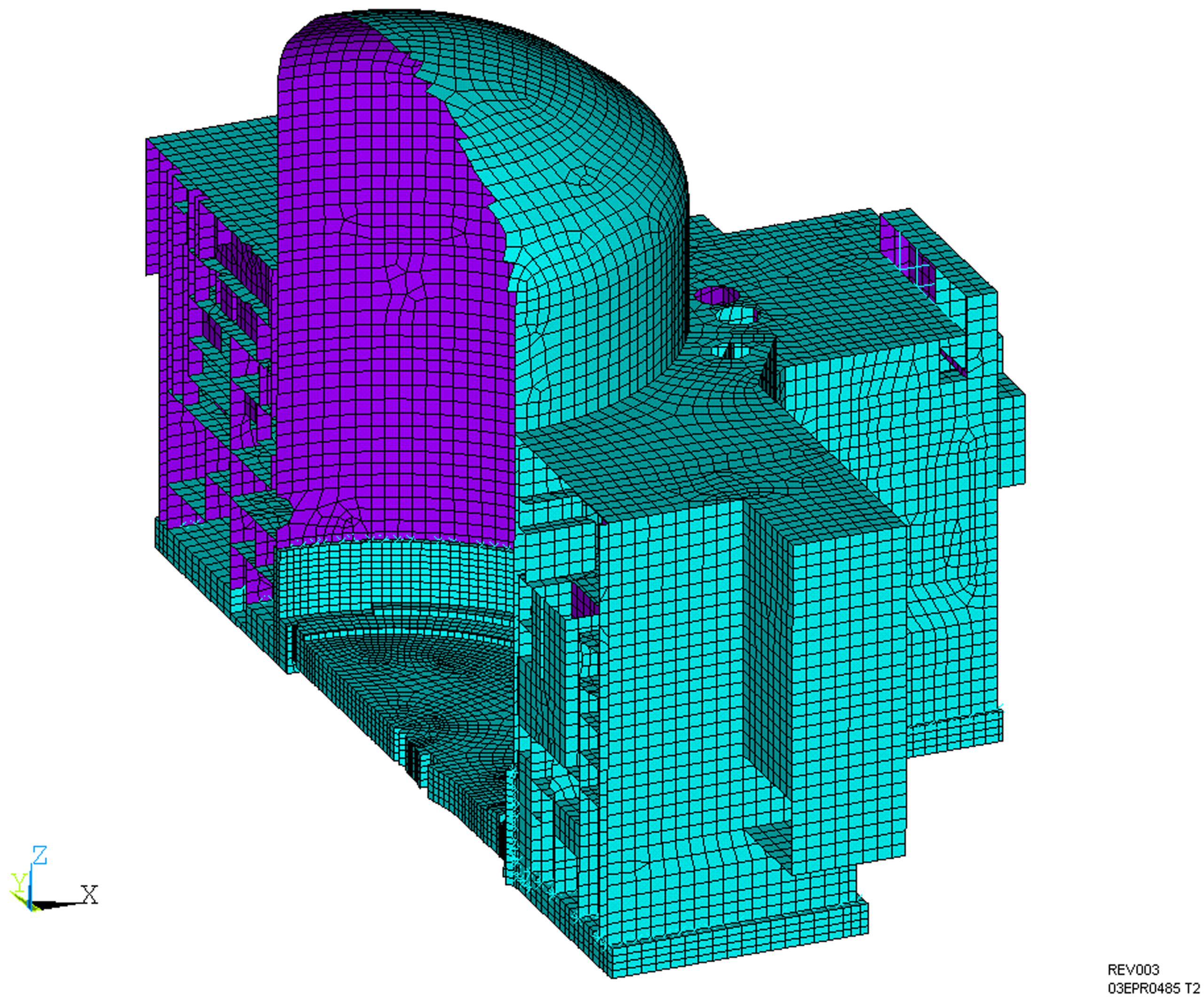

Figure 3.7.2-7—Static 3D Finite Element Model of Balance of NI Common Basemat Structures Cutoff View on X-Z Plane

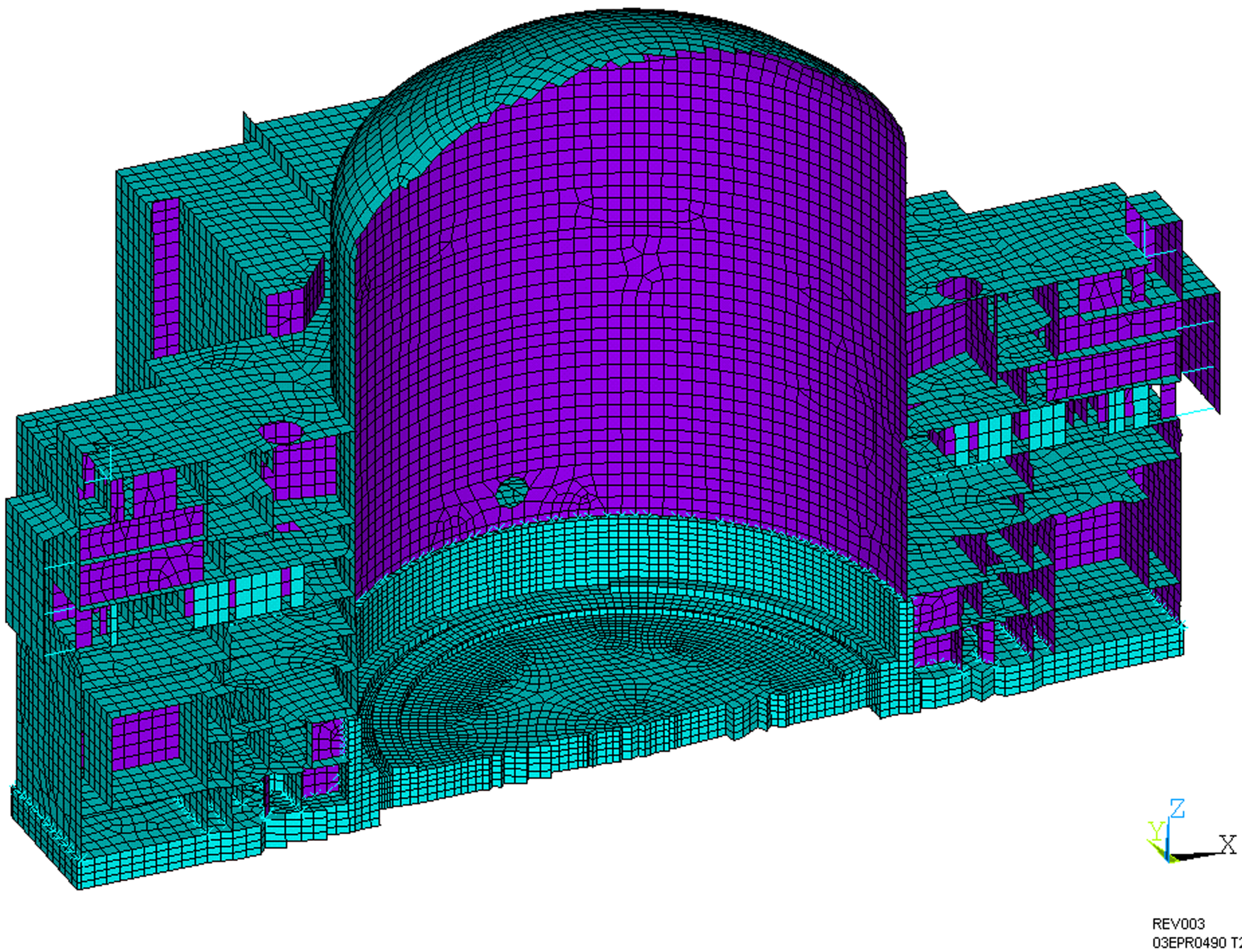

Figure 3.7.2-8—Static 3D Finite Element Model of Reactor Containment Building

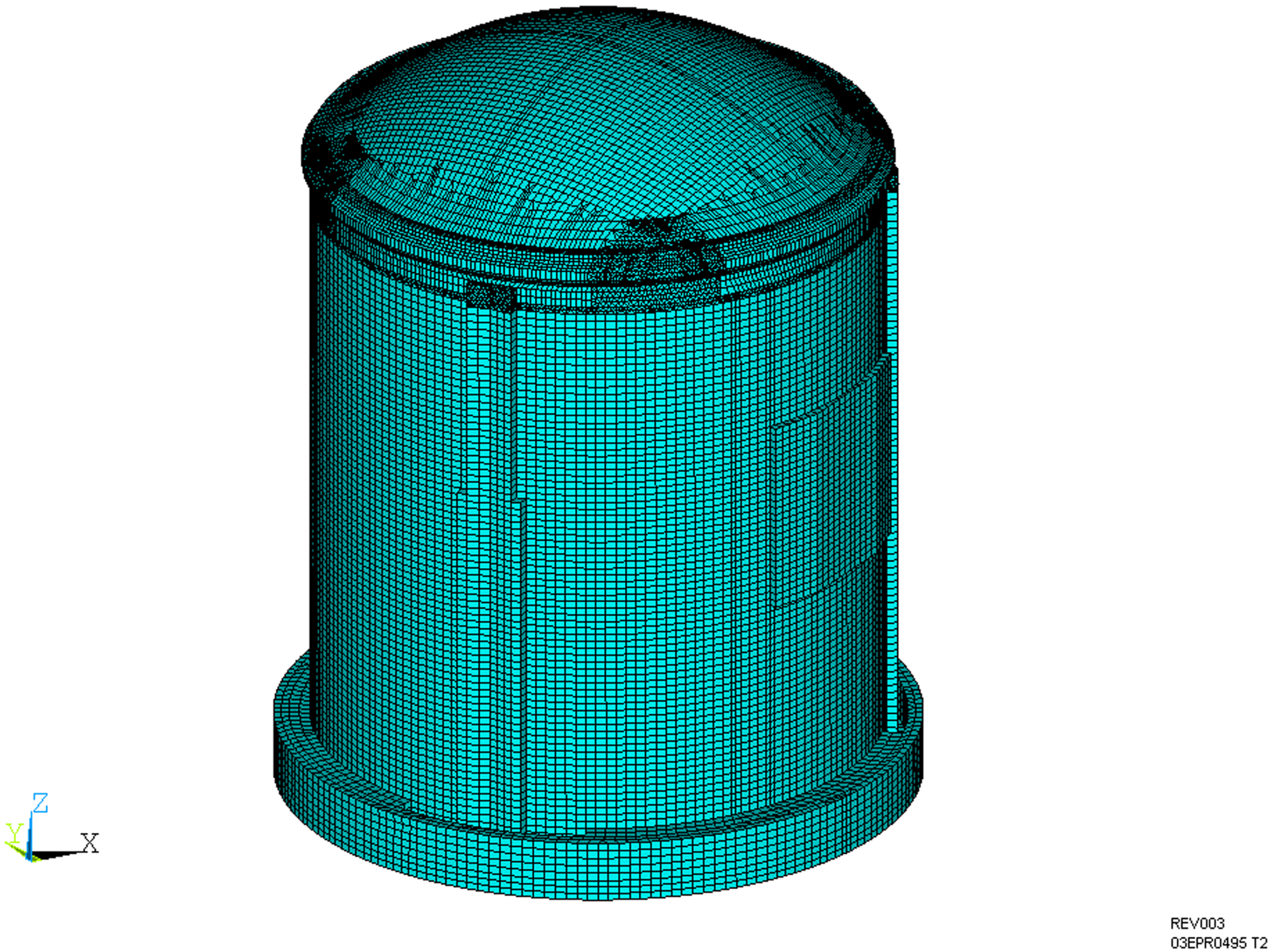

Figure 3.7.2-9—Static 3D Finite Element Model of Reactor Building Internal Structures

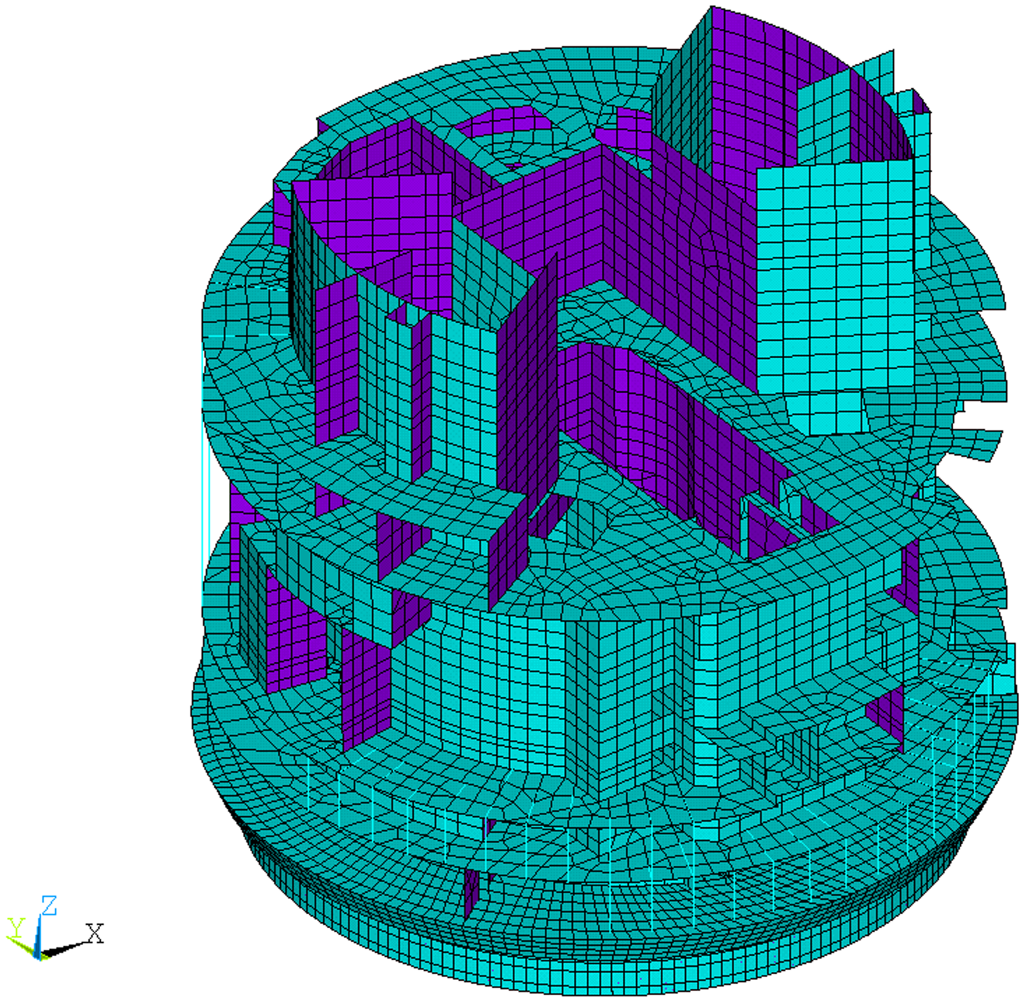

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Figure 3.7.2-10—Deleted

Figure 3.7.2-11—Deleted

Figure 3.7.2-12—Deleted

Figure 3.7.2-13—Stick Model STICK-1T for Reactor Building Internal Structure - Perspective View

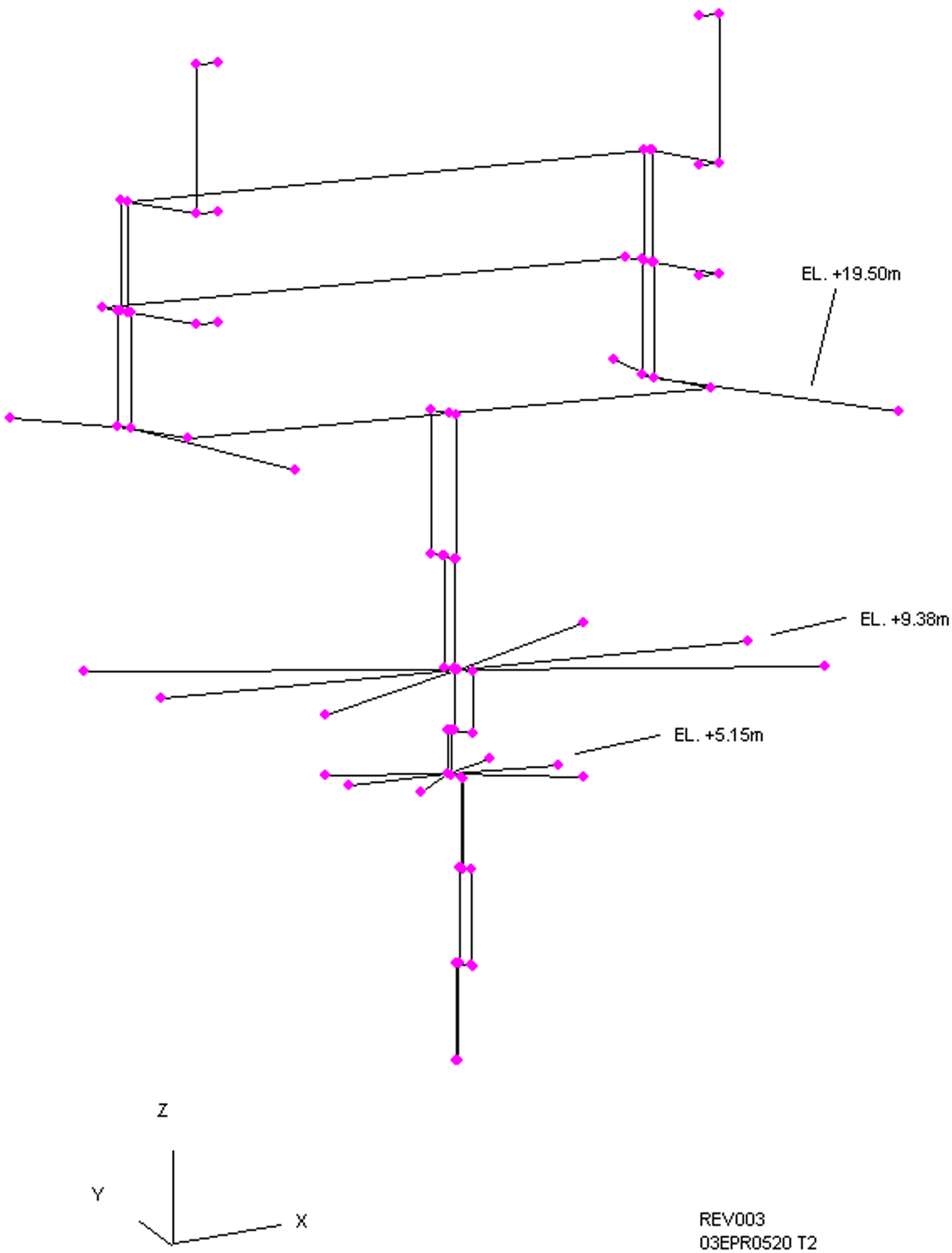

Figure 3.7.2-14—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +200 ft, 5 in (+61.09m) (Dome Apex) of Reactor Shield Building, 5% Damping, X-Direction

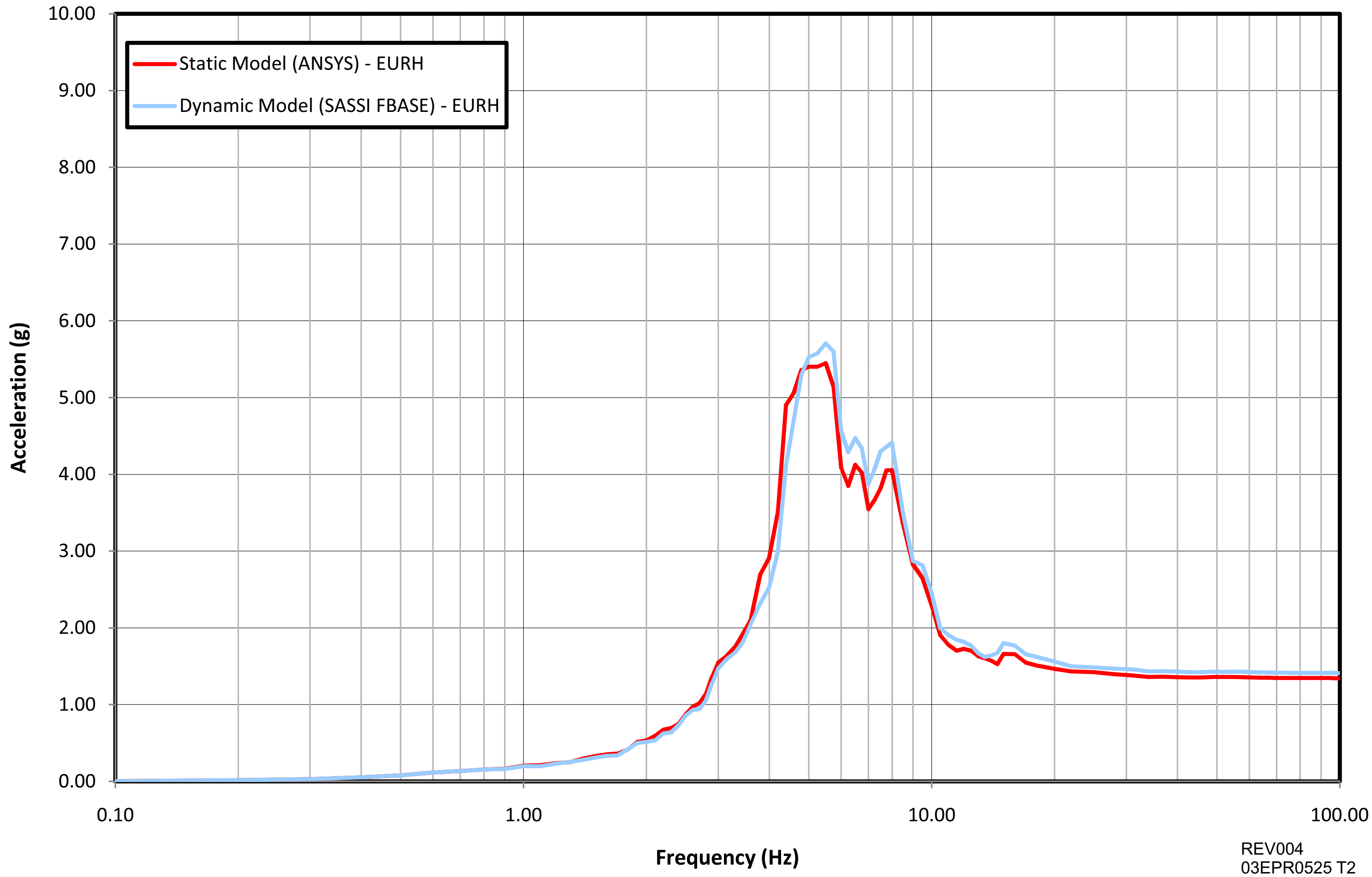

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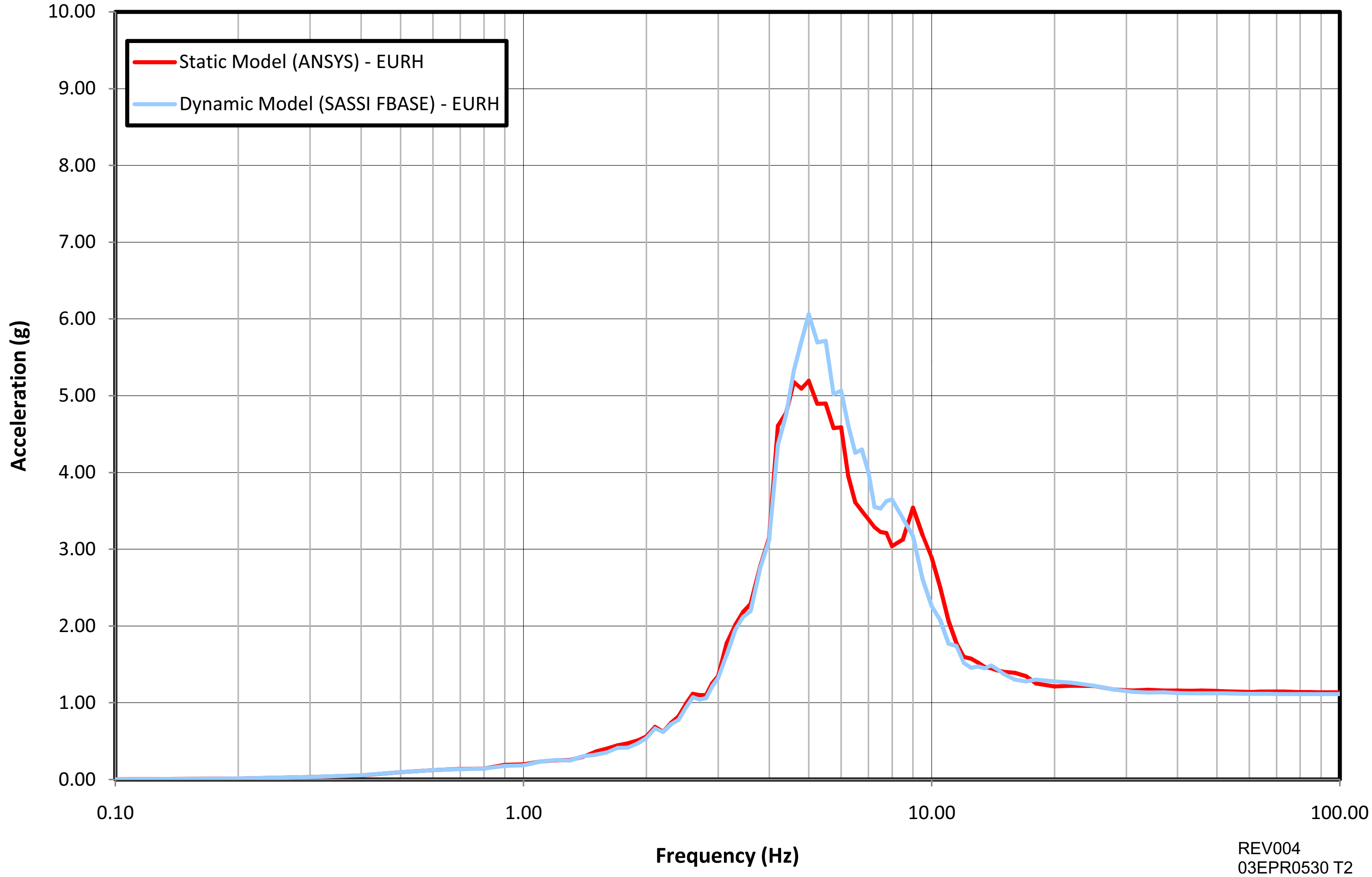
Figure 3.7.2-15—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +200 ft, 5 in (+61.09m) (Dome Apex) of Reactor Shield Building, 5% Damping, Y-Direction



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03EPR0530 T2

Figure 3.7.2-16—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +200ft, 5 in (+61.09m) (Dome Apex) of Reactor Shield Building, 5% Damping, Z-Direction

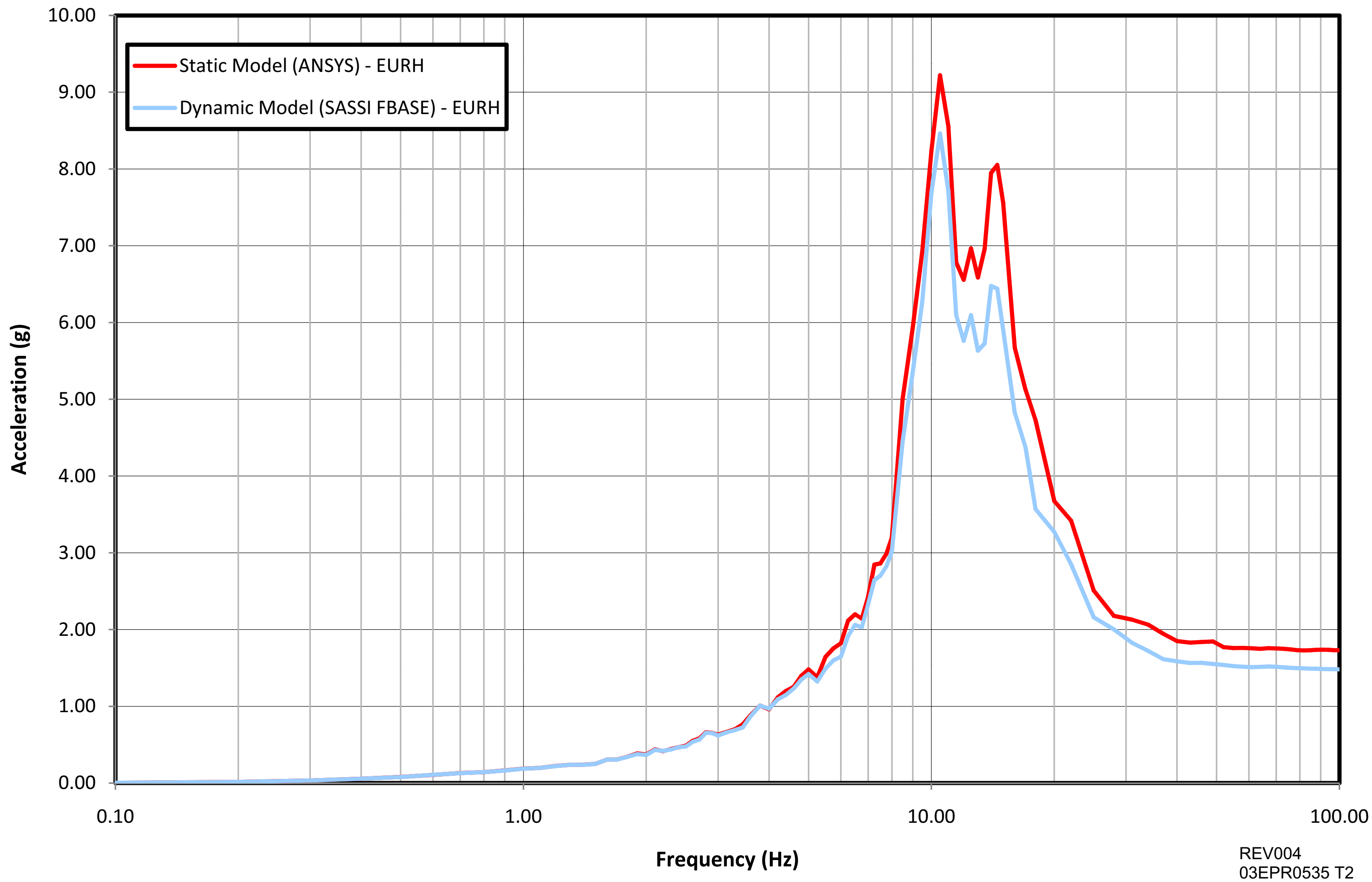

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Figure 3.7.2-17—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +95 ft, 1-3/4 in (+29.00m) - Safeguard Building 1, 5% Damping, X-Direction

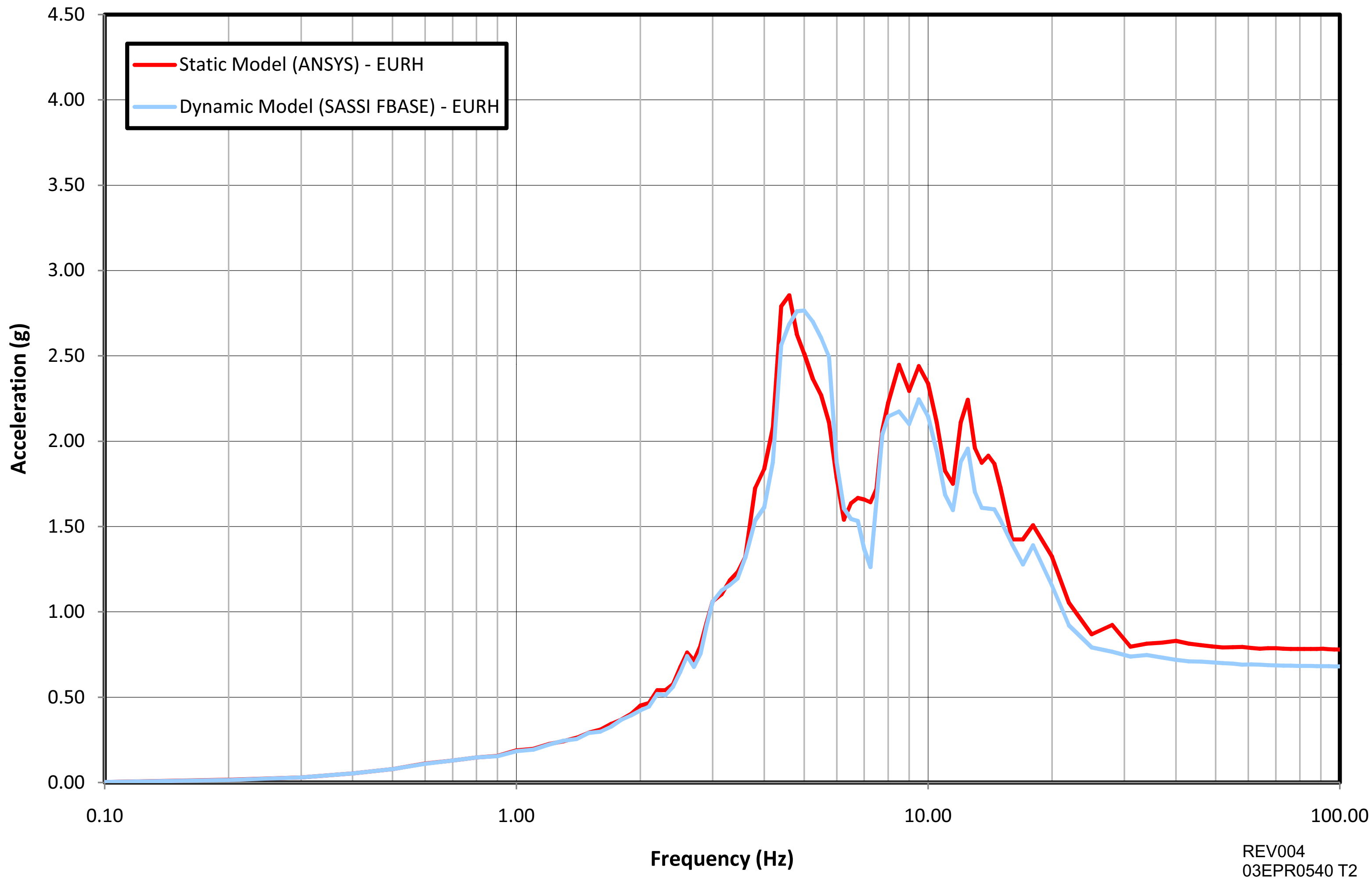
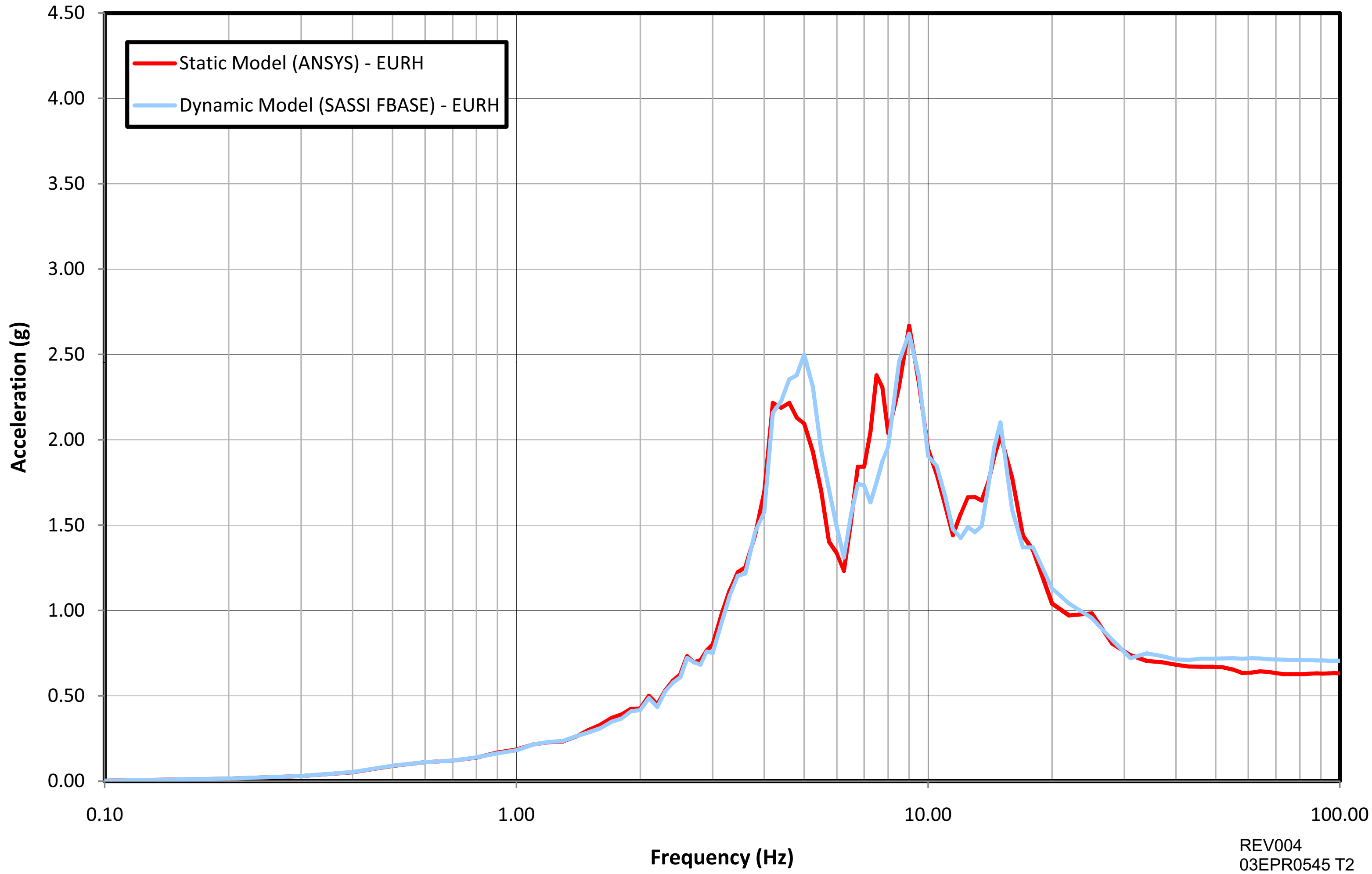


Figure 3.7.2-18—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +95 ft, 1-3/4 in (+29.00m) - Safeguard Building 1, 5% Damping, Y-Direction



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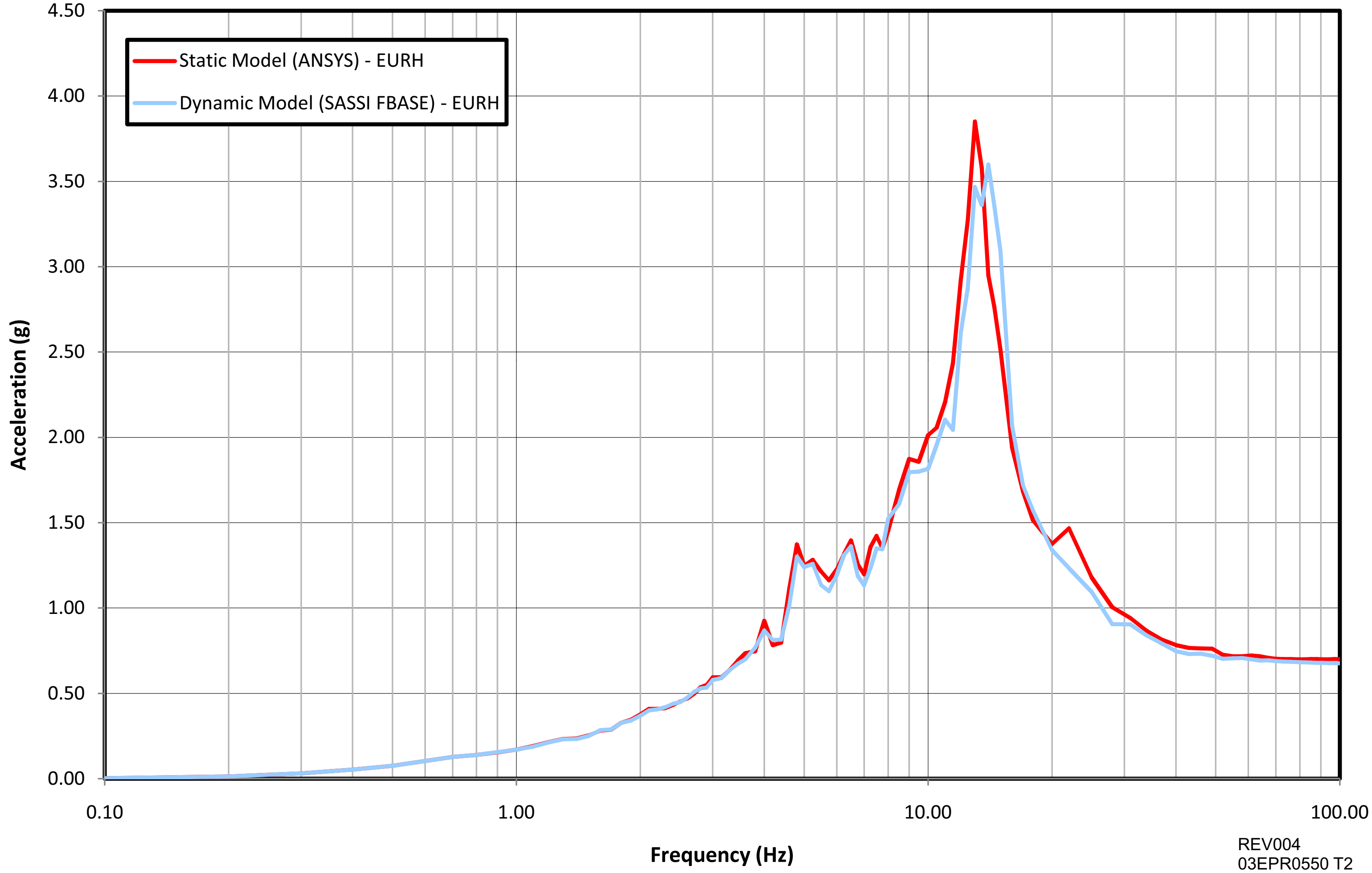
03EPR0545 T2

Figure 3.7.2-19—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +95 ft, 1-3/4 in (+29.00m) - Safeguard Building 1, 5% Damping, Z-Direction



REV004
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Figure 3.7.2-20—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +26 ft, 3 in (+8.00m) - Safeguard Building 1, 5% Damping, X-Direction

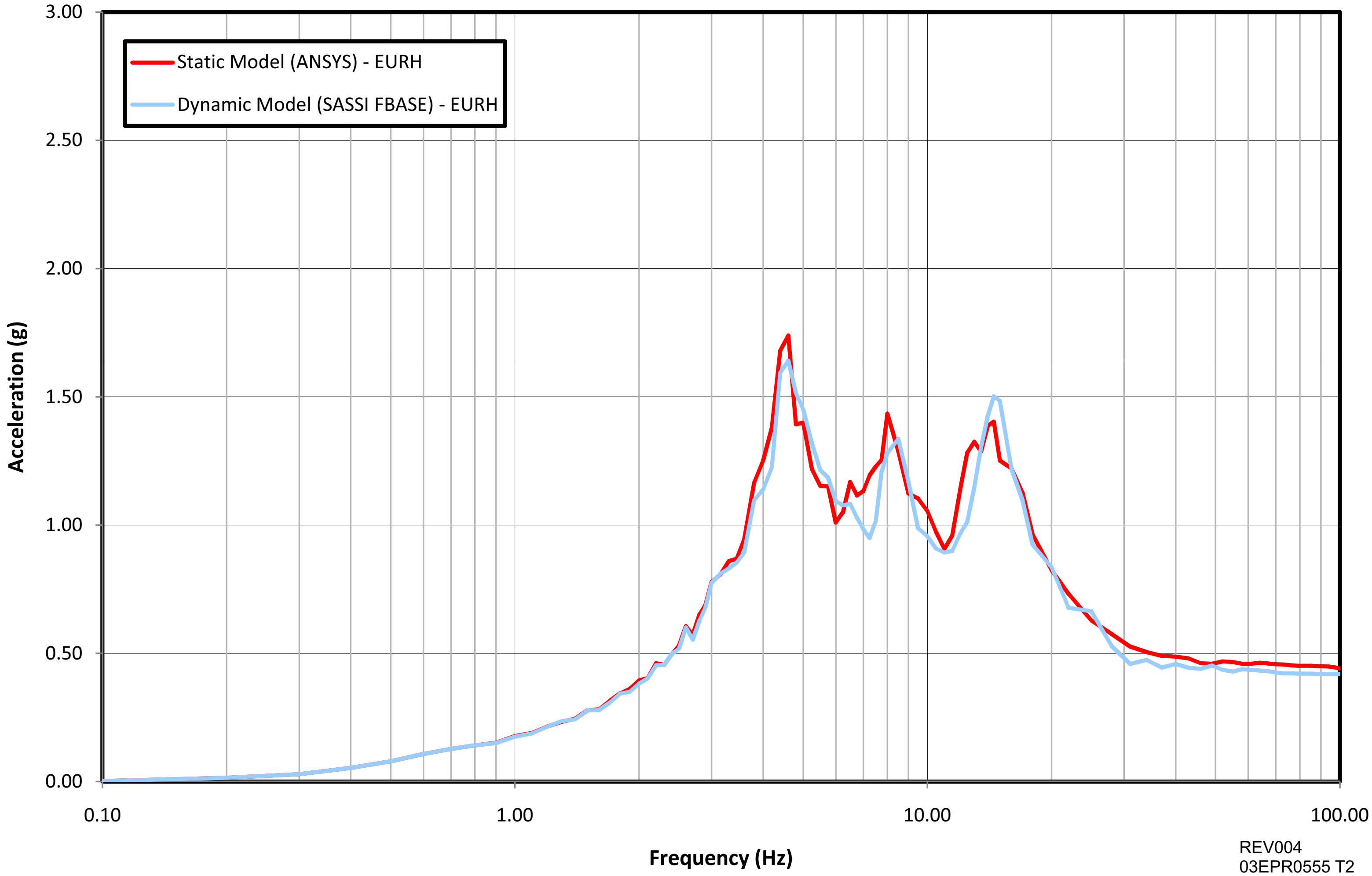

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Figure 3.7.2-21—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +26 ft, 3 in (+8.00m) - Safeguard Building 1, 5% Damping, Y-Direction

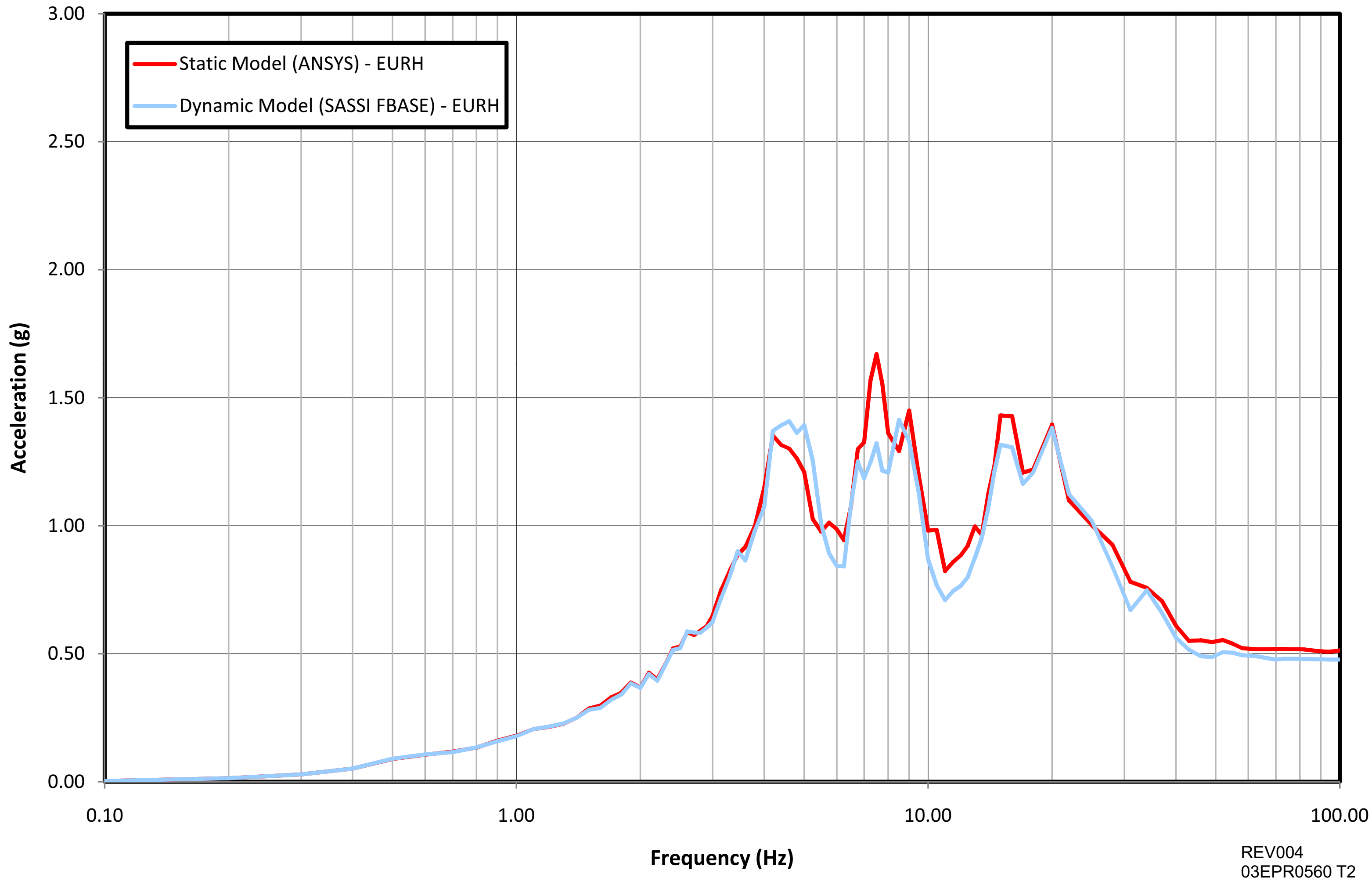

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Figure 3.7.2-22—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +26 ft, 3 in (+8.00m) - Safeguard Building 1, 5% Damping, Z-Direction

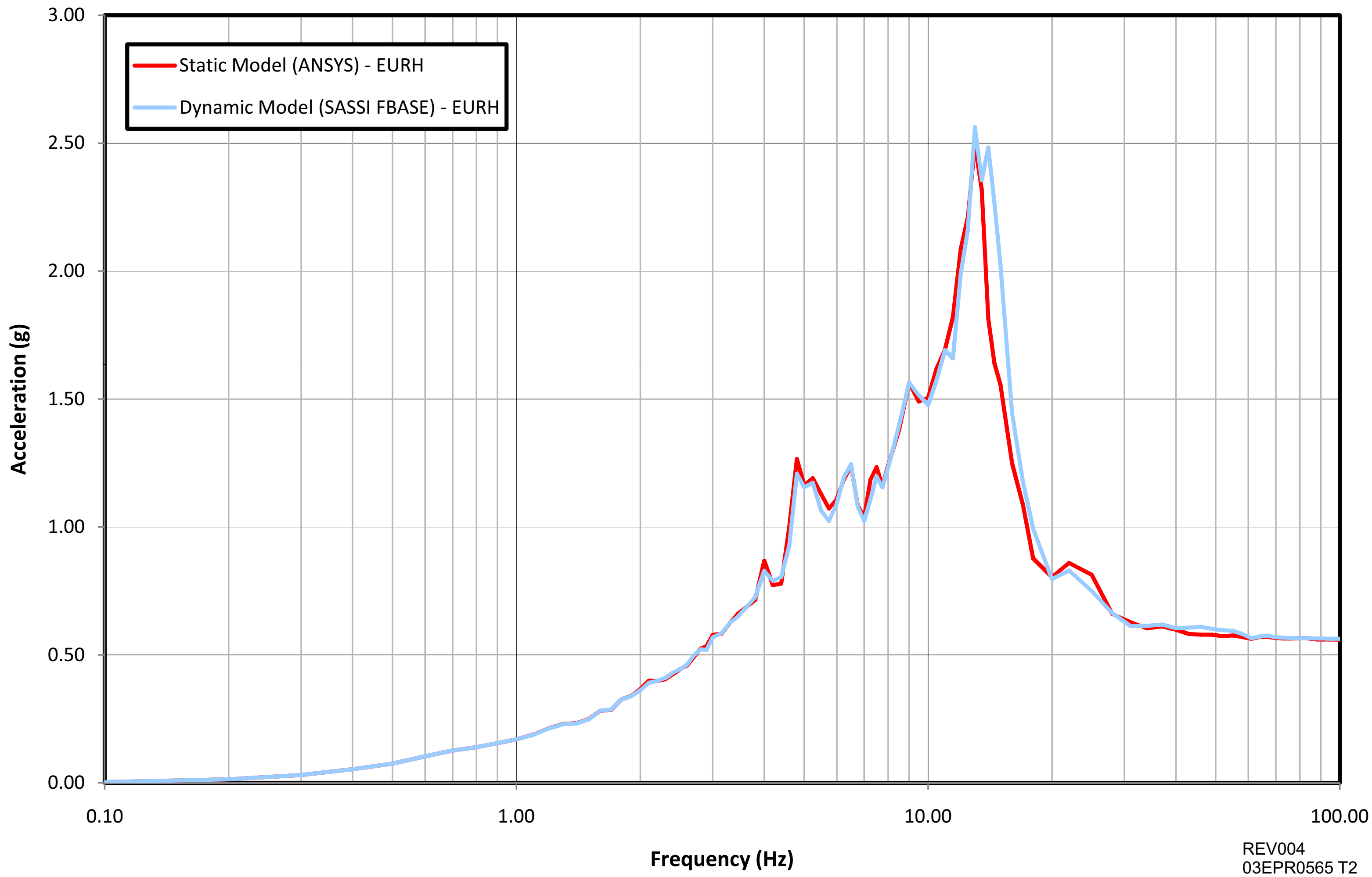

Figure 3.7.2-23—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +95 ft, 1-3/4 in (+29.00m) - Safeguard Building 4, 5% Damping, X-Direction

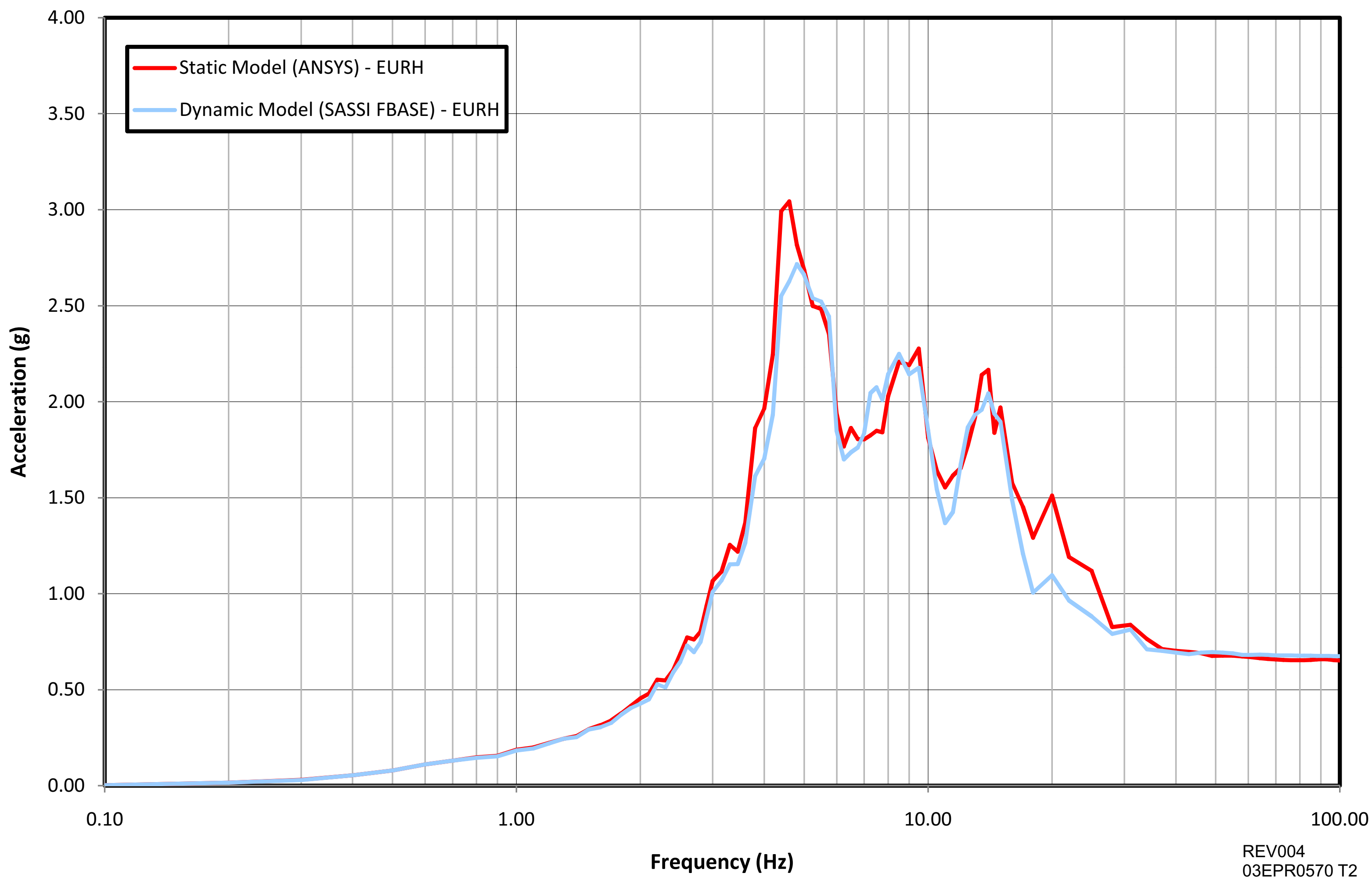

Figure 3.7.2-24—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +95 ft, 1-3/4 in (+29.00m) - Safeguard Building 4, 5% Damping, Y-Direction

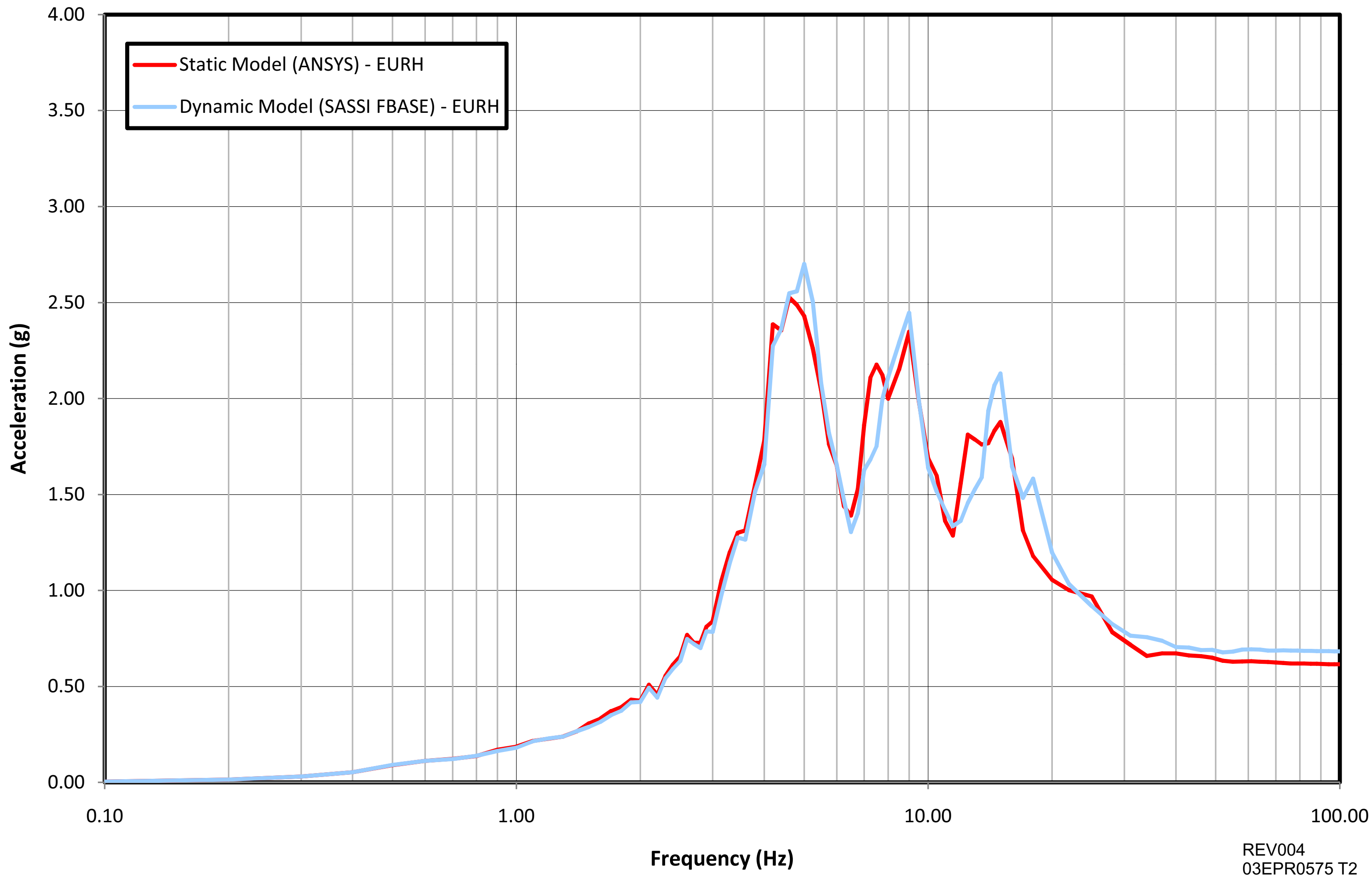

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Figure 3.7.2-25—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +95 ft, 1-3/4 in (+29.00m) - Safeguard Building 4, 5% Damping, Z-Direction

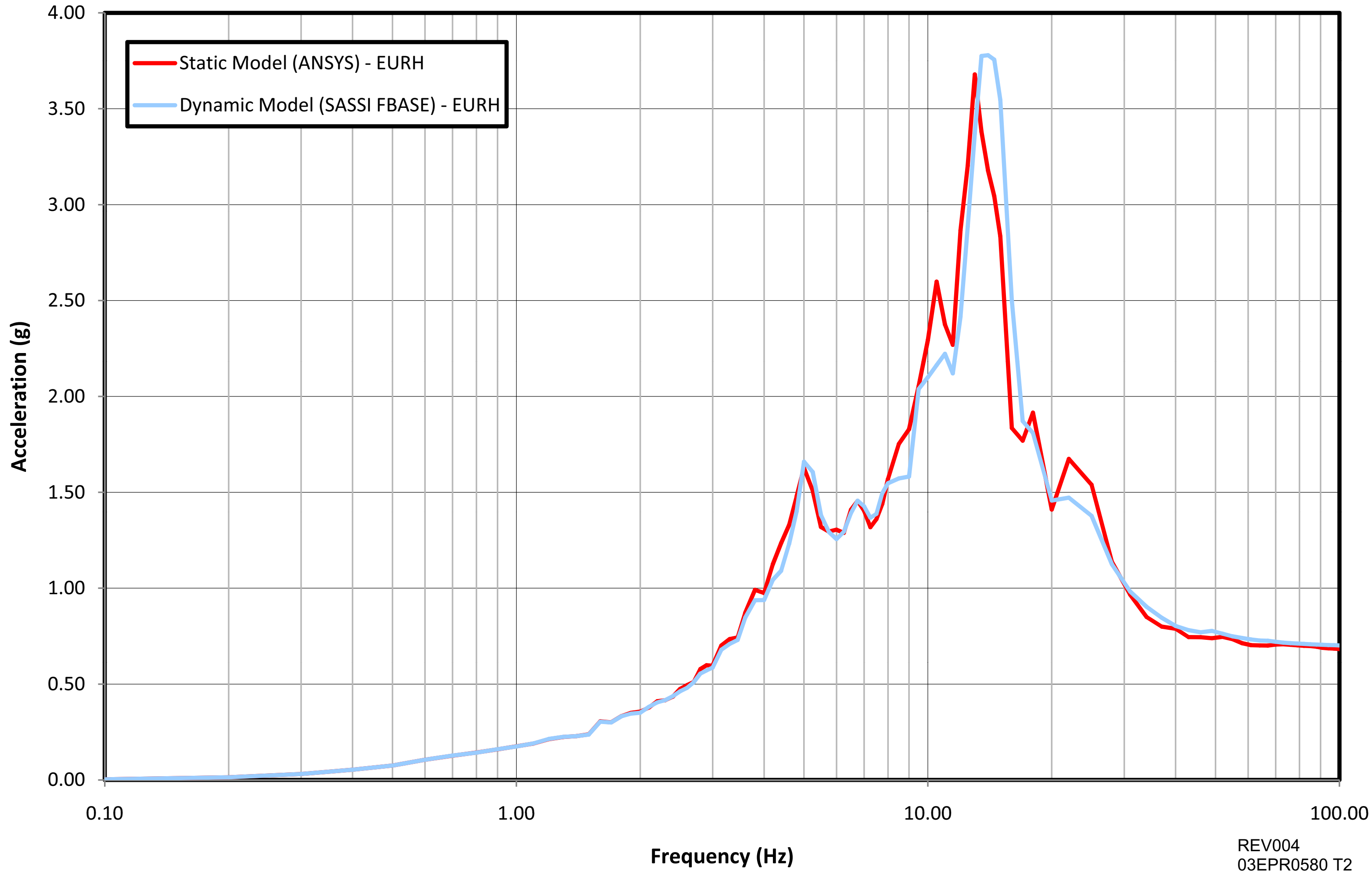

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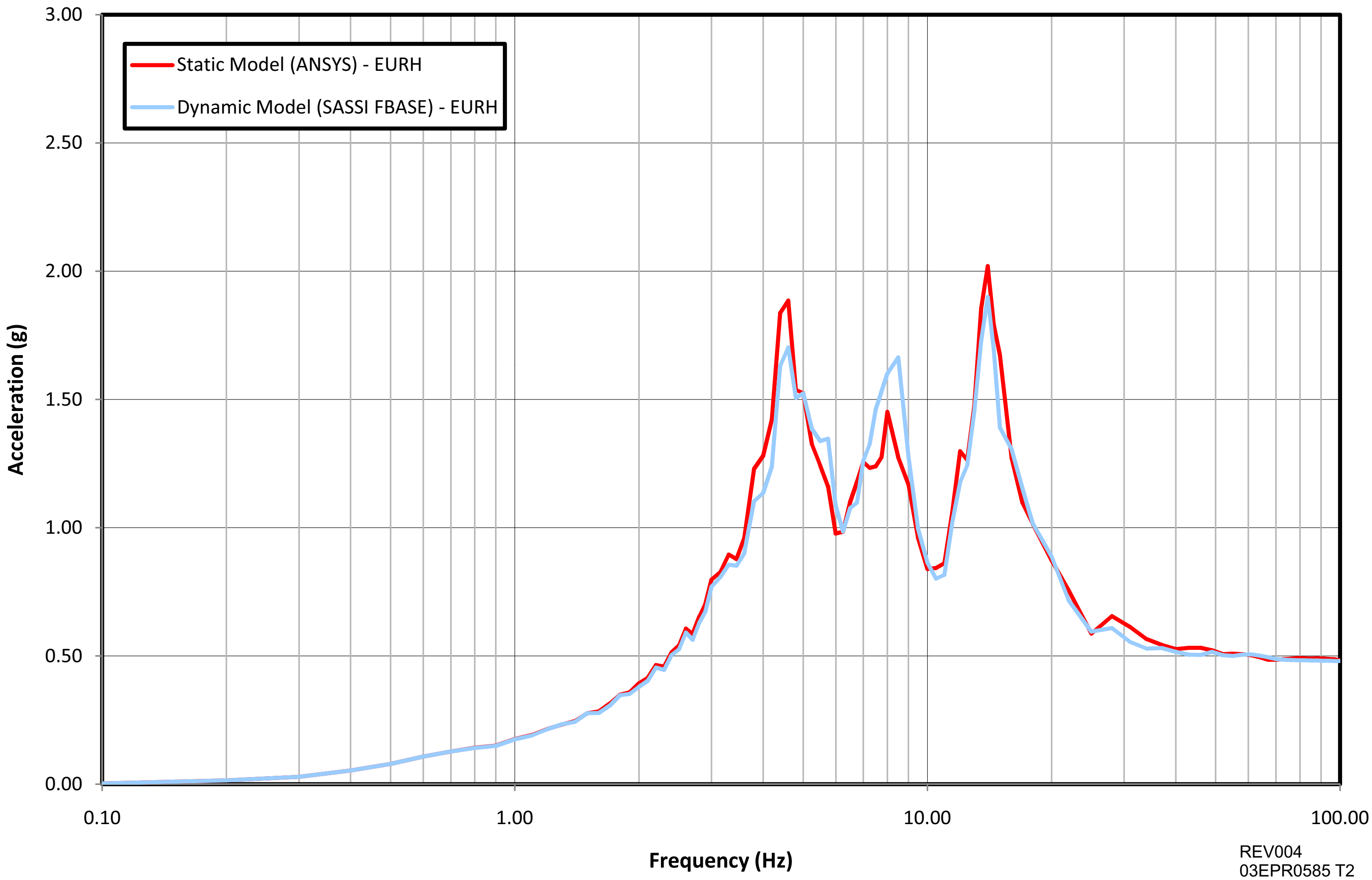
Figure 3.7.2-26—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +26 ft, 3 in (+8.00m) - Safeguard Building 4, 5% Damping, X-Direction



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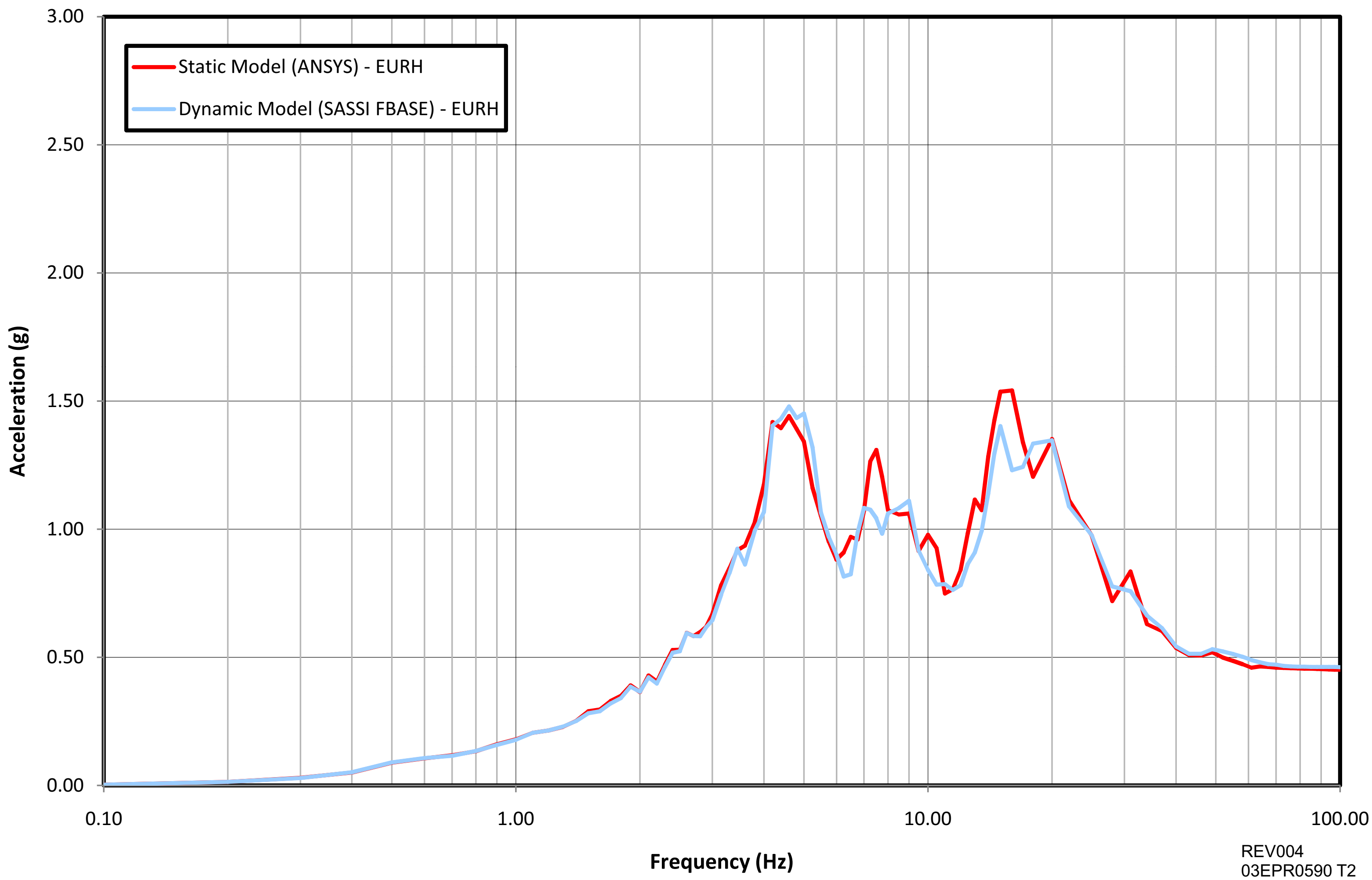
03EPR0585 T2

Figure 3.7.2-27—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +26 ft, 3 in (+8.00m) - Safeguard Building 4, 5% Damping, Y-Direction



REV004
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Figure 3.7.2-28—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +26 ft, 3 in (+8.00m) - Safeguard Building 4, 5% Damping, Z-Direction

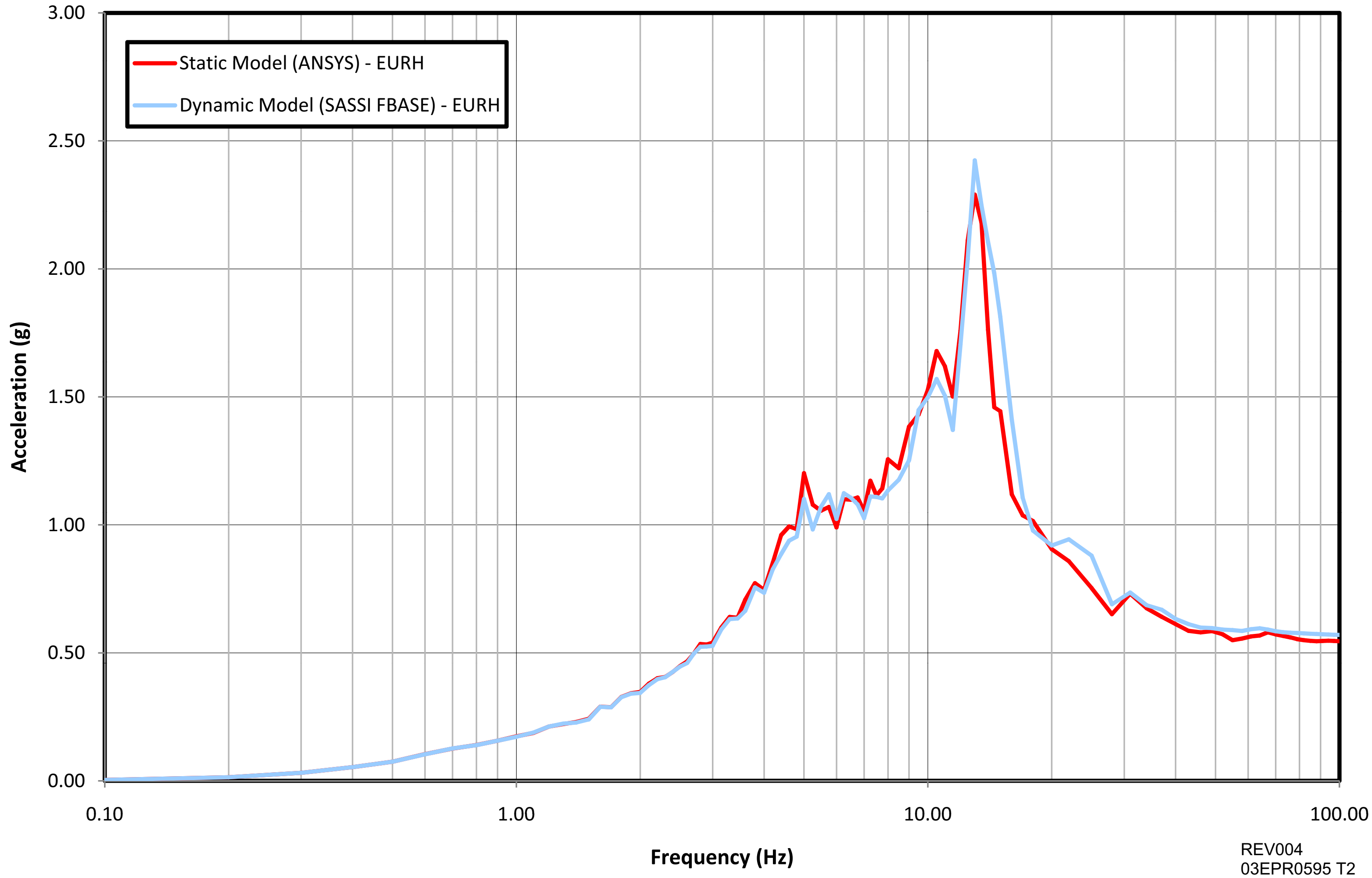

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Figure 3.7.2-29—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +68 ft, 10-3/4 in (+21.00m) - Safeguard Building 2/3, 5% Damping, X-Direction

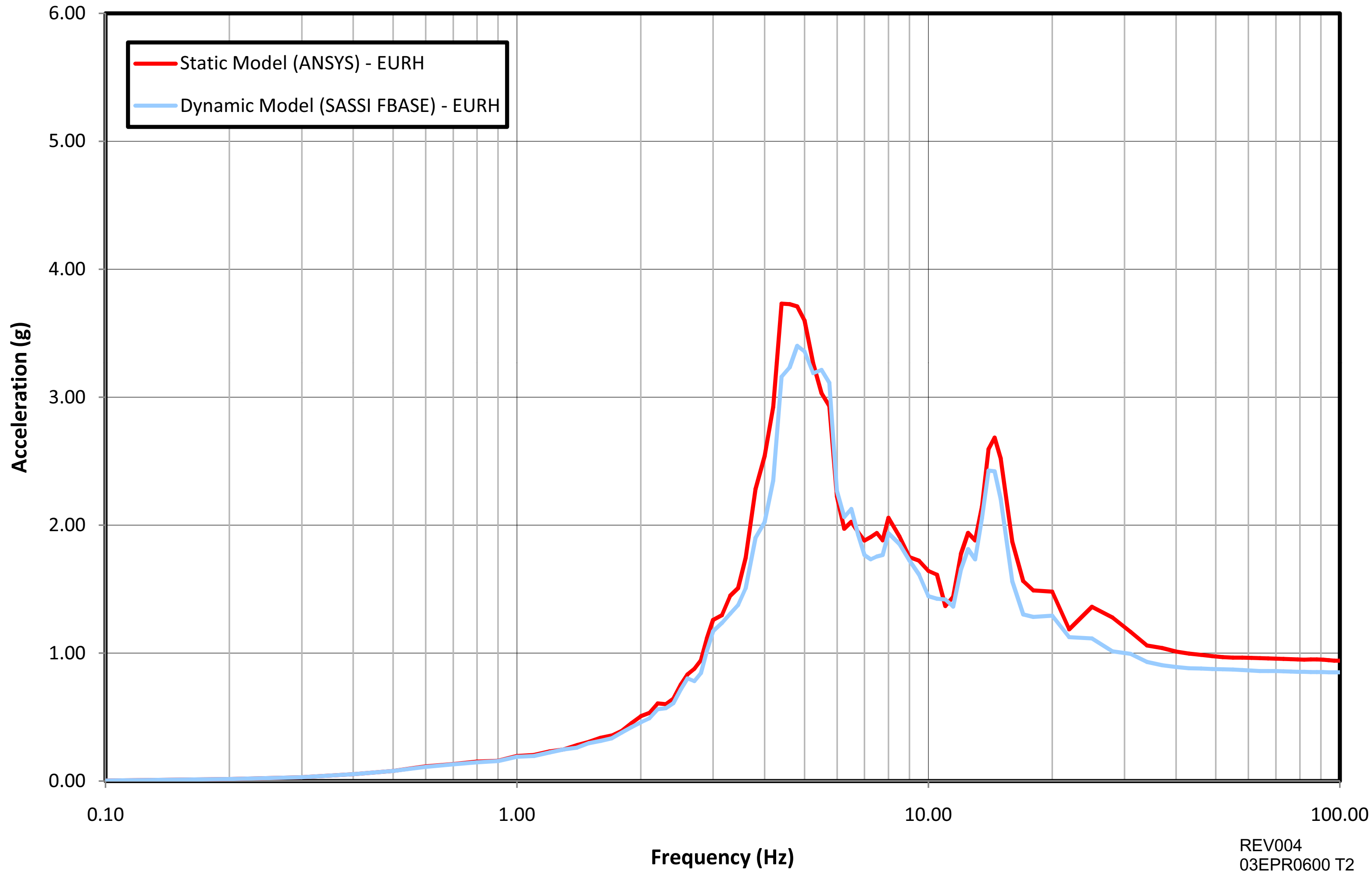

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Figure 3.7.2-30—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +68 ft, 10-3/4 in (+21.00m) - Safeguard Building 2/3, 5% Damping, Y-Direction

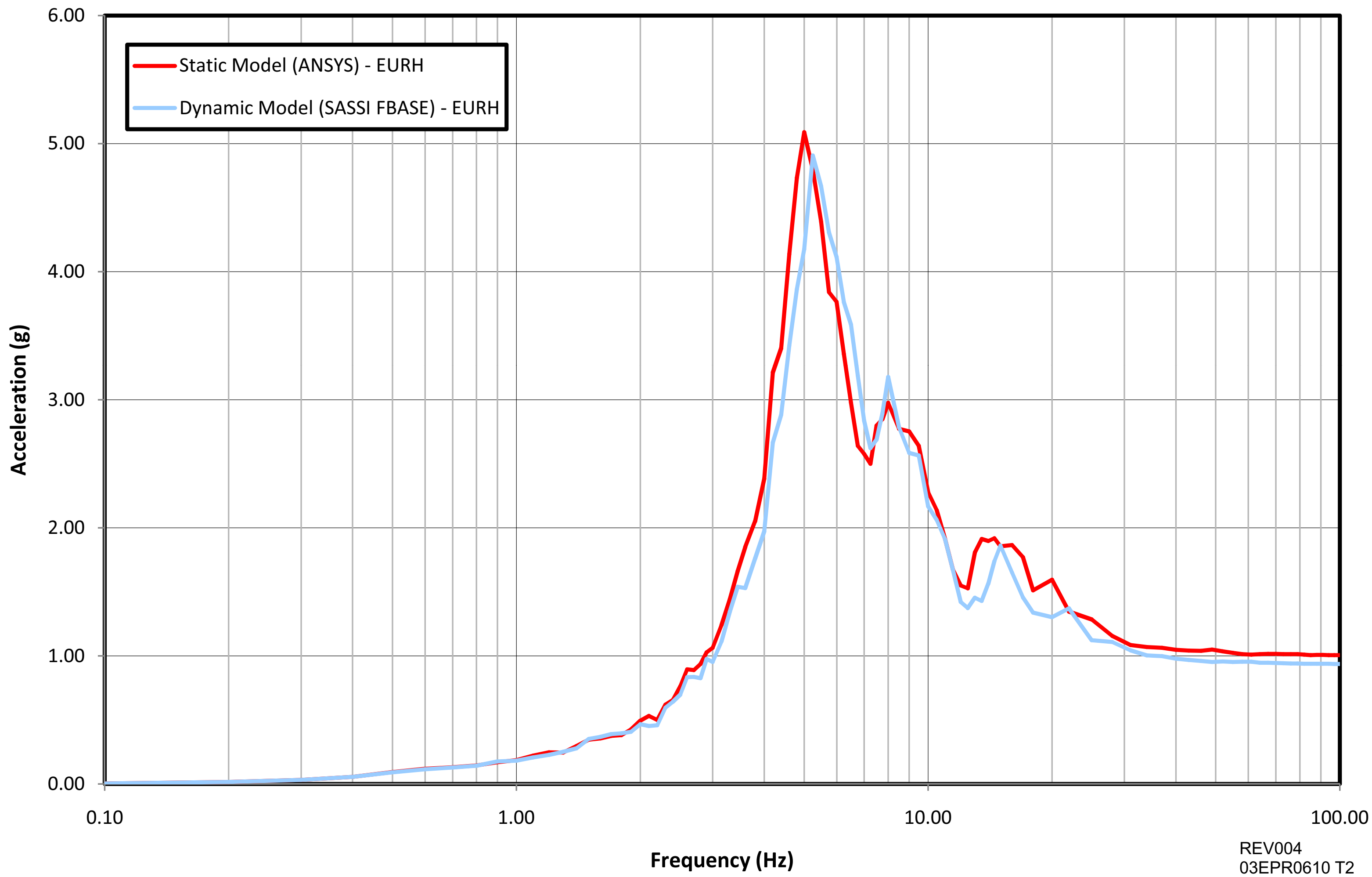

Figure 3.7.2-31—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +68 ft, 10-3/4 in (+21.00m) - Safeguard Building 2/3, 5% Damping, Z-Direction

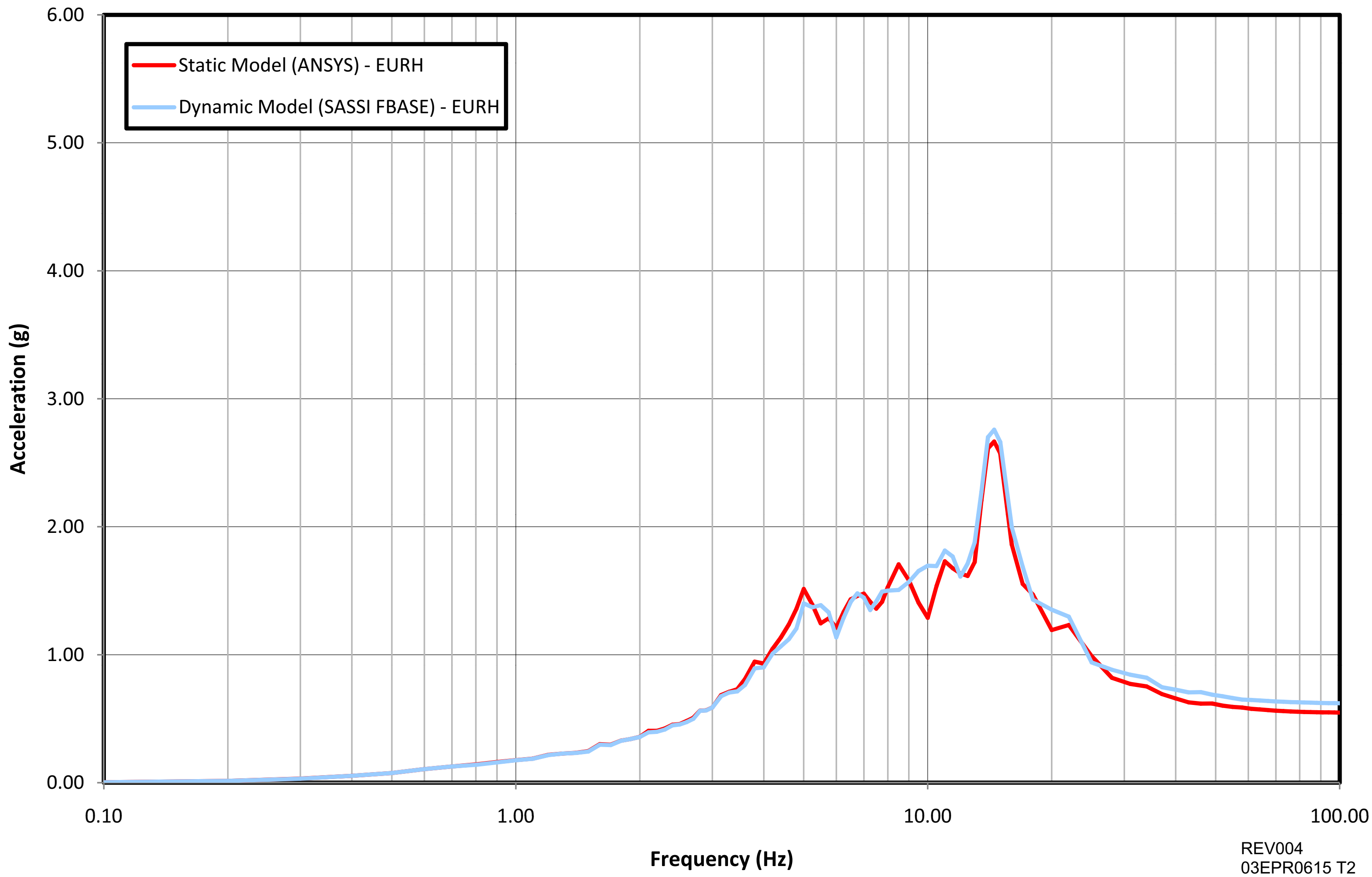

Figure 3.7.2-32—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +26 ft, 3 in (+8.00m) - Safeguard Building 2/3, 5% Damping, X-Direction

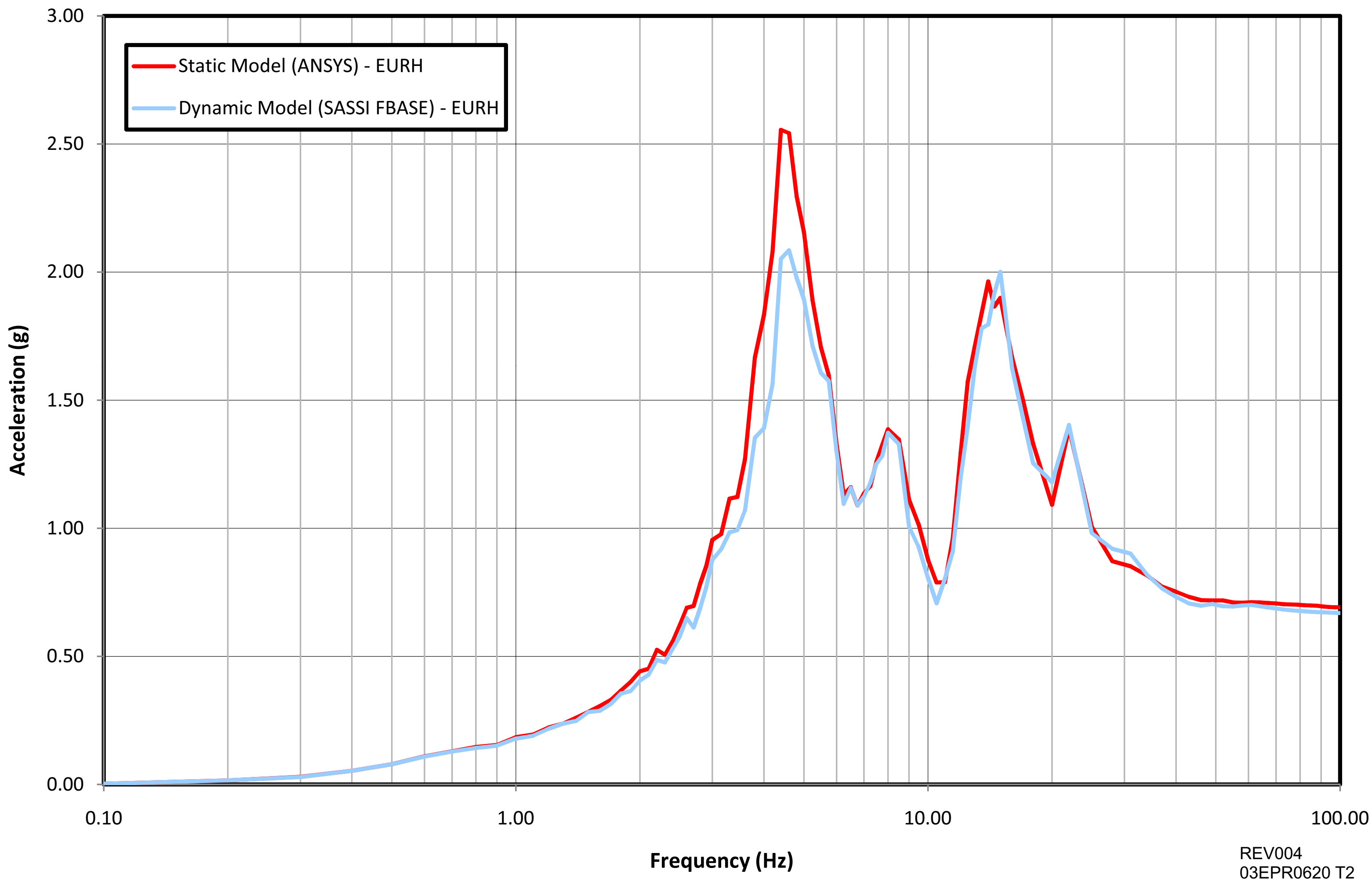

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Figure 3.7.2-33—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +26 ft, 3 in (+8.00m) - Safeguard Building 2/3, 5% Damping, Y-Direction

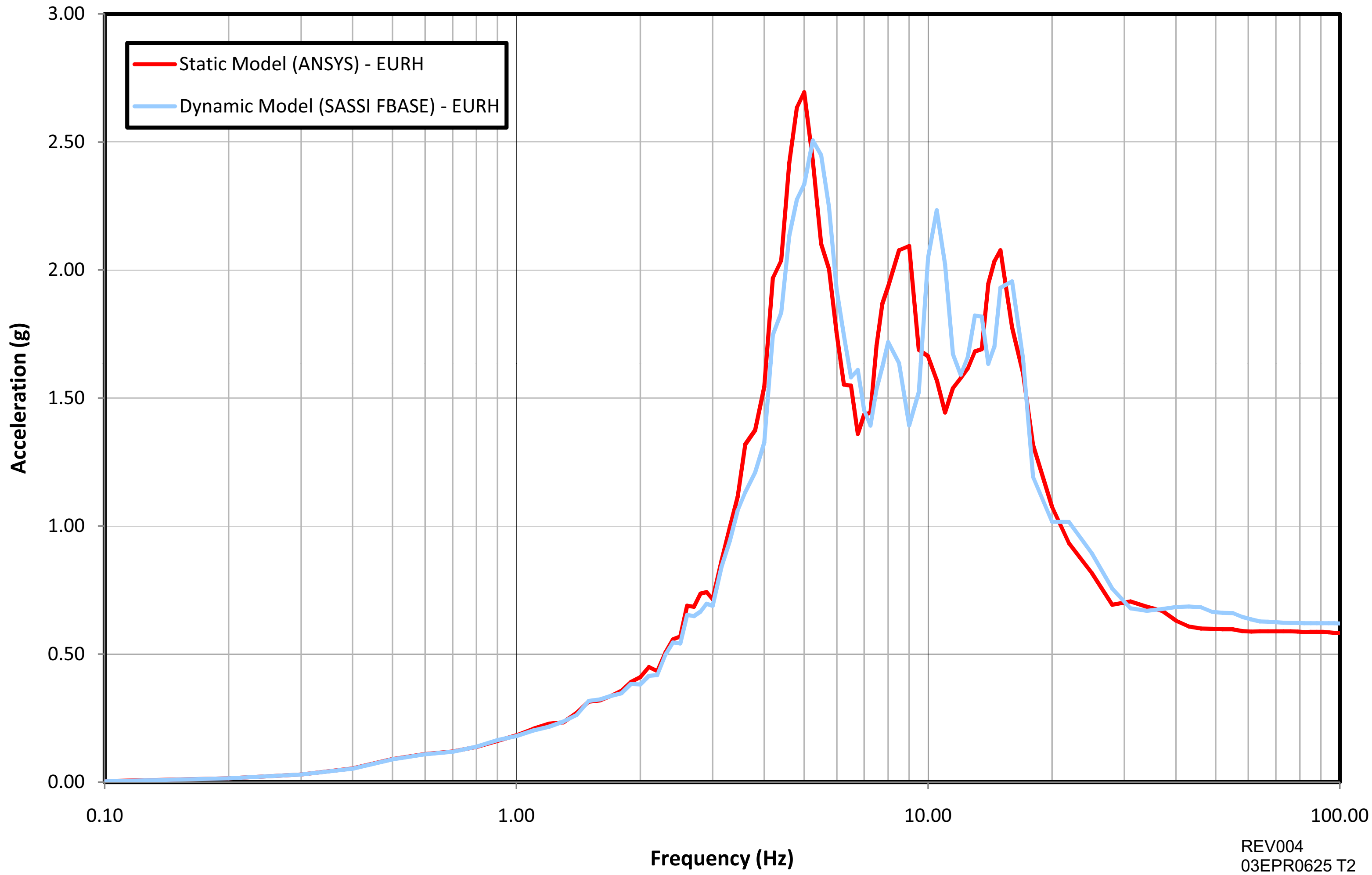

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Figure 3.7.2-34—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +26 ft, 3 in (+8.00m) - Safeguard Building 2/3, 5% Damping, Z-Direction

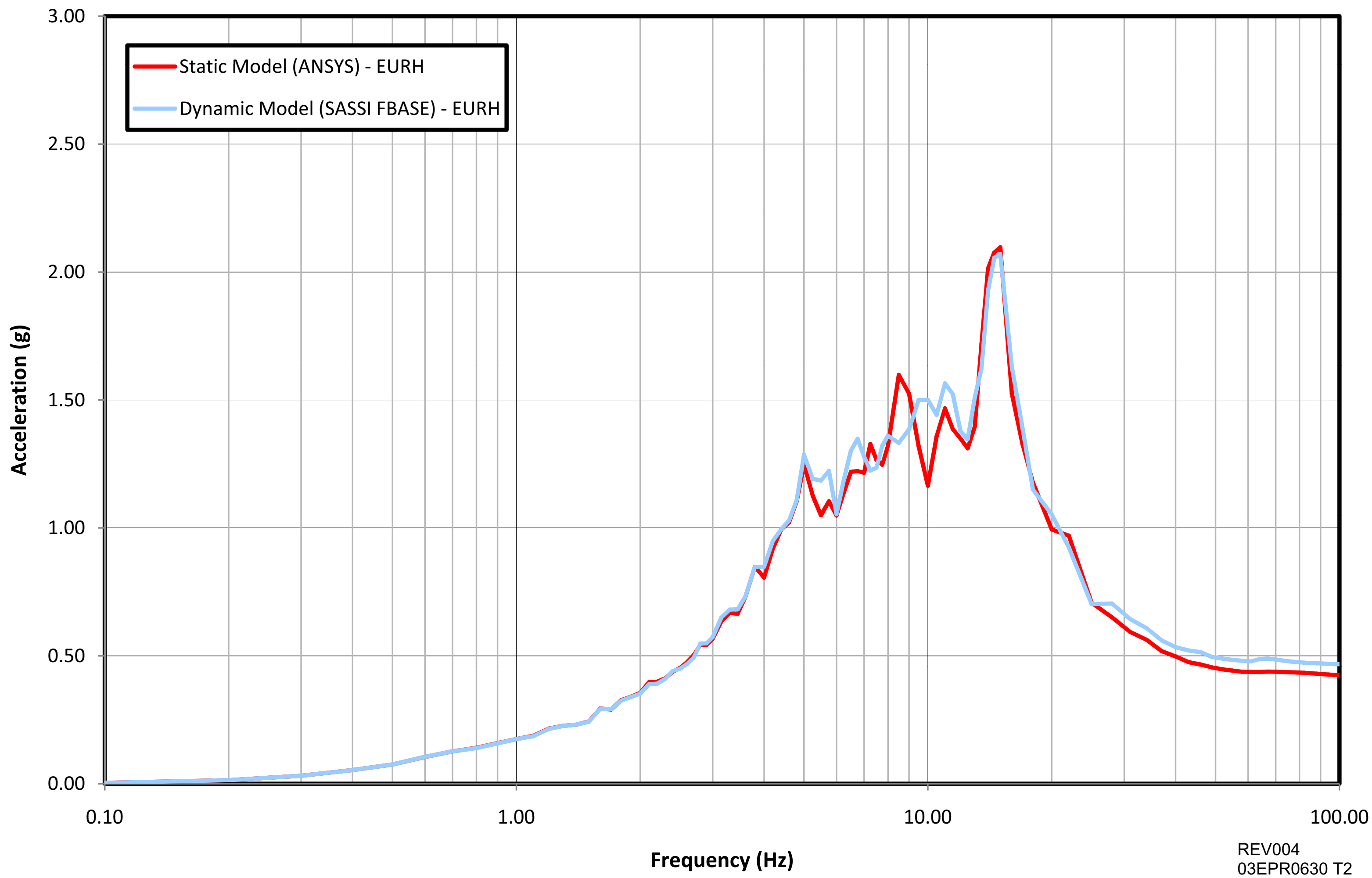

Figure 3.7.2-35—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +62 ft, 4-1/4 in (+19.00m) - Fuel Building, 5% Damping, X-Direction

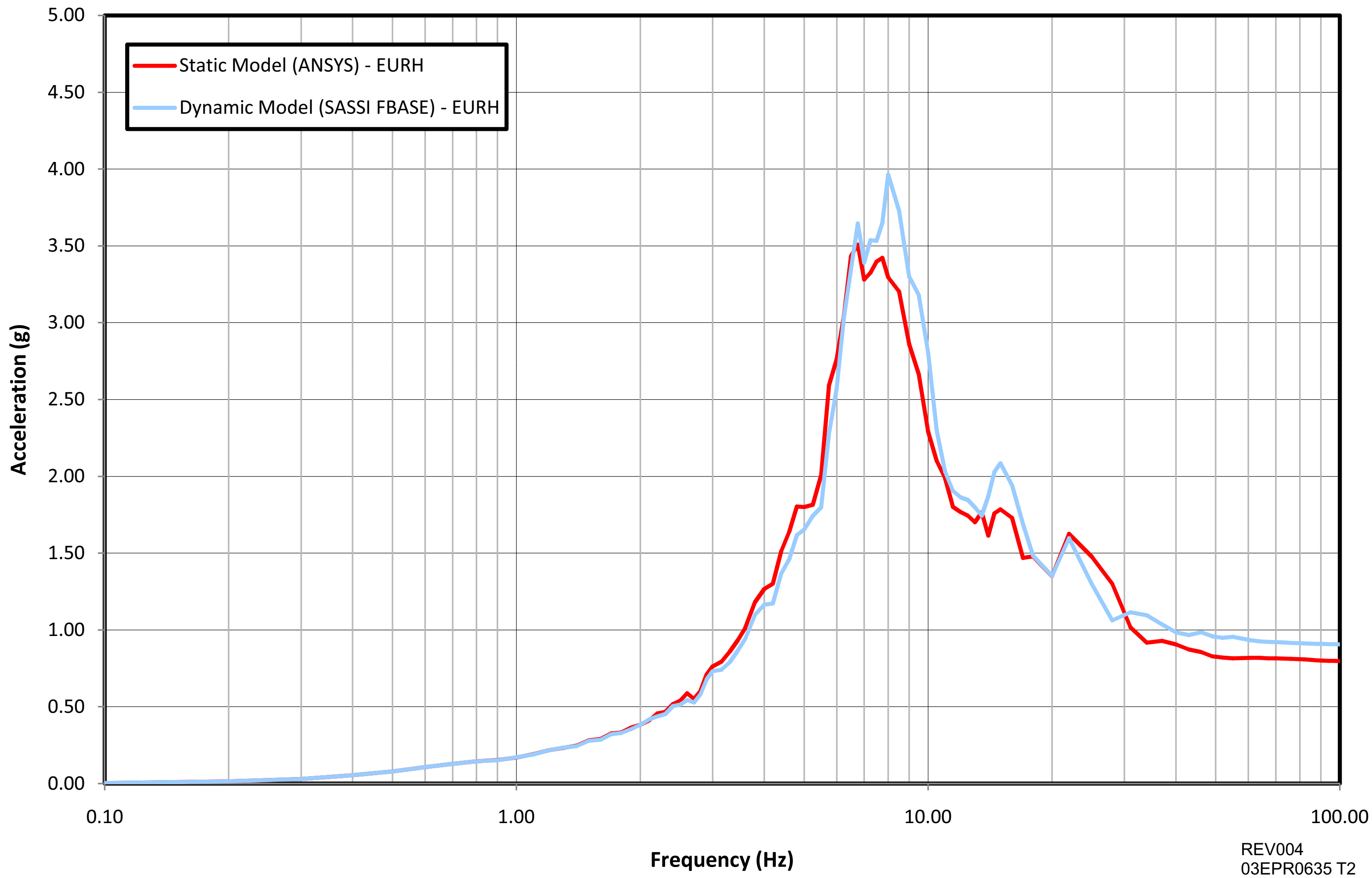

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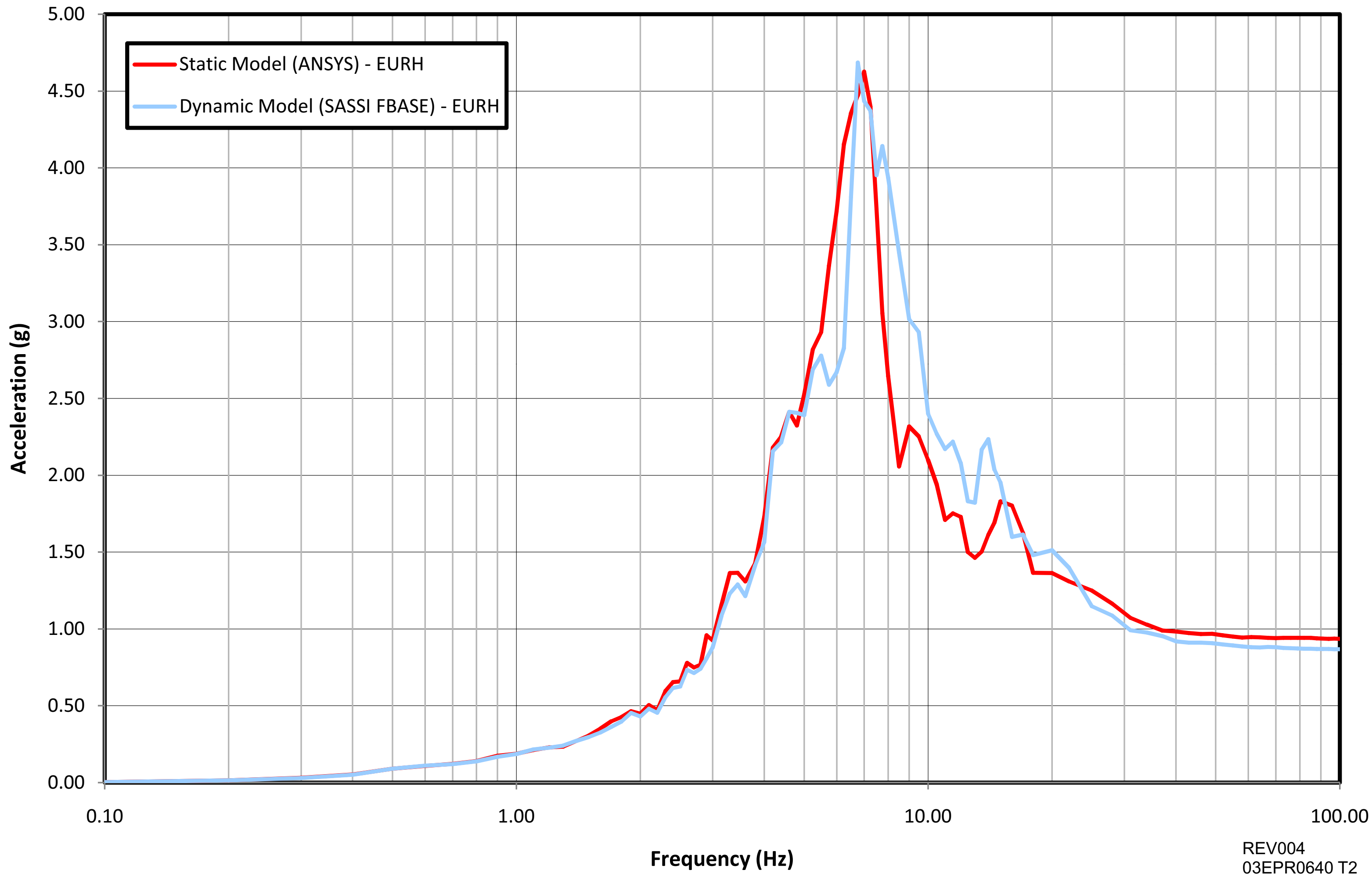
Figure 3.7.2-36—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +62 ft, 4-1/4 in (+19.00m) - Fuel Building, 5% Damping Y-Direction



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03EPR0640 T2

Figure 3.7.2-37—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +62 ft, 4-1/4 in (+19.00m) - Fuel Building, 5% Damping, Z-Direction

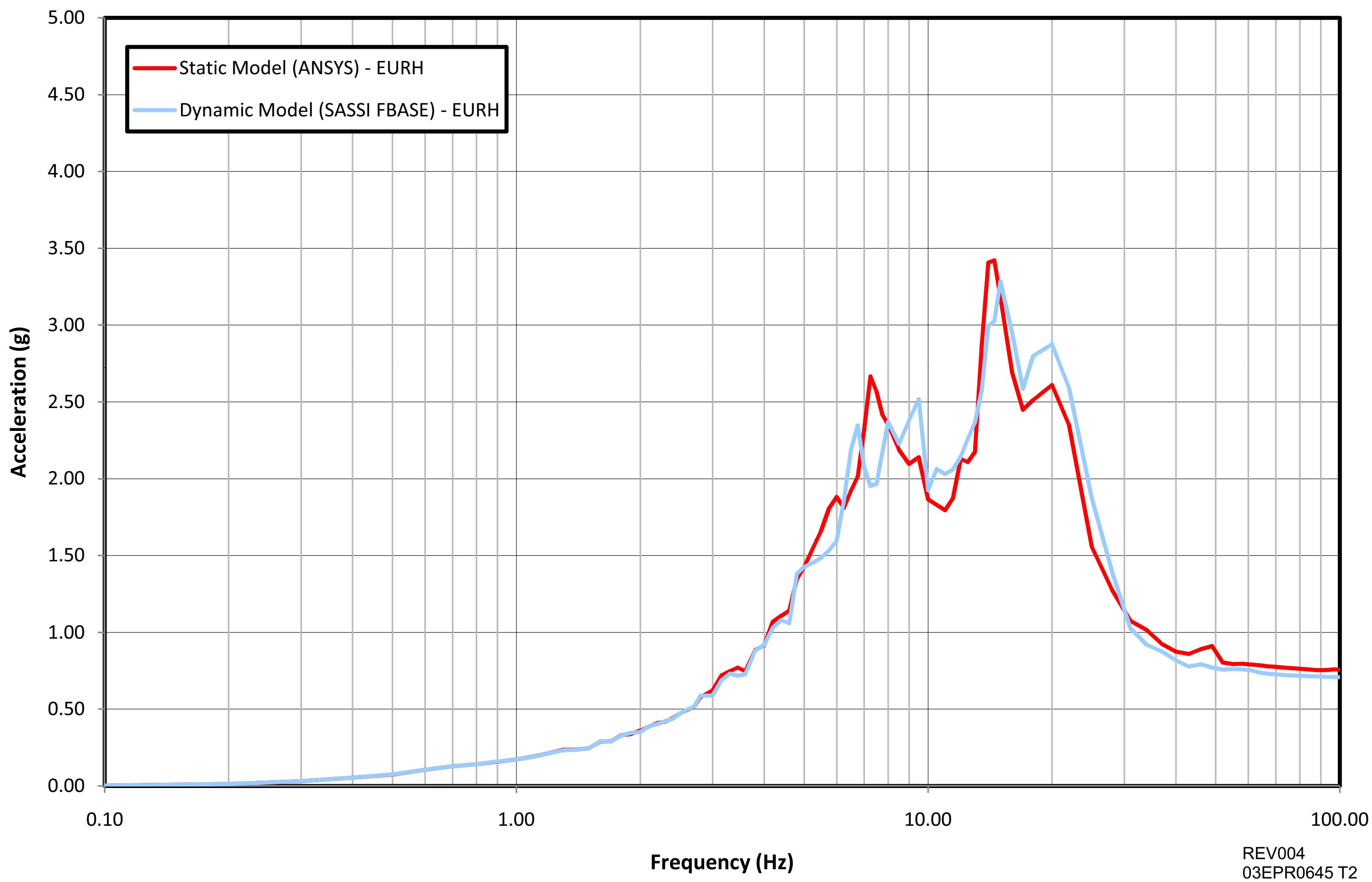

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Figure 3.7.2-38—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +23 ft, 7-1/2 in (+7.20m) - Fuel Building, 5% Damping, X-Direction

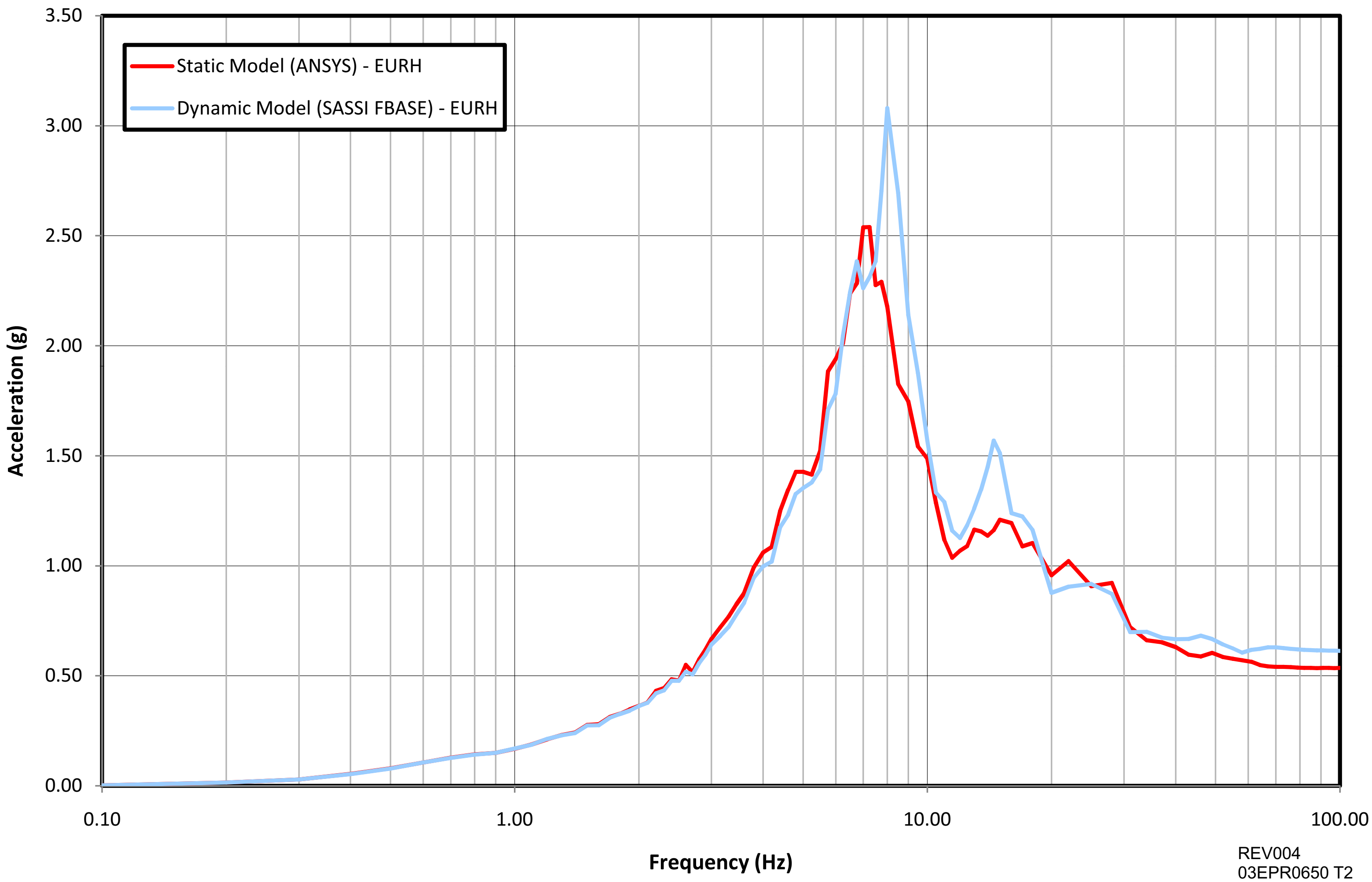

Figure 3.7.2-39—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +23 ft, 7-1/2 in (+7.20m) - Fuel Building, 5% Damping, Y-Direction

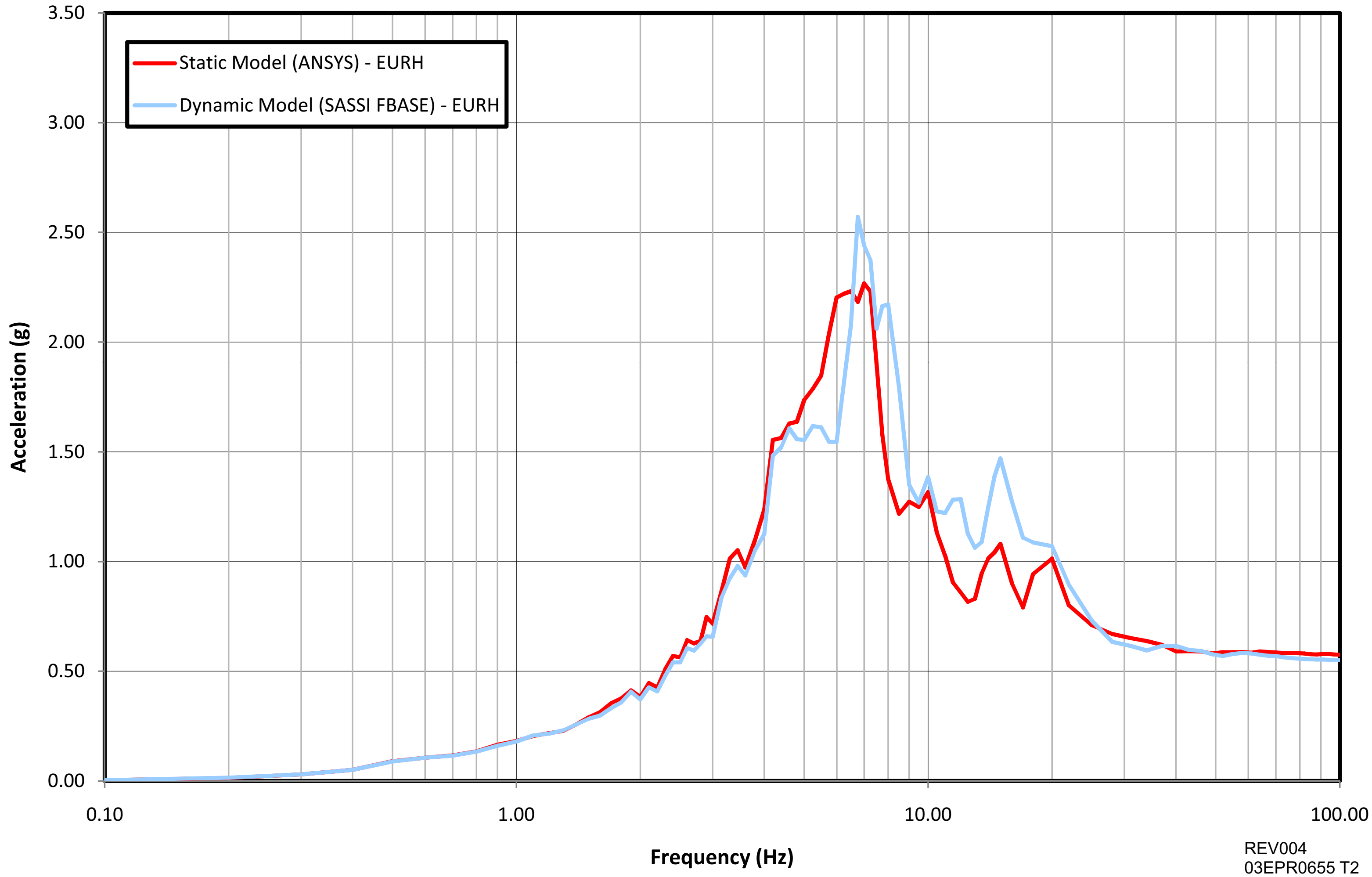

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Figure 3.7.2-40—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +23 ft, 7-1/2 in (+7.20m) - Fuel Building, 5% Damping, Z-Direction

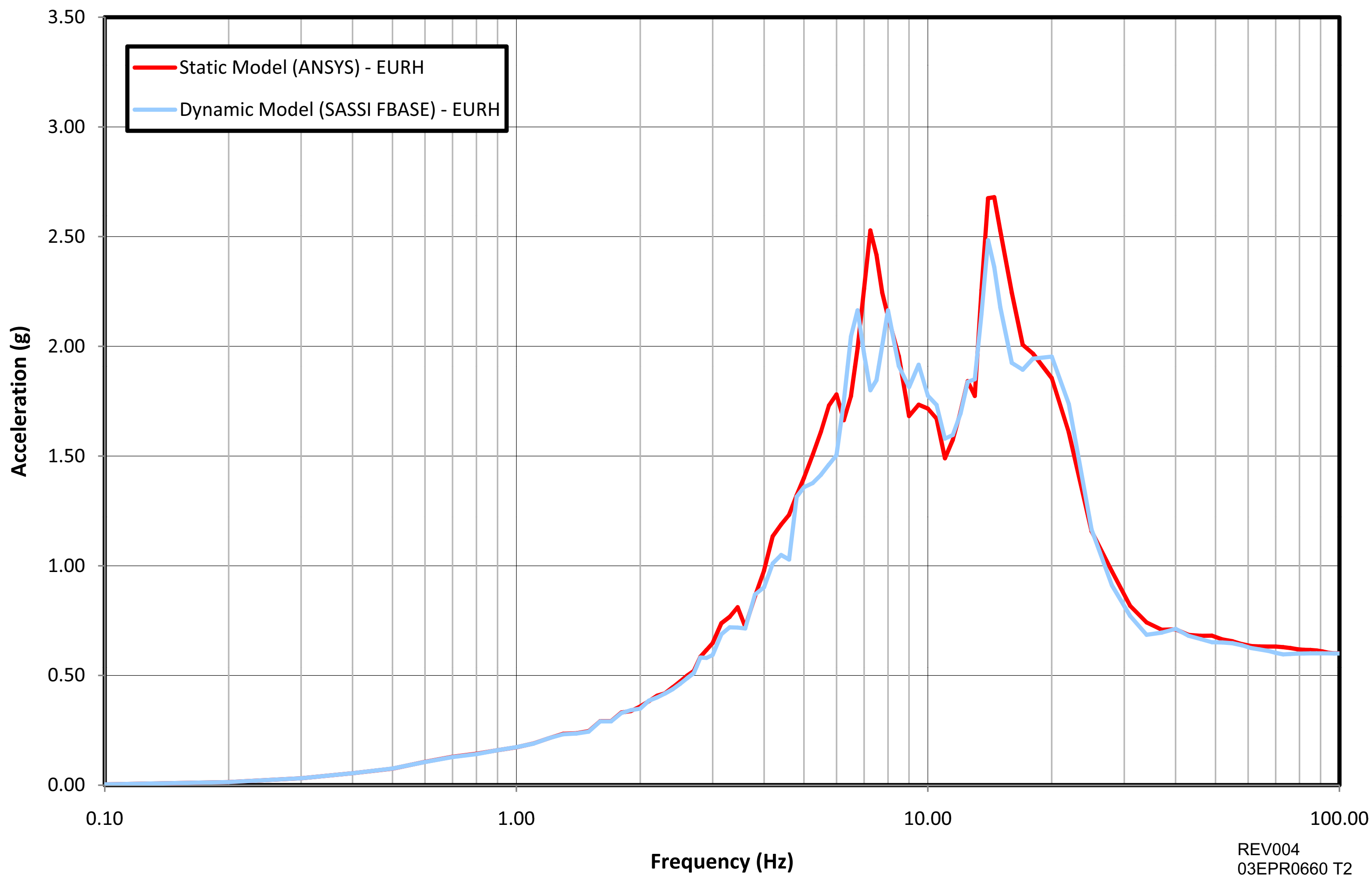
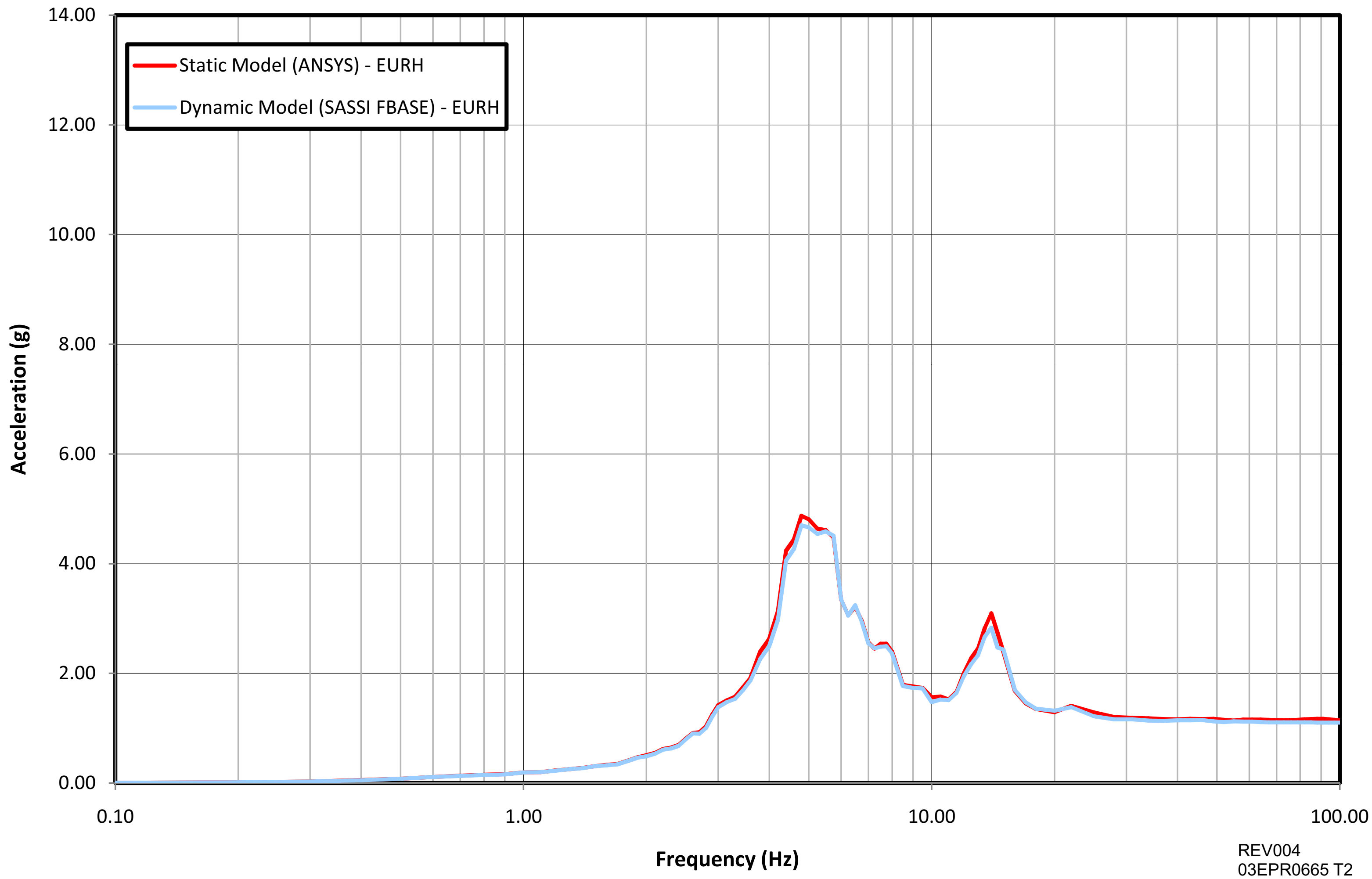


Figure 3.7.2-41—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +190 ft, 3-1/2 in (+58.00m) - Containment Dome Apex, 5% Damping, X-Direction



REV004
03EPR0665 T2

Figure 3.7.2-42—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +190 ft, 3-1/2 in (+58.00m) - Containment Dome Apex, 5% Damping, Y-Direction

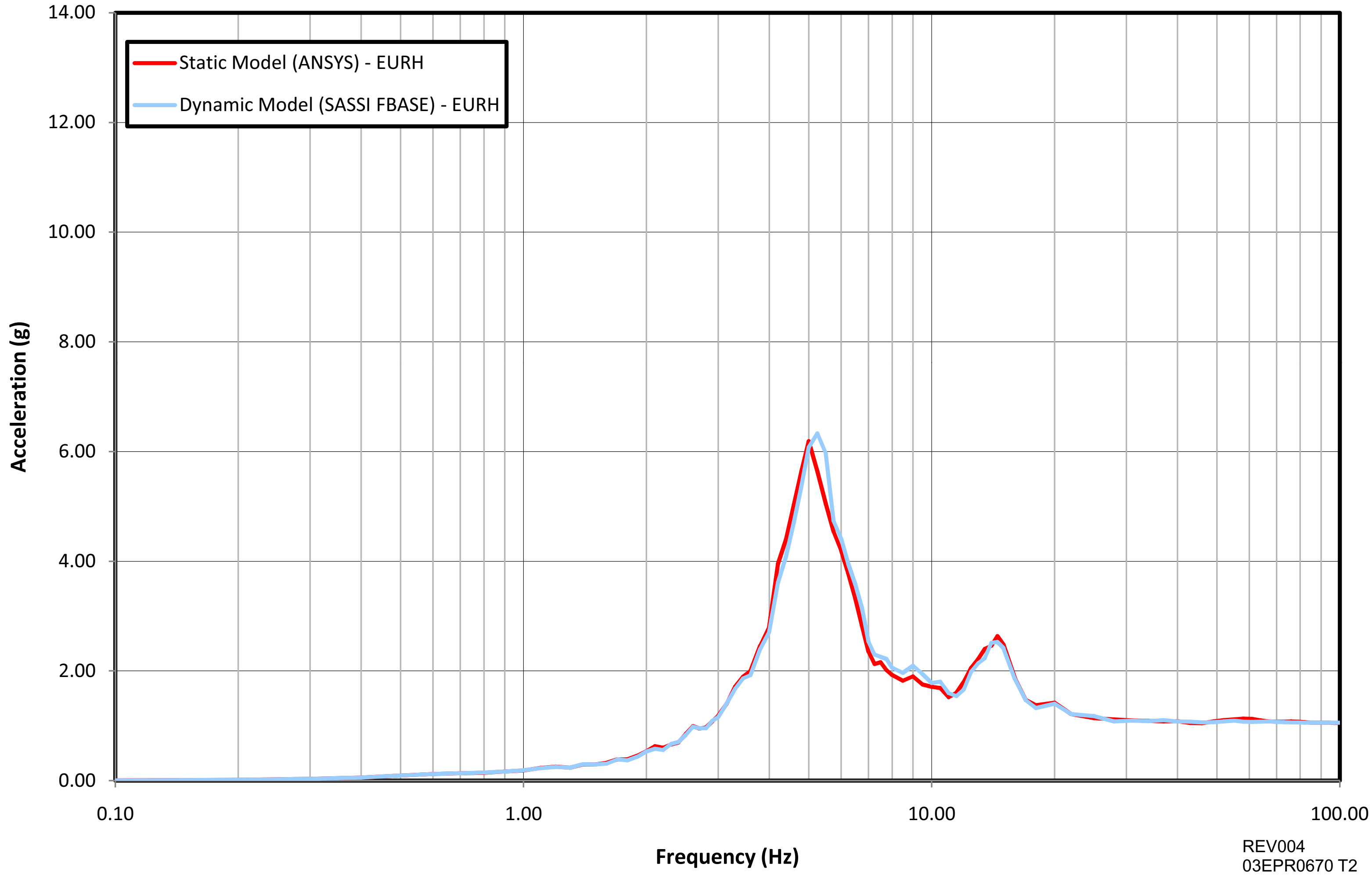


Figure 3.7.2-43—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +190 ft, 3-1/2 in (+58.00m) - Containment Dome Apex, 5% Damping, Z-Direction

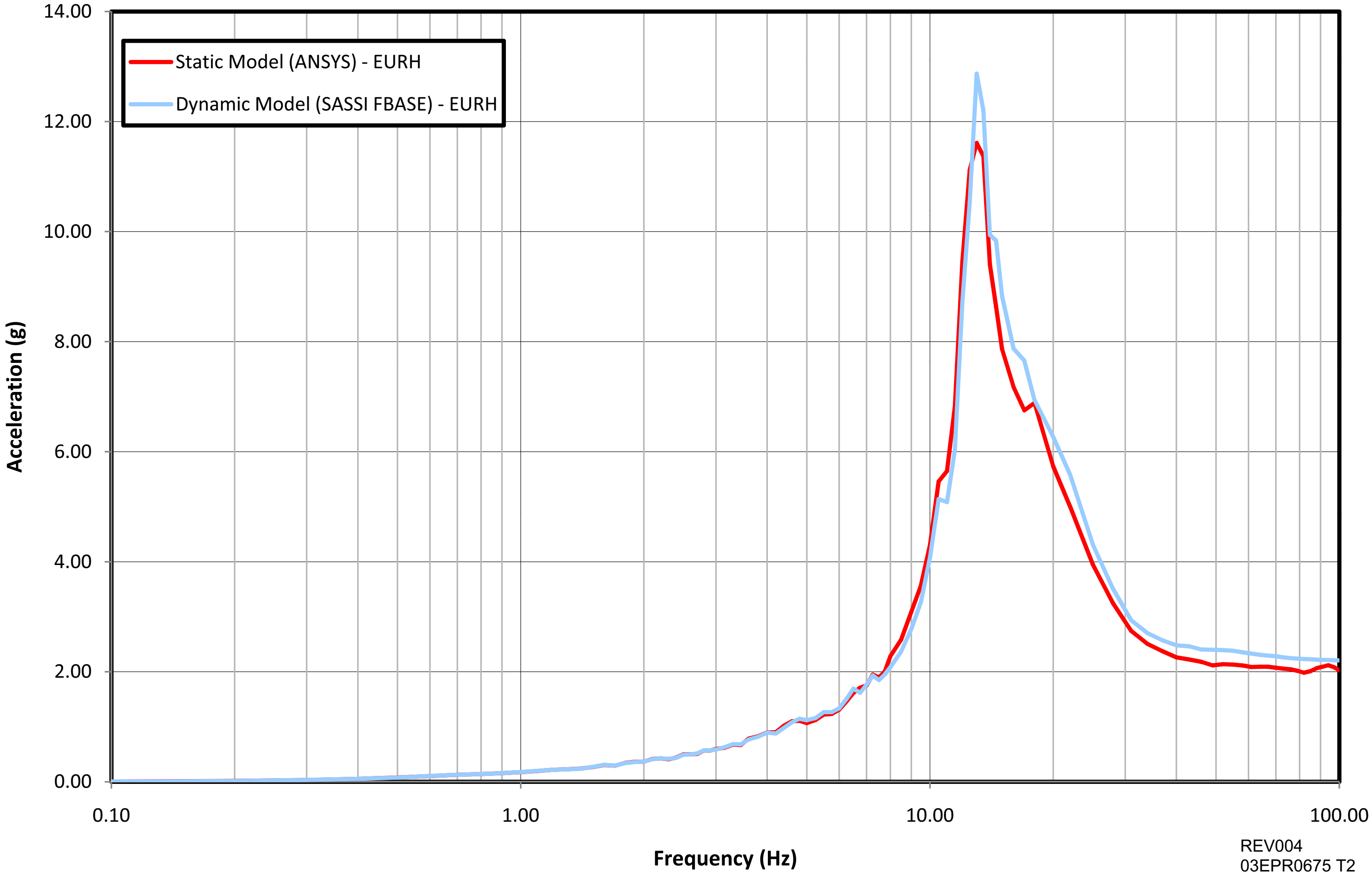
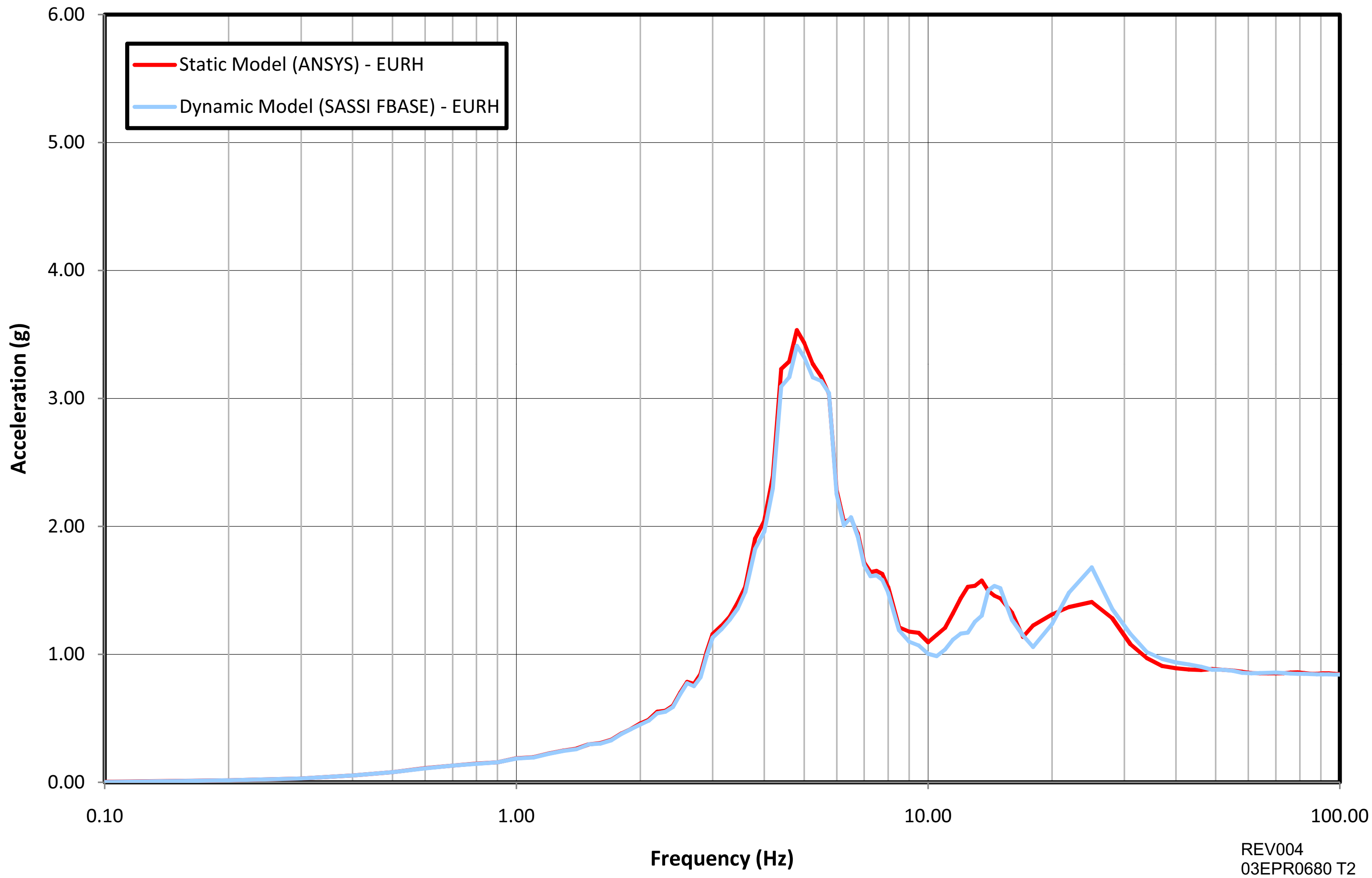
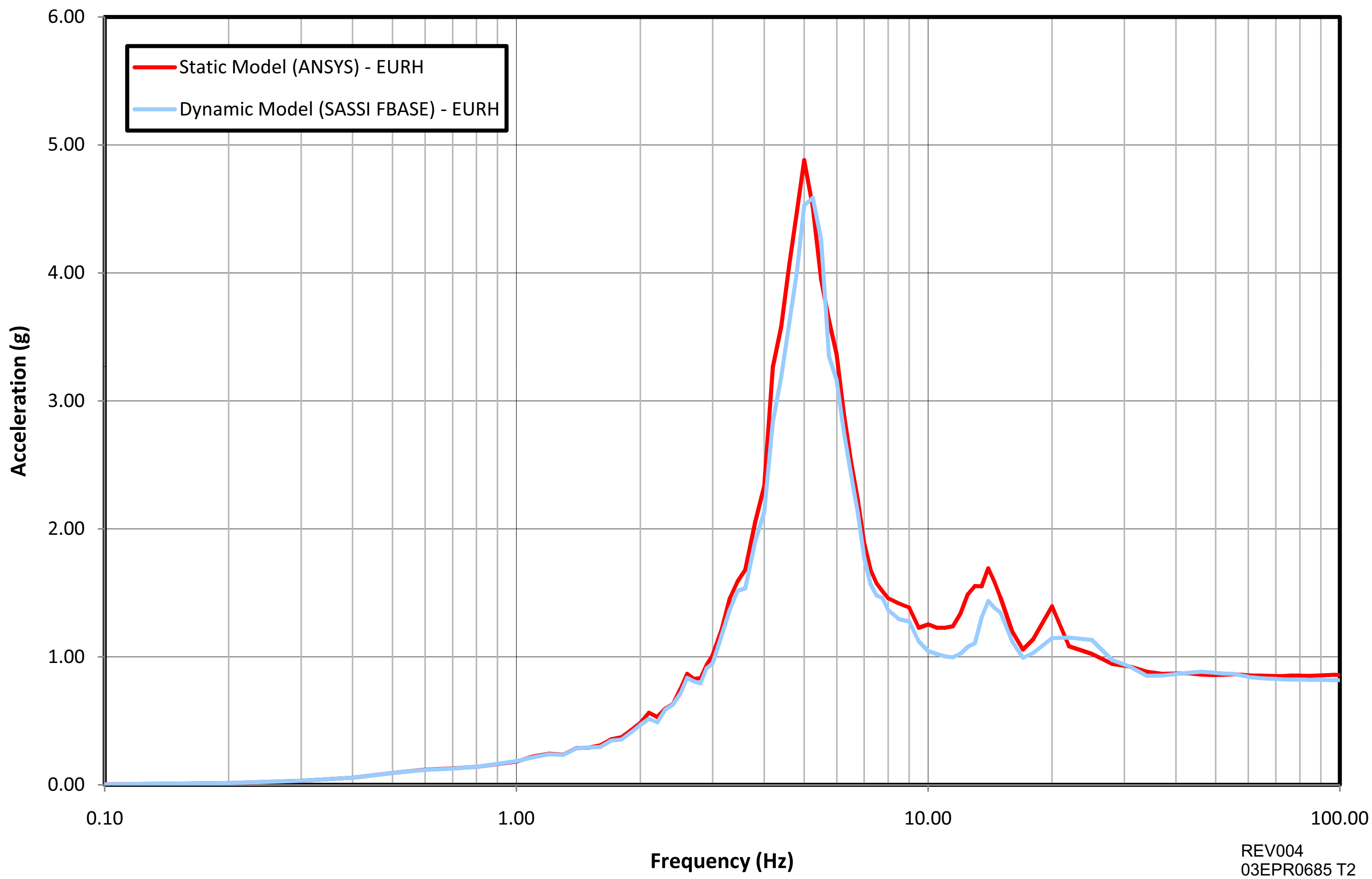


Figure 3.7.2-44—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +123 ft, 4-1/4 in (+37.60m) - Containment Building, 5% Damping, X-Direction



REV004
03EPR0680 T2

Figure 3.7.2-45—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +123 ft, 4-1/4 in (+37.60m) - Containment Building, 5% Damping, Y-Direction



REV004
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Figure 3.7.2-46—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +123 ft, 4-1/4 in (+37.60m) - Containment Building, 5% Damping, Z-Direction

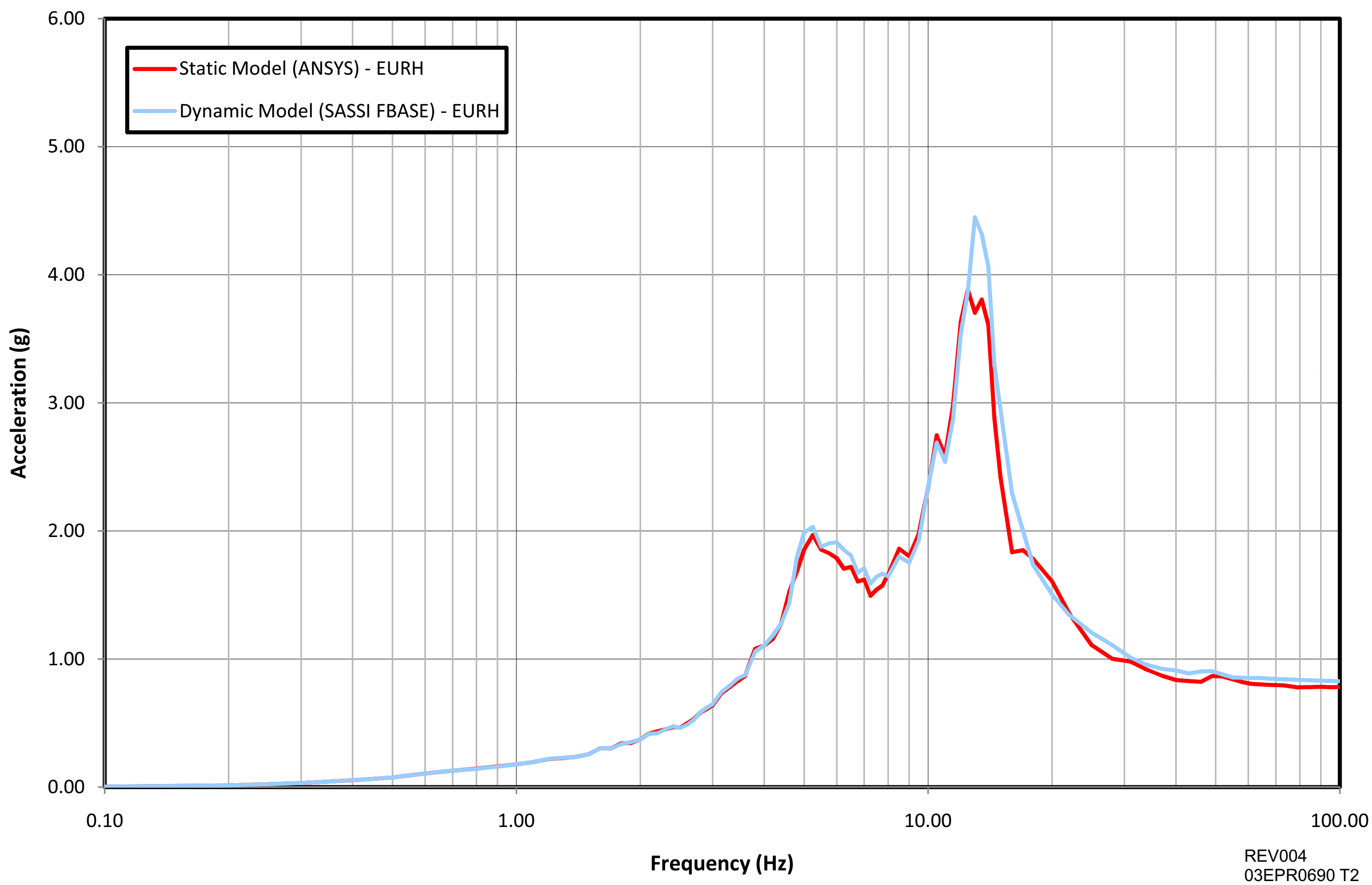
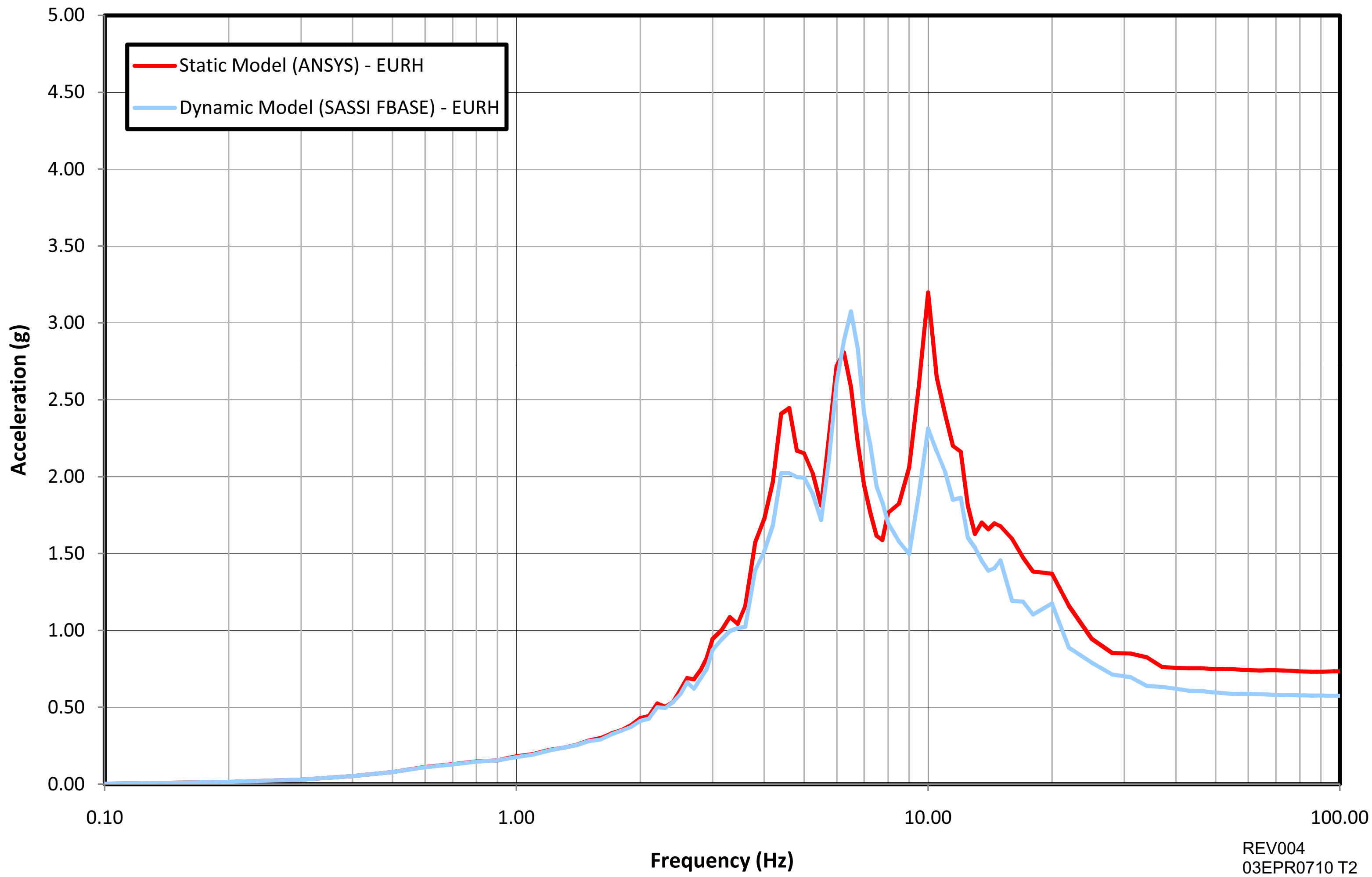


Figure 3.7.2-47—Deleted

Figure 3.7.2-48—Deleted

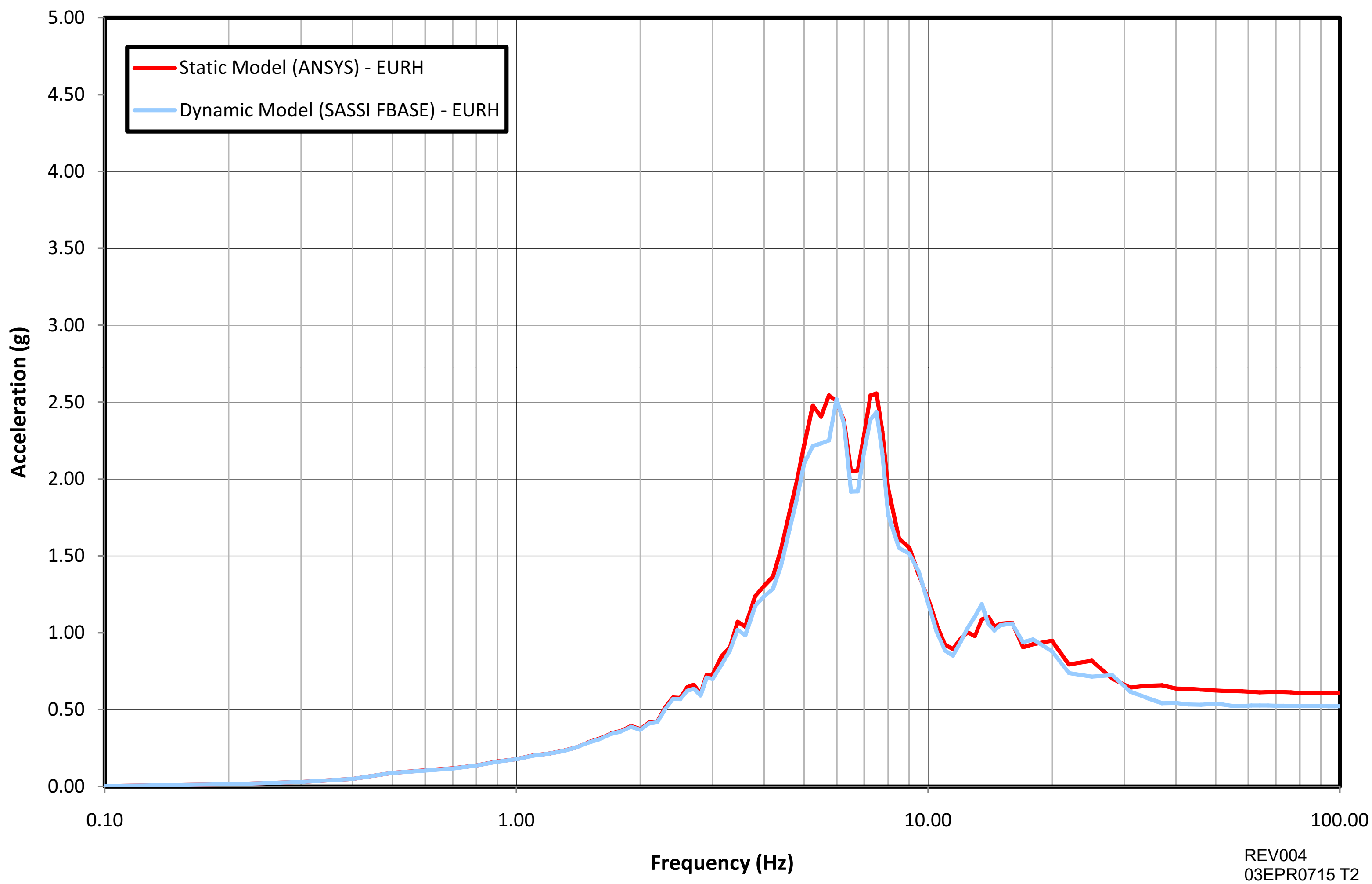
Figure 3.7.2-49—Deleted

Figure 3.7.2-50—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +63 ft, 11-3/4 in (+19.50m) - Reactor Building Internal Structure, 5% Damping, X-Direction



REV004
03EPR0710 T2

Figure 3.7.2-51—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +63 ft, 11-3/4 in (+19.50m) - Reactor Building Internal Structure, 5% Damping, Y-Direction



REV004
03EPR0715 T2

Figure 3.7.2-52—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +63 ft, 11-3/4 in (+19.50m) - Reactor Building Internal Structure, 5% Damping, Z-Direction

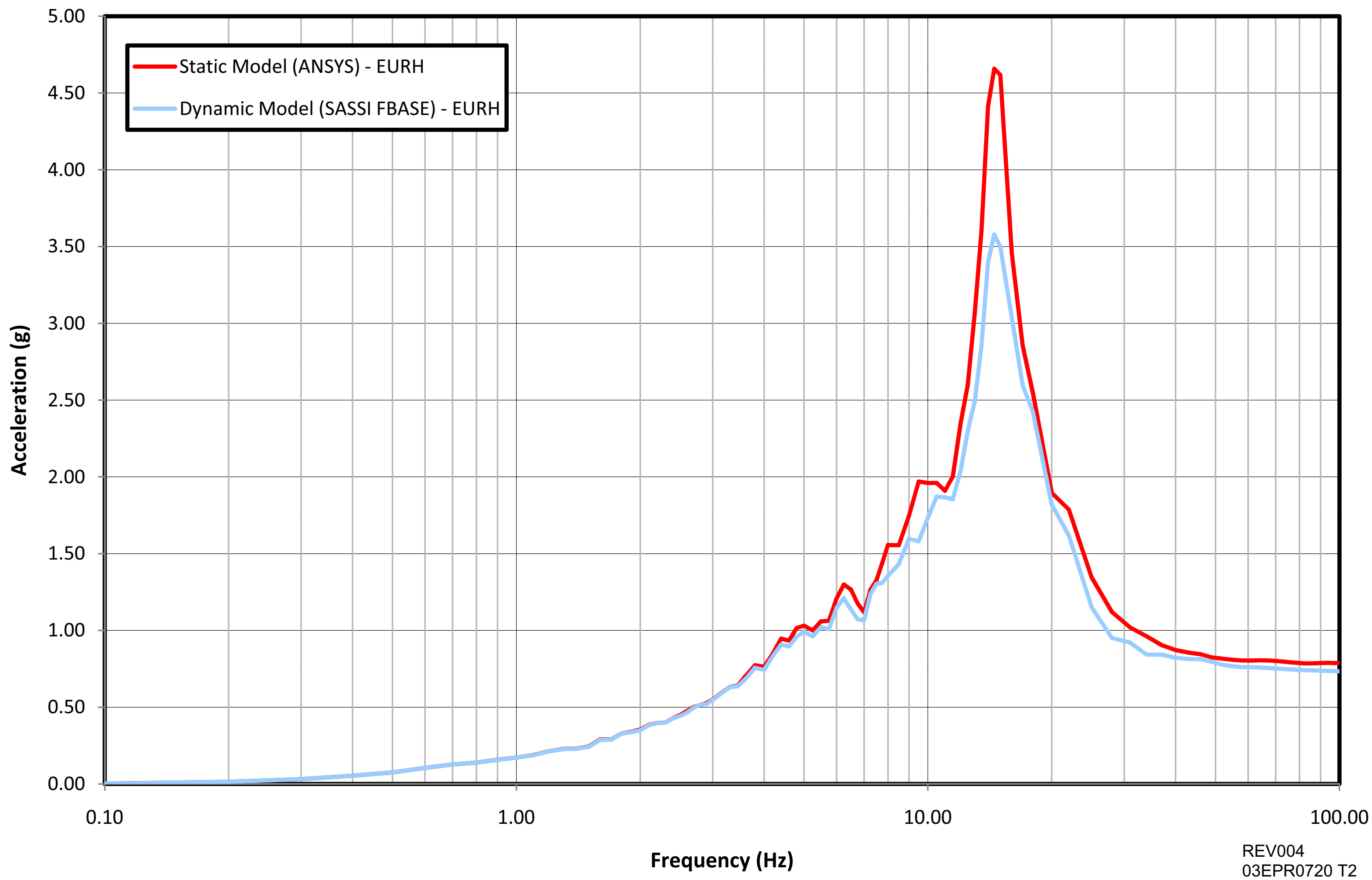
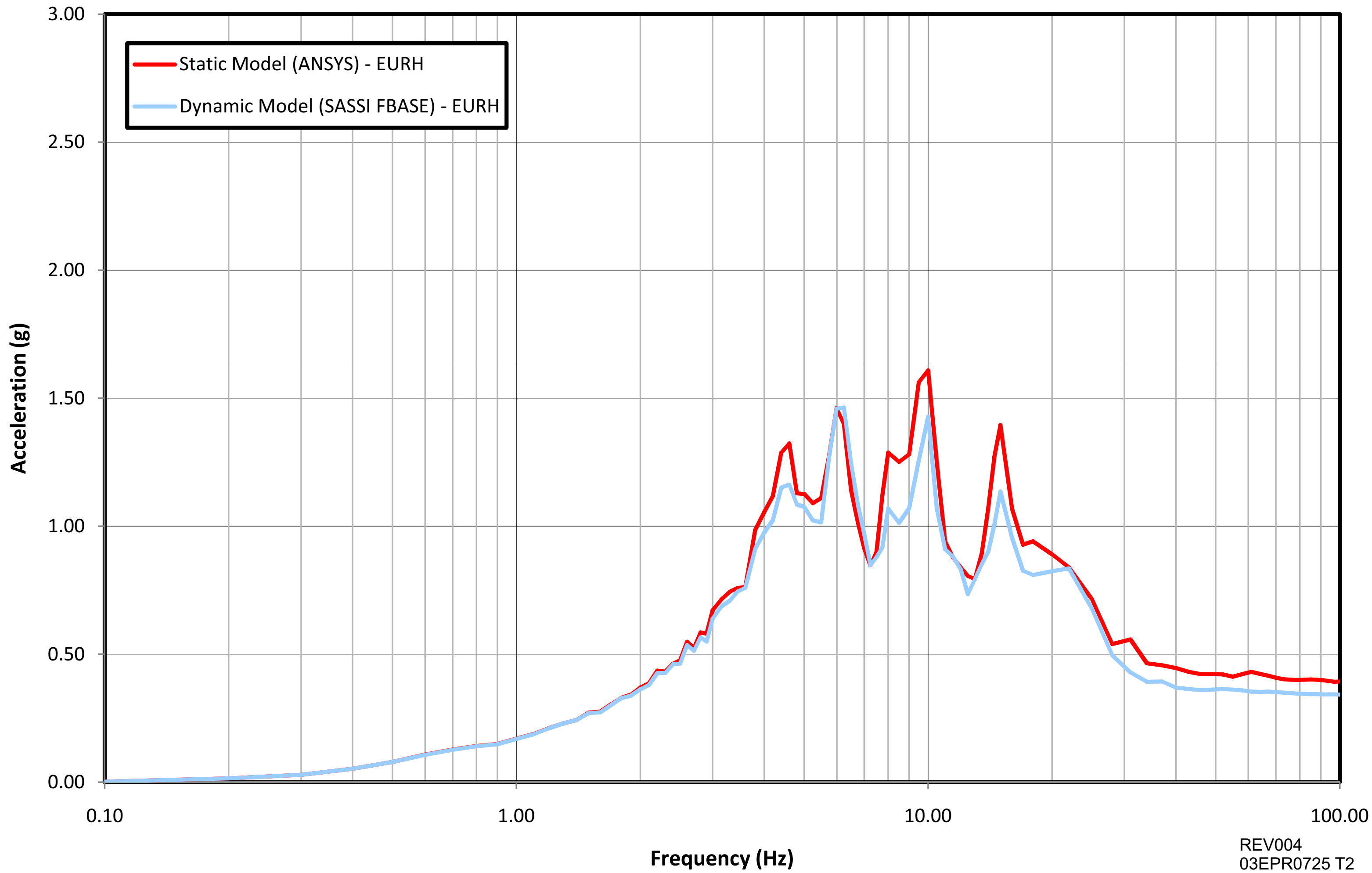


Figure 3.7.2-53—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +16 ft, 10-3/4 in (+5.15m) - Reactor Building Internal Structure, 5% Damping, X-Direction



REV004
03EPR0725 T2

Figure 3.7.2-54—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +16 ft, 10-3/4 in (+5.15m) - Reactor Building Internal Structure, 5% Damping, Y-Direction

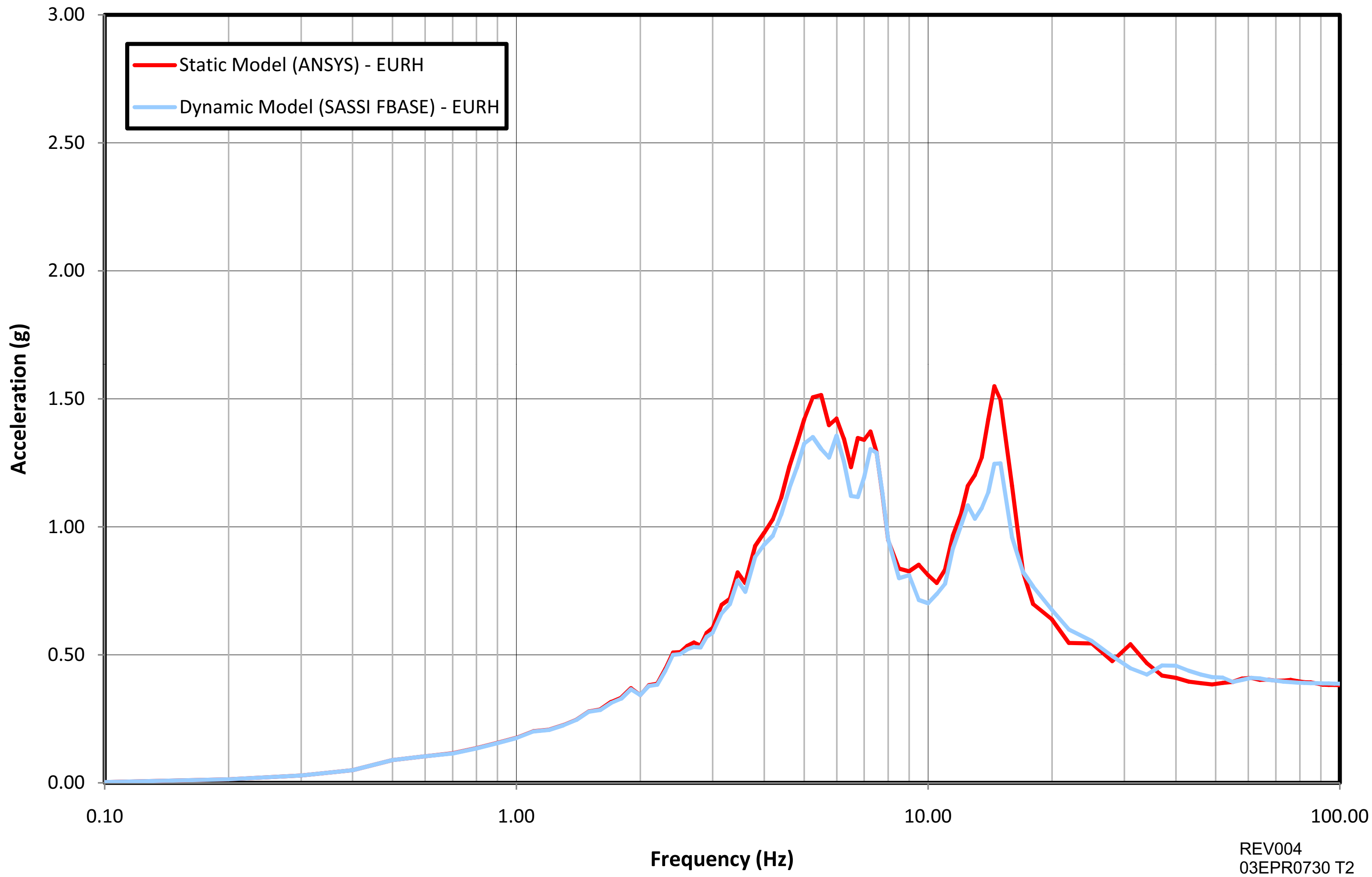


Figure 3.7.2-55—Static FEM vs. Dynamic FEM Spectrum Comparison at Elev. +16 ft, 10-3/4 in (+5.15m) - Reactor Building Internal Structure, 5% Damping, Z-Direction

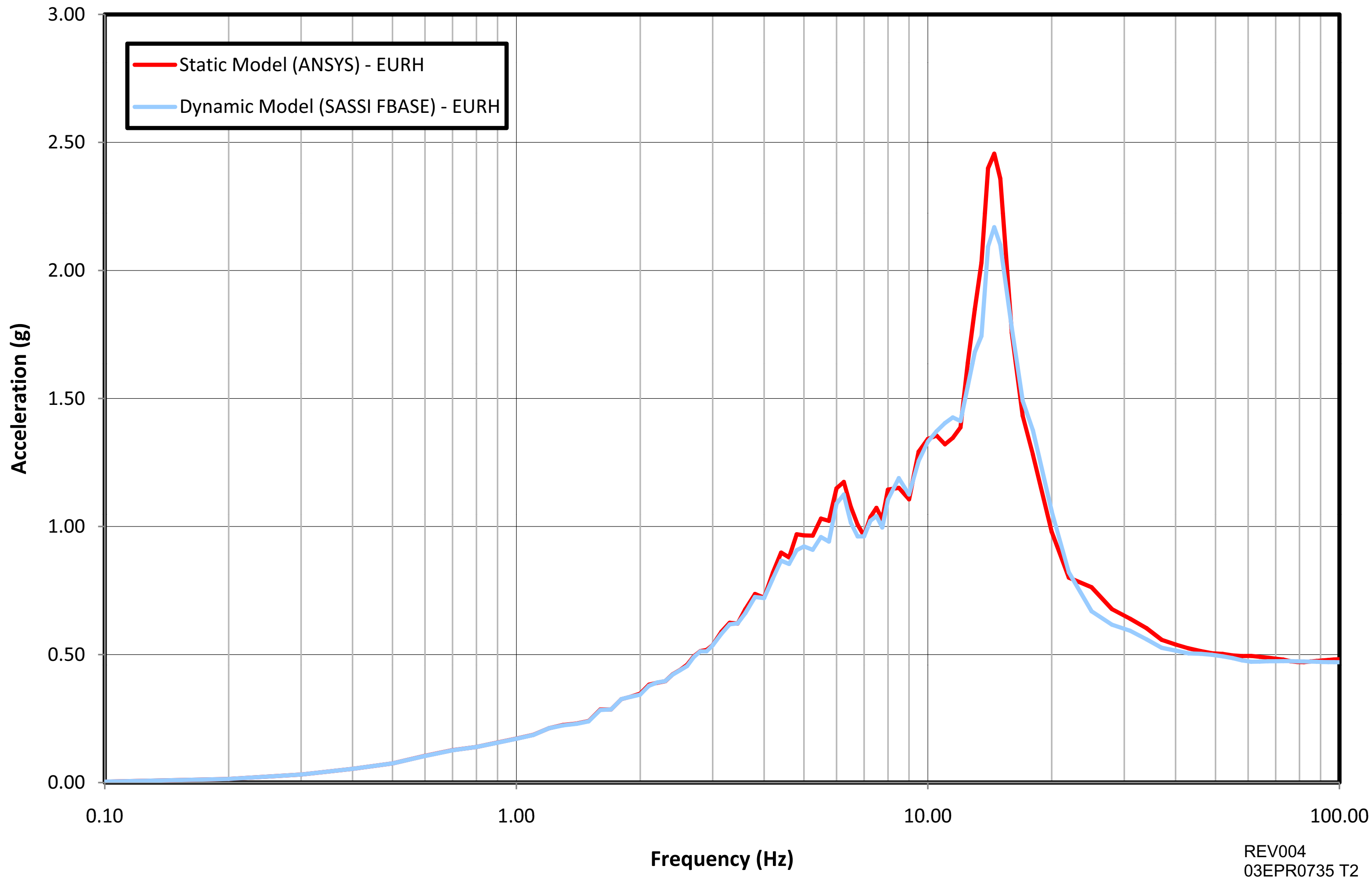


Figure 3.7.2-56—Simplified Stick Model of Reactor Coolant Loop

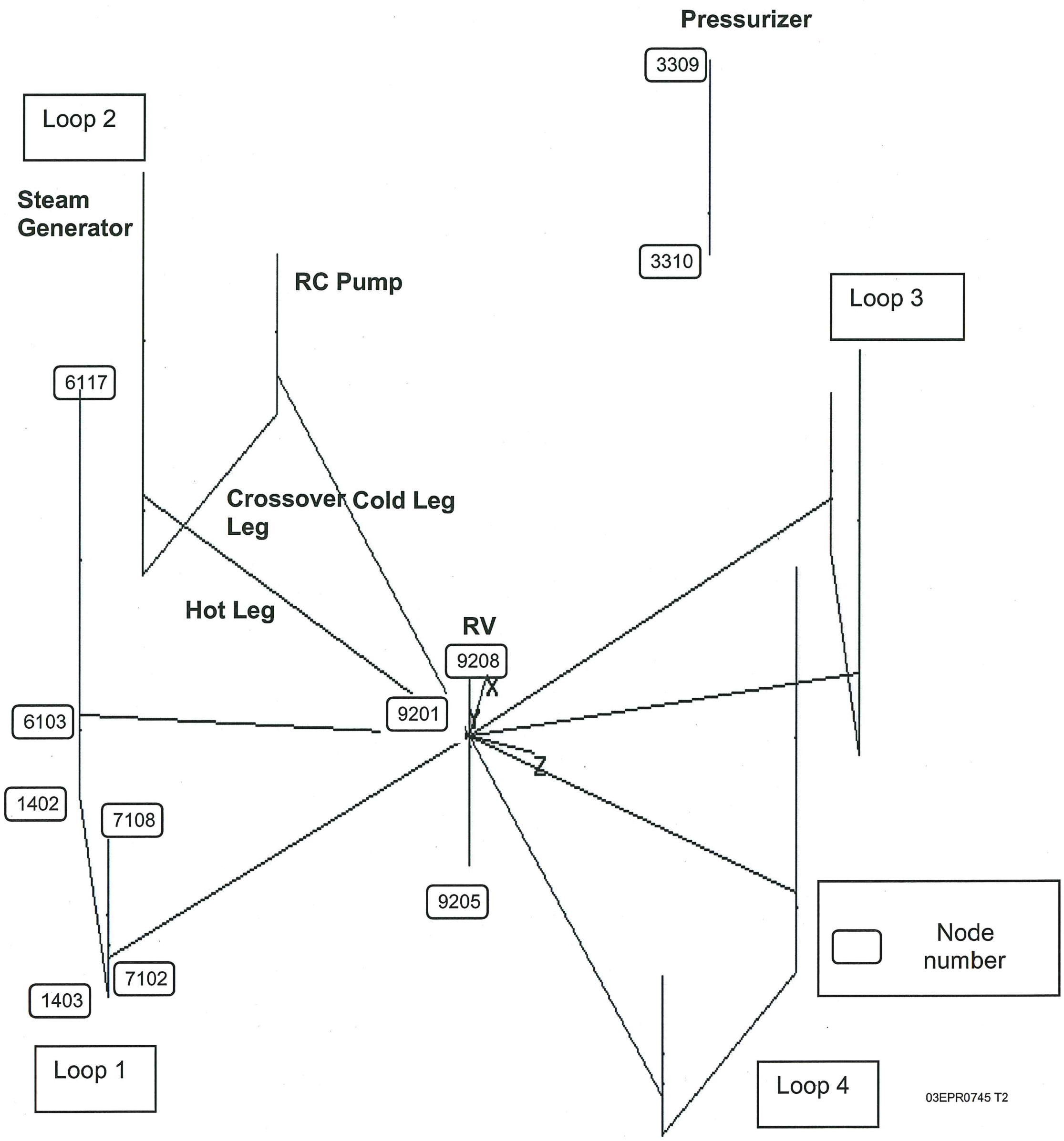
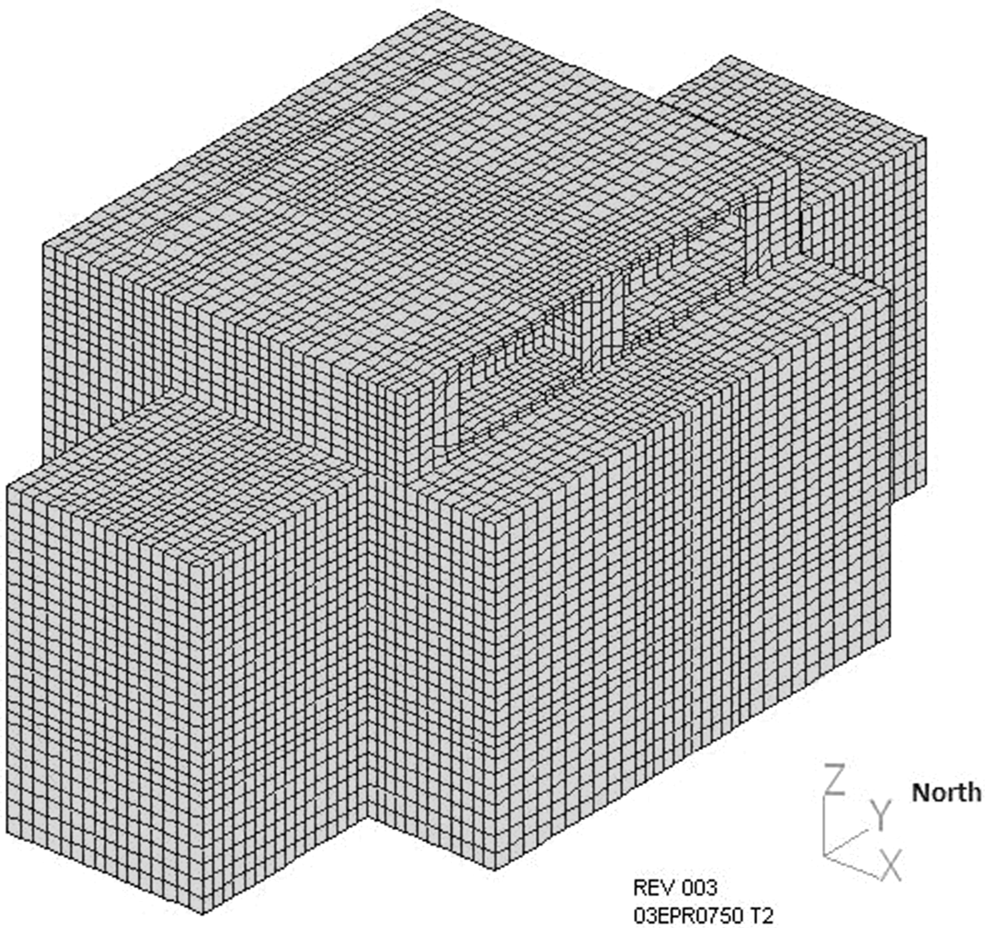


Figure 3.7.2-57—Isometric View of GTSTRUDL FEM for Emergency Power Generating Building

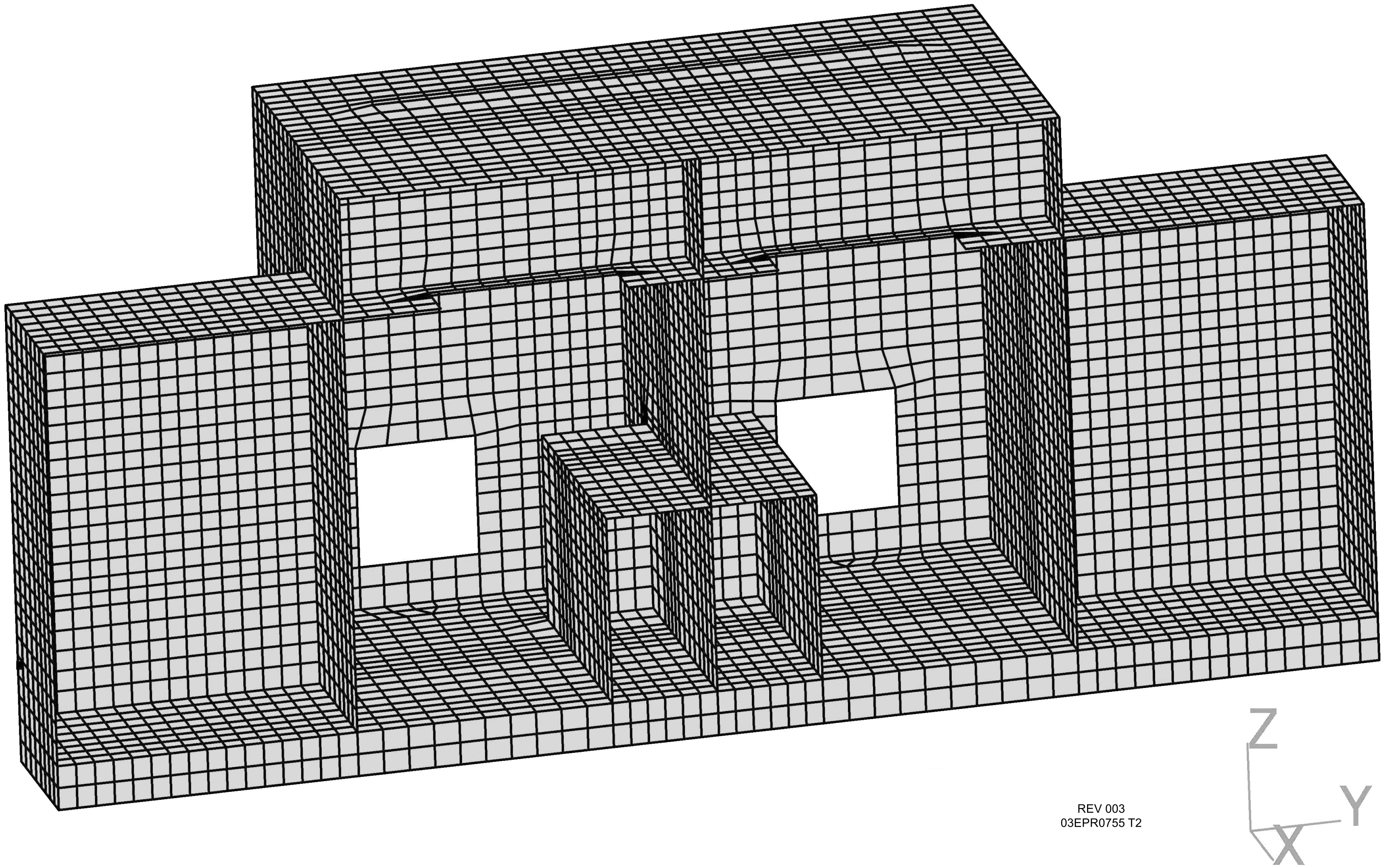


Note:

Bottom two layers represent the shear key.

Also see Figure 3.8-94 for details.

Figure 3.7.2-58—Section View of GTSTRUDL FEM for Emergency Power Generating Building



Note:

Bottom two layers represent the shear key. Also see Figure 3.8-94 for details.

Figure 3.7.2-59—Isometric View of GTSTRUDL FEM for Essential Service Water Building (EUR Motions)

Will be provided later.

Figure 3.7.2-60—Section View of GTSTRUDL FEM for Essential Service Water Building (EUR Motions)

Will be provided later.

Figure 3.7.2-61—Deleted

Figure 3.7.2-62—Deleted

Figure 3.7.2-63—Deleted

Figure 3.7.2-64—Deleted

Figure 3.7.2-65—Deleted

Figure 3.7.2-66—Deleted

Figure 3.7.2-67—Elevation View of NAB Stick Model in Y-Z Plane

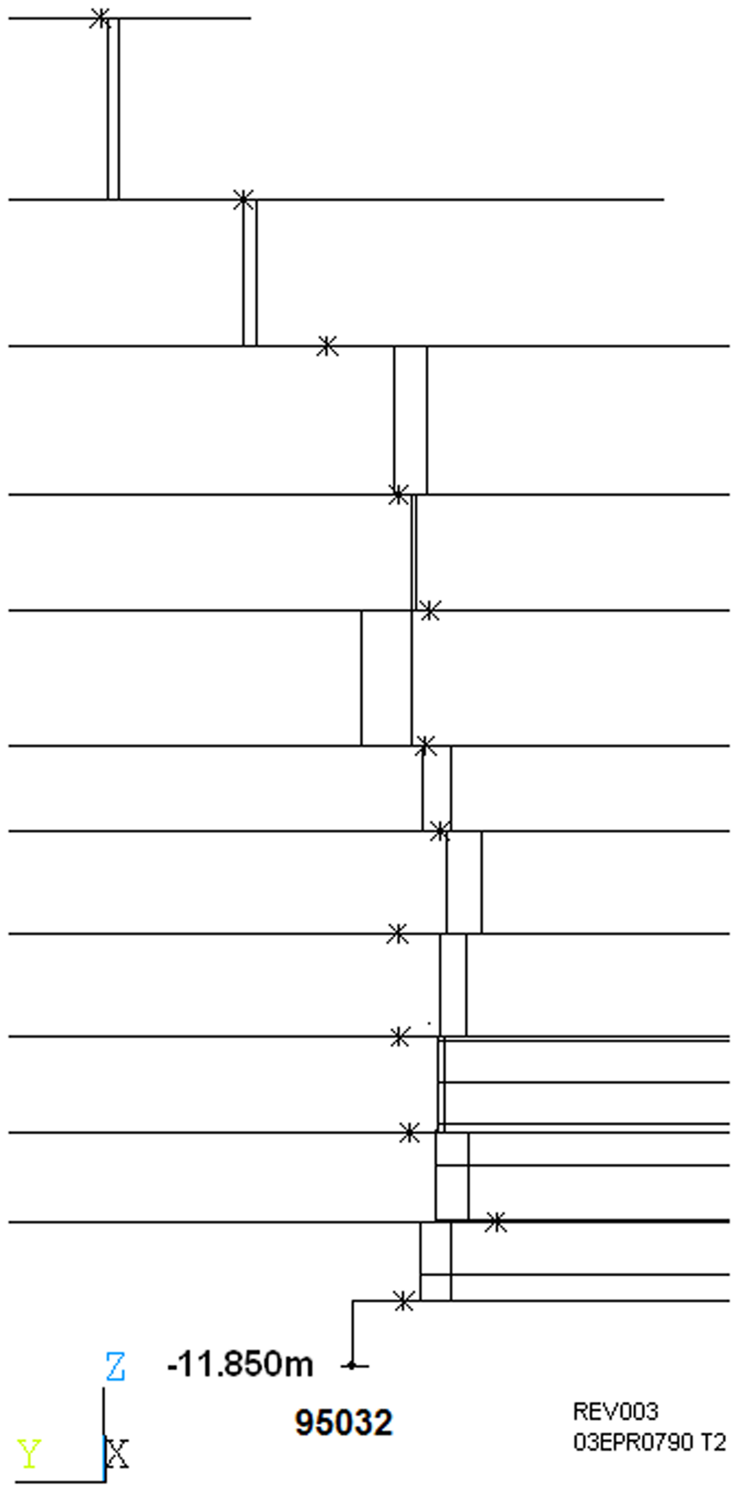


Figure 3.7.2-68—Response Spectra at NI Common Basemat Bottom Node 274 - 5% Damping, X-Direction

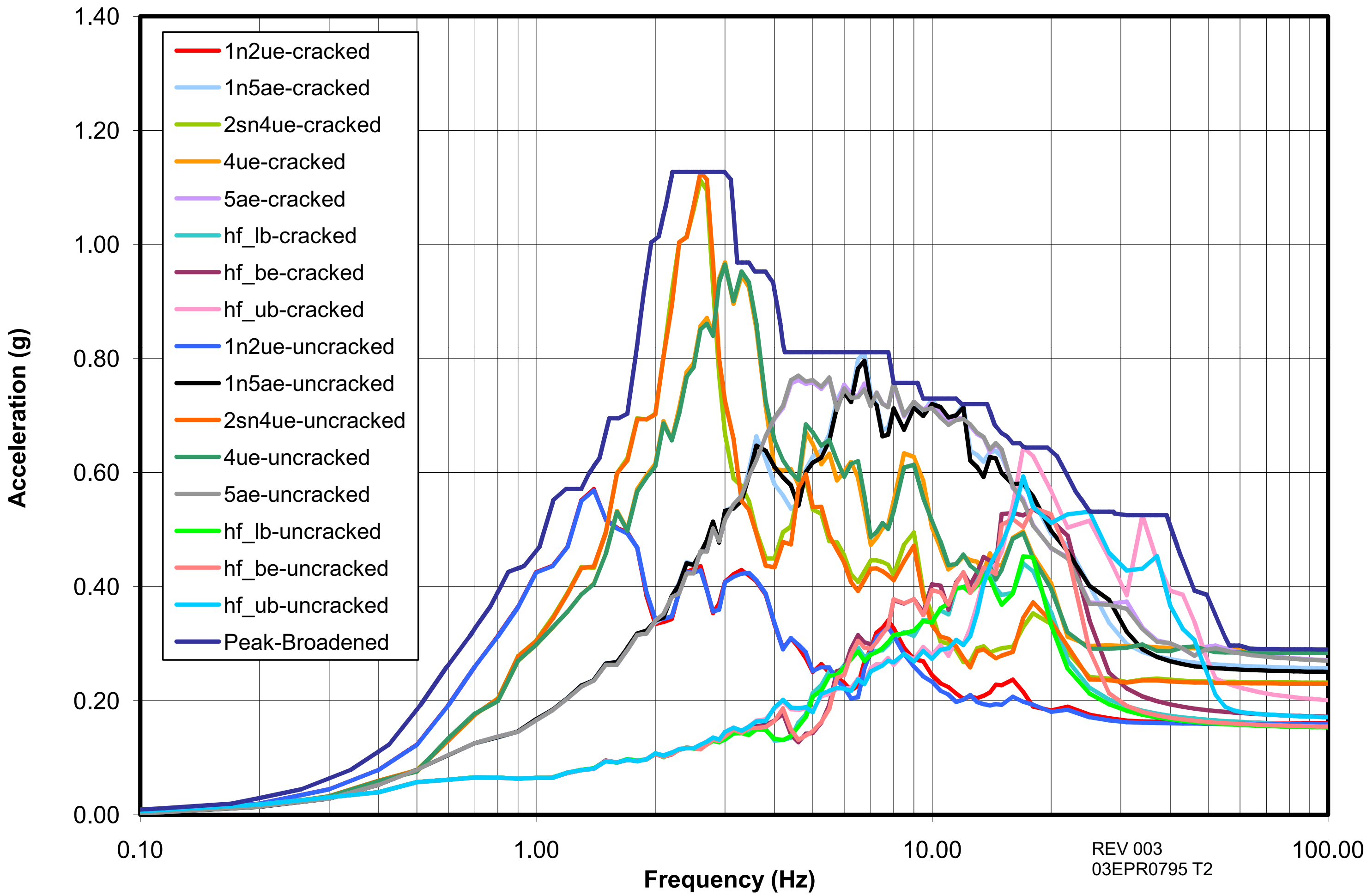


Figure 3.7.2-69—Response Spectra at NI Common Basemat Bottom Node 274 - 5% Damping, Y-Direction

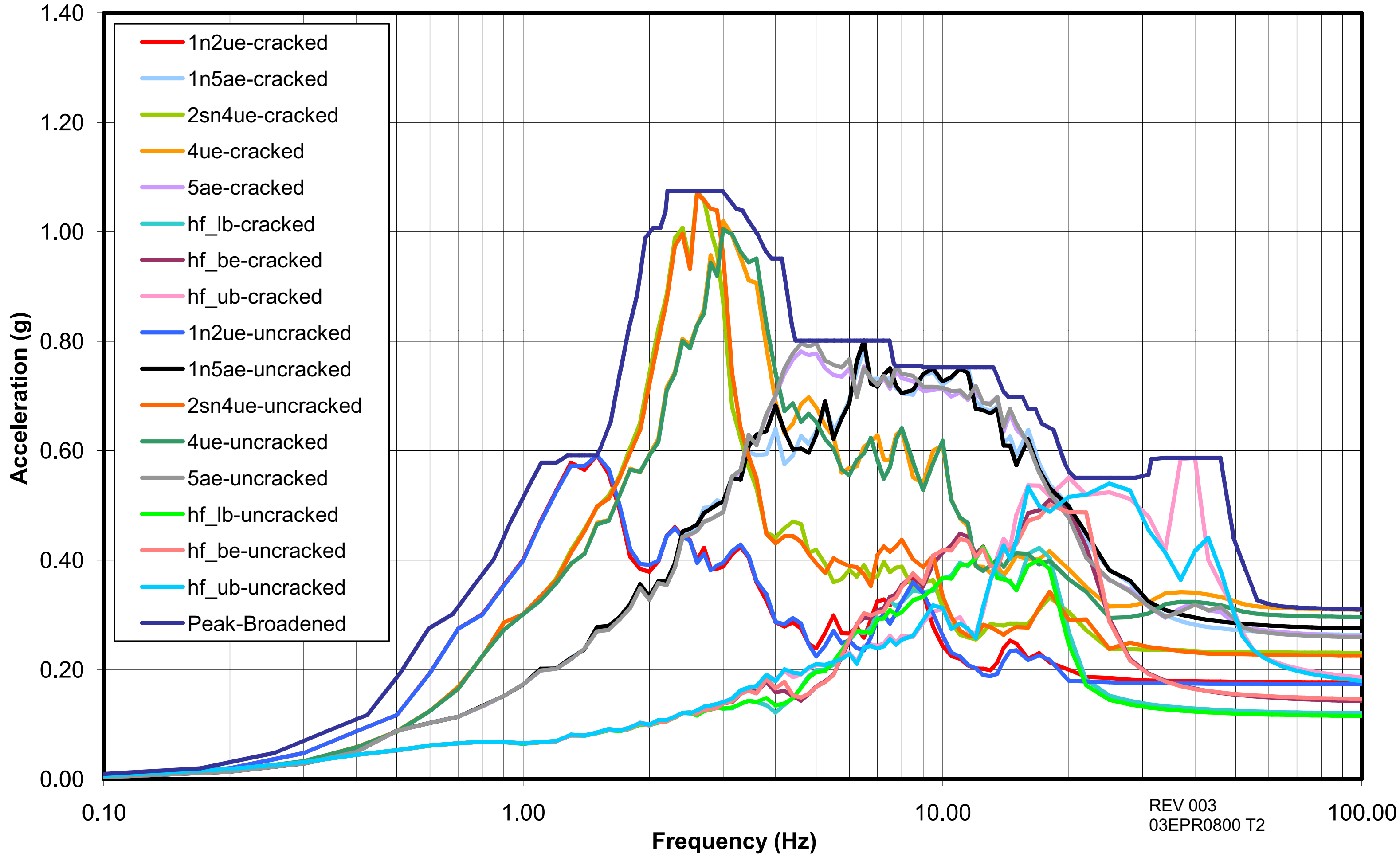


Figure 3.7.2-70—Response Spectra at NI Common Basemat Bottom Node 274 - 5% Damping, Z-Direction

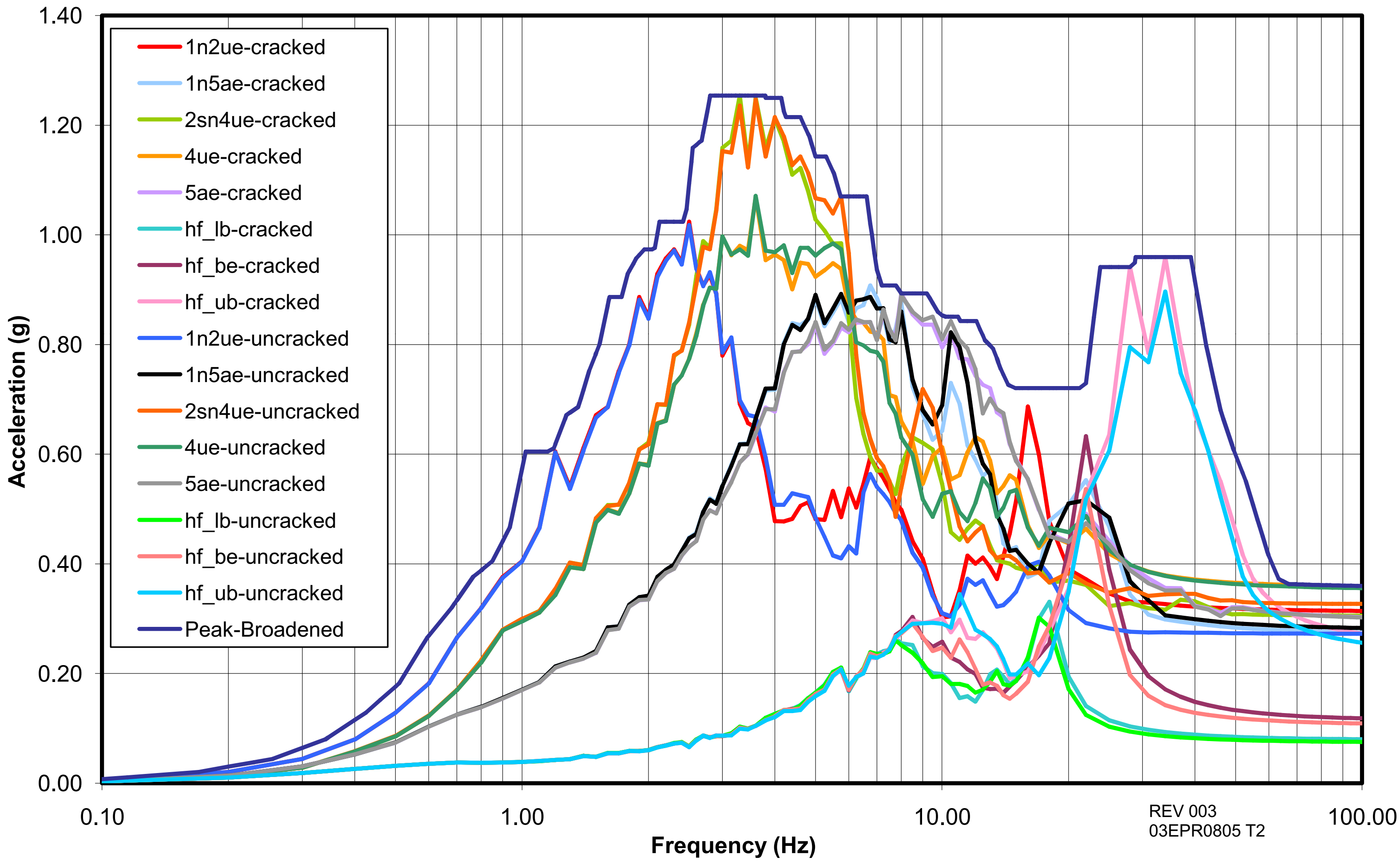
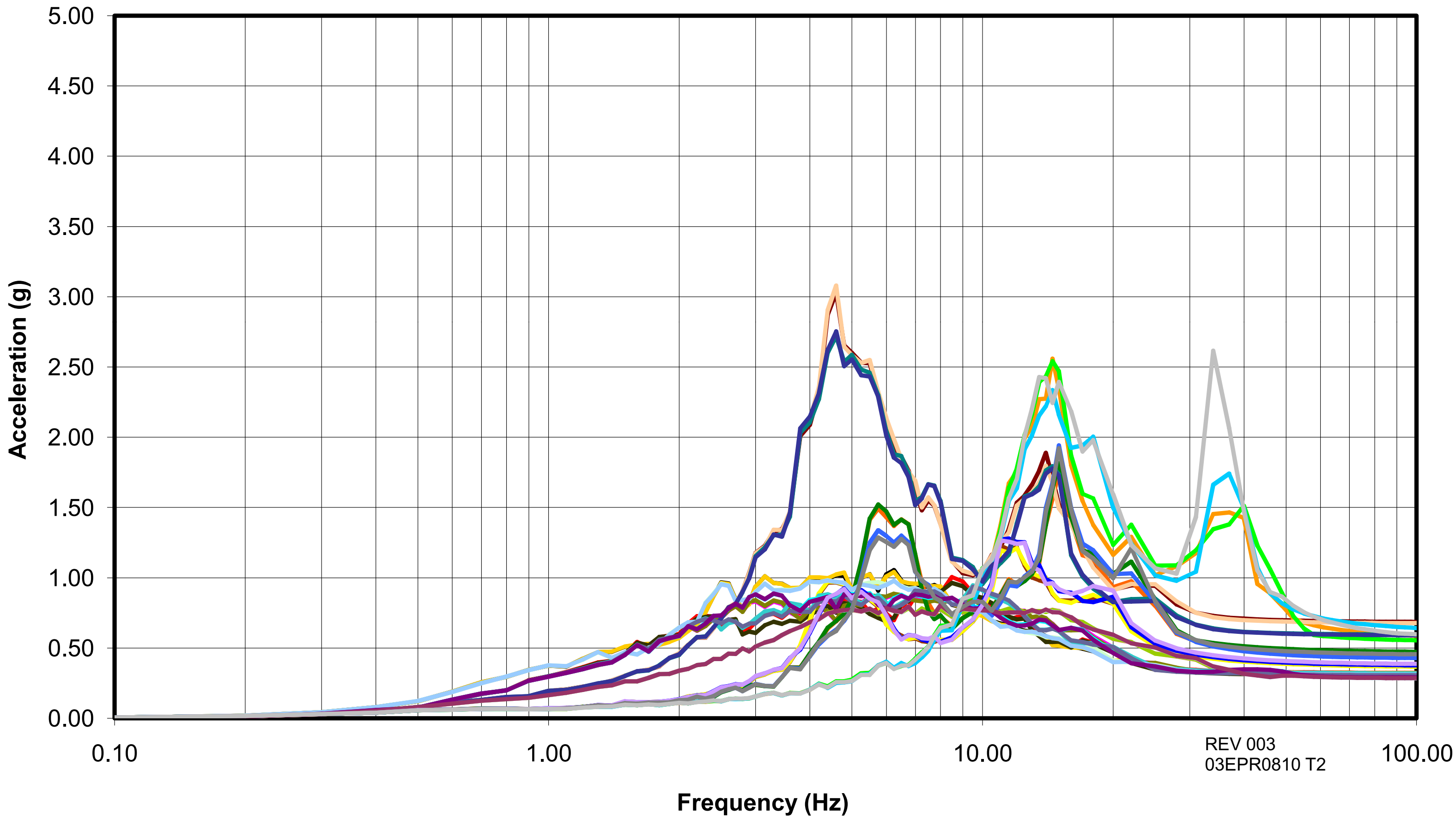


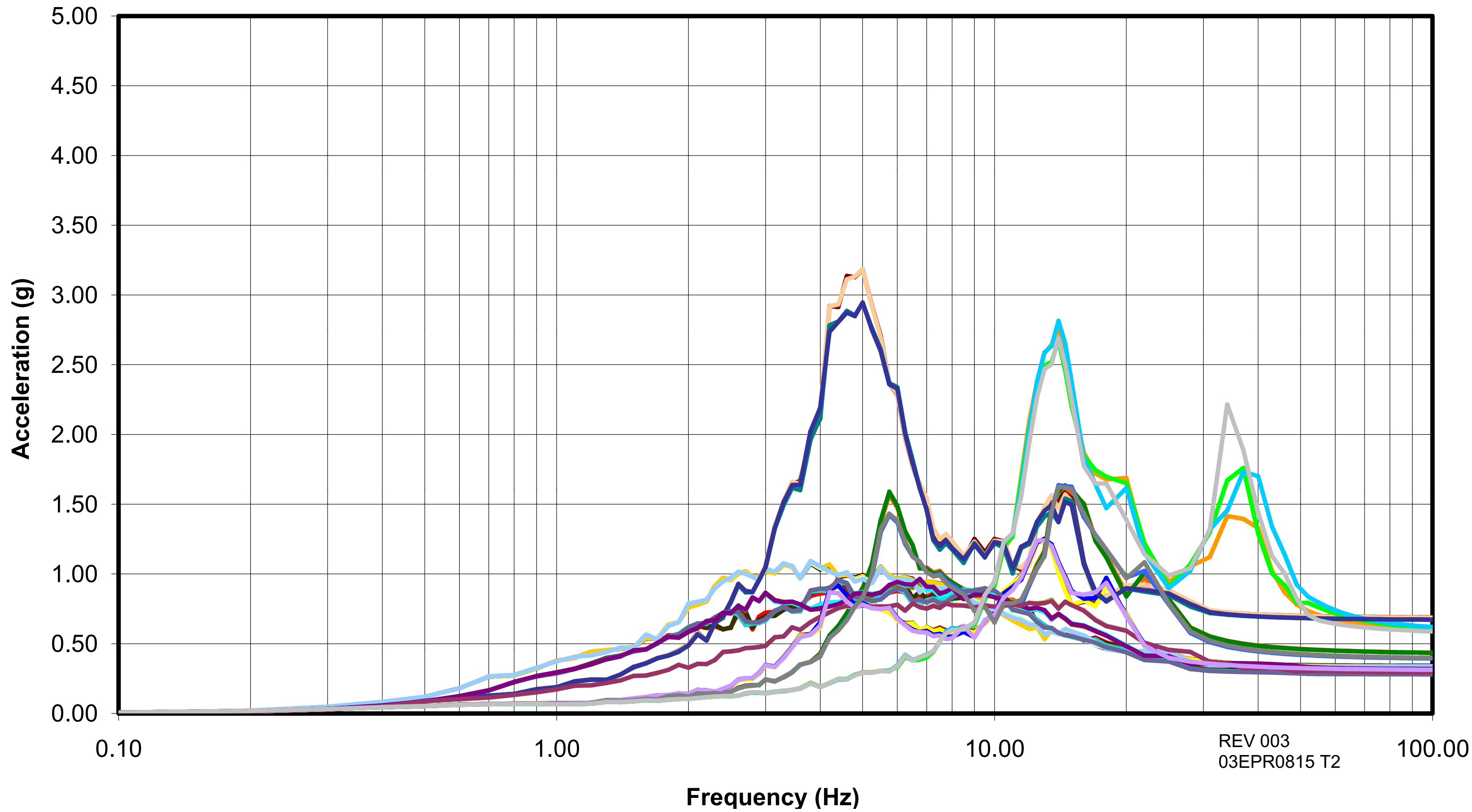
Figure 3.7.2-71—Soil Model Surface Response Spectra at Centers of Footprint of EPGB - 5% Damping, X-Direction



Note:

Plots include the soil profiles in Table 3.7.1-6 for the footprint locations of both EPGBs with cracked and un-cracked properties.

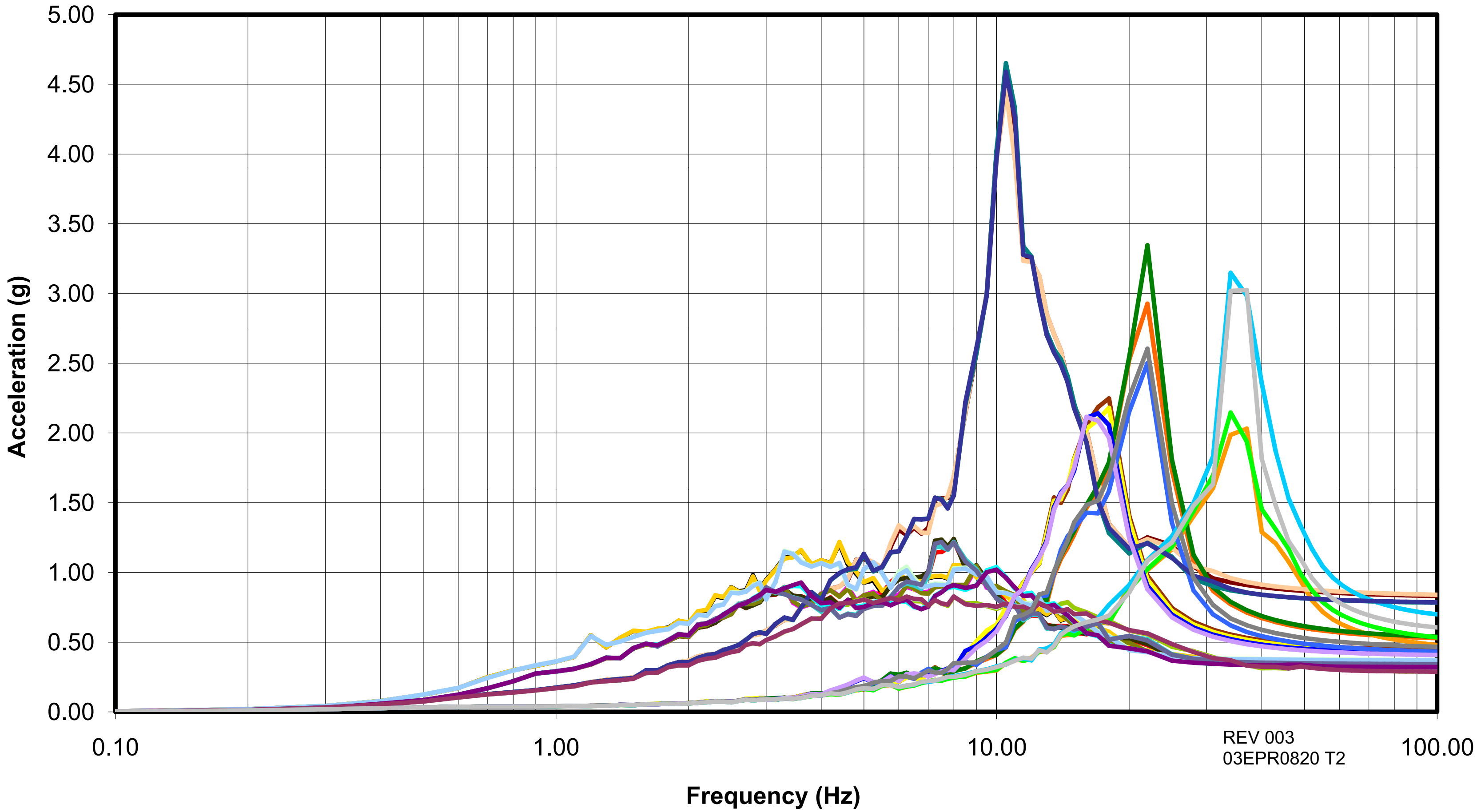
Figure 3.7.2-72—Soil Model Surface Response Spectra at Centers of Footprint of EPGB - 5% Damping, Y-Direction



Note:

Plots include the soil profiles in Table 3.7.1-6 for the footprint locations of both EPGBs with cracked and un-cracked properties.

Figure 3.7.2-73—Soil Model Surface Response Spectra at Centers of Footprint of EPGB - 5% Damping, Z-Direction



Note:

Plots include the soil profiles in Table 3.7.1-6 for the footprint locations of both EPGBs with cracked and un-cracked properties.

Figure 3.7.2-74—Spectrum Envelope of Reactor Building Internal Structure - Elev. +16 ft, 10-3/4 in (+5.15m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction

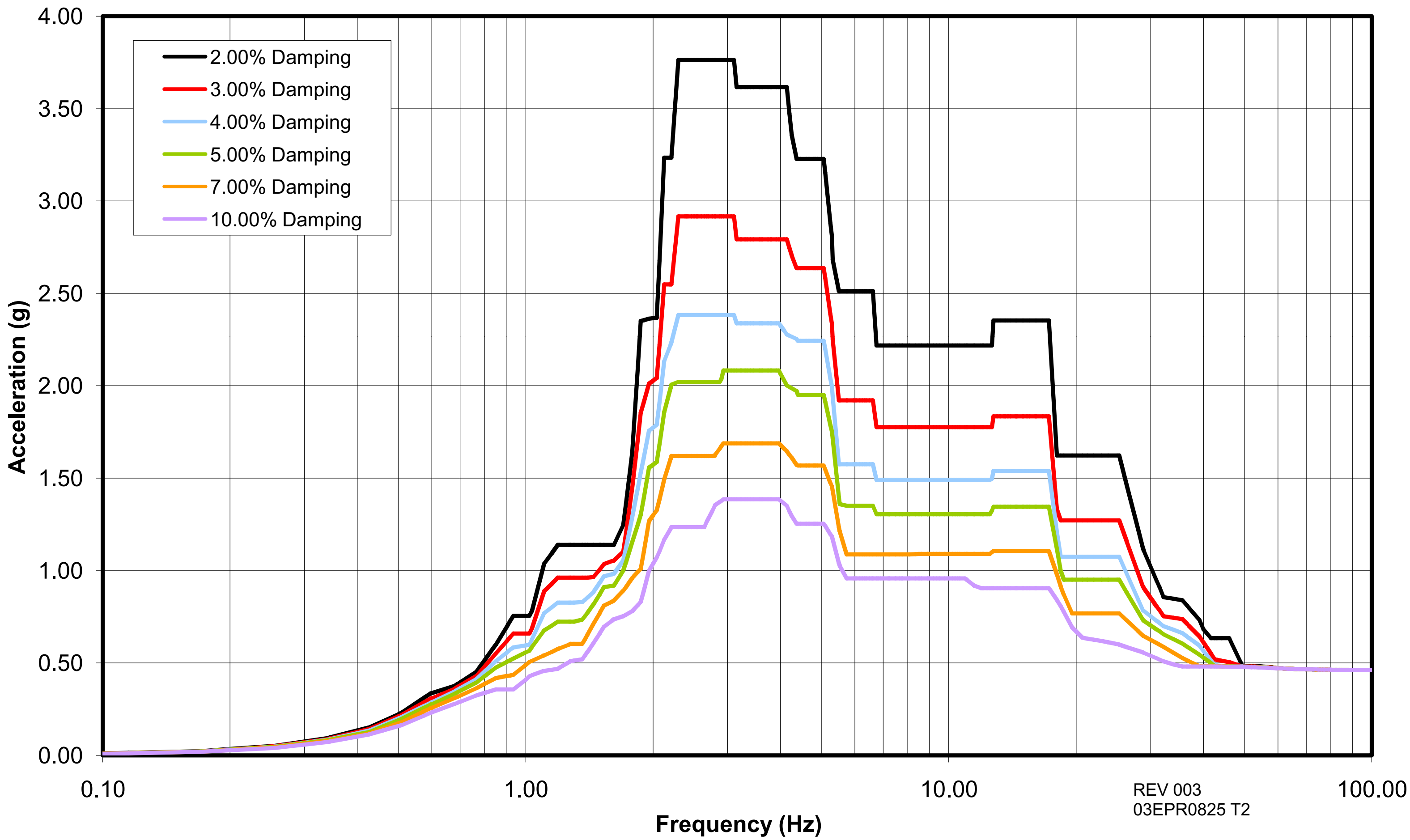


Figure 3.7.2-75—Spectrum Envelope of Reactor Building Internal Structure - Elev. +16 ft, 10-3/4 in (+5.15m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Y-Direction

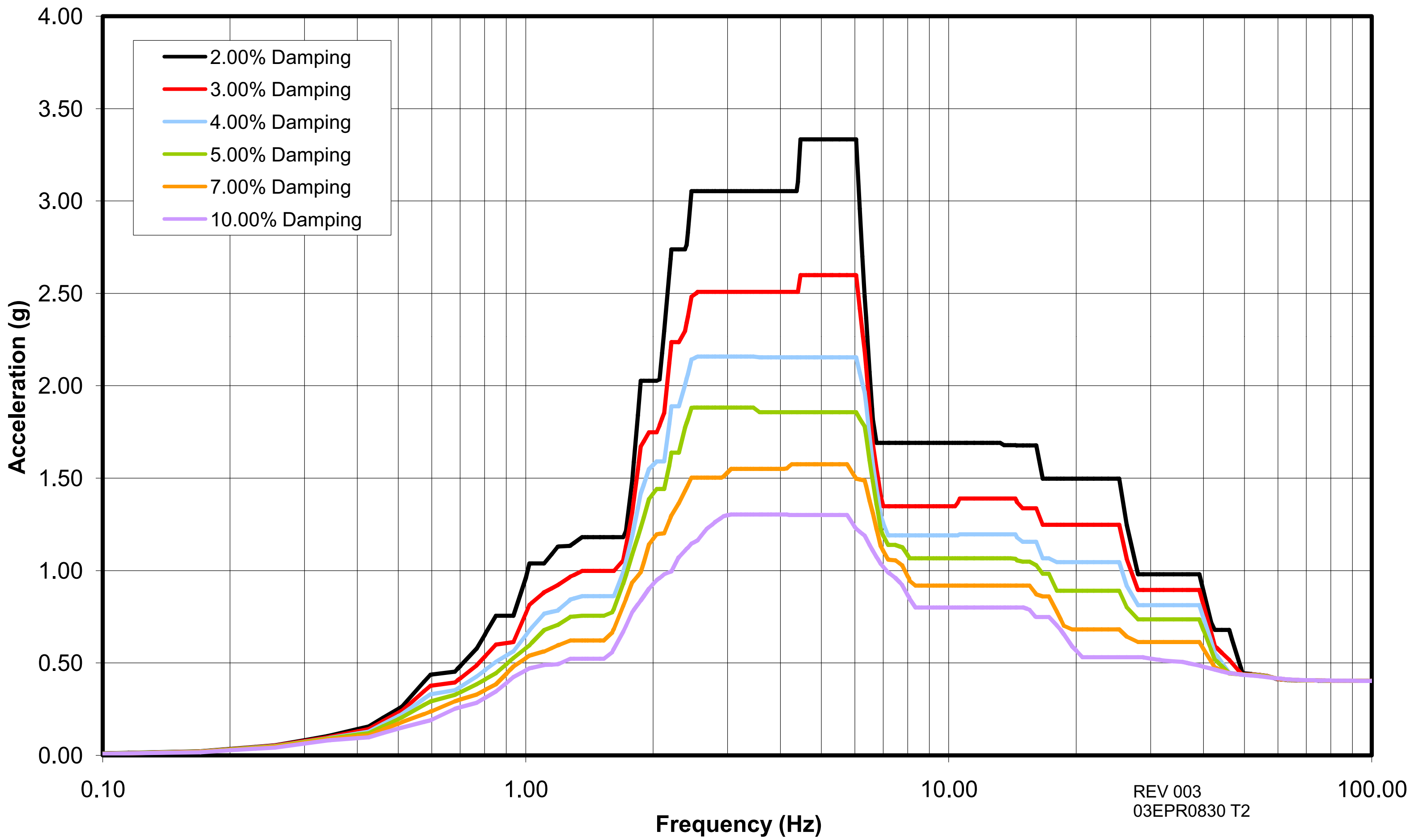


Figure 3.7.2-76—Spectrum Envelope of Reactor Building Internal Structure - Elev. +16 ft, 10-3/4 in (+5.15m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction

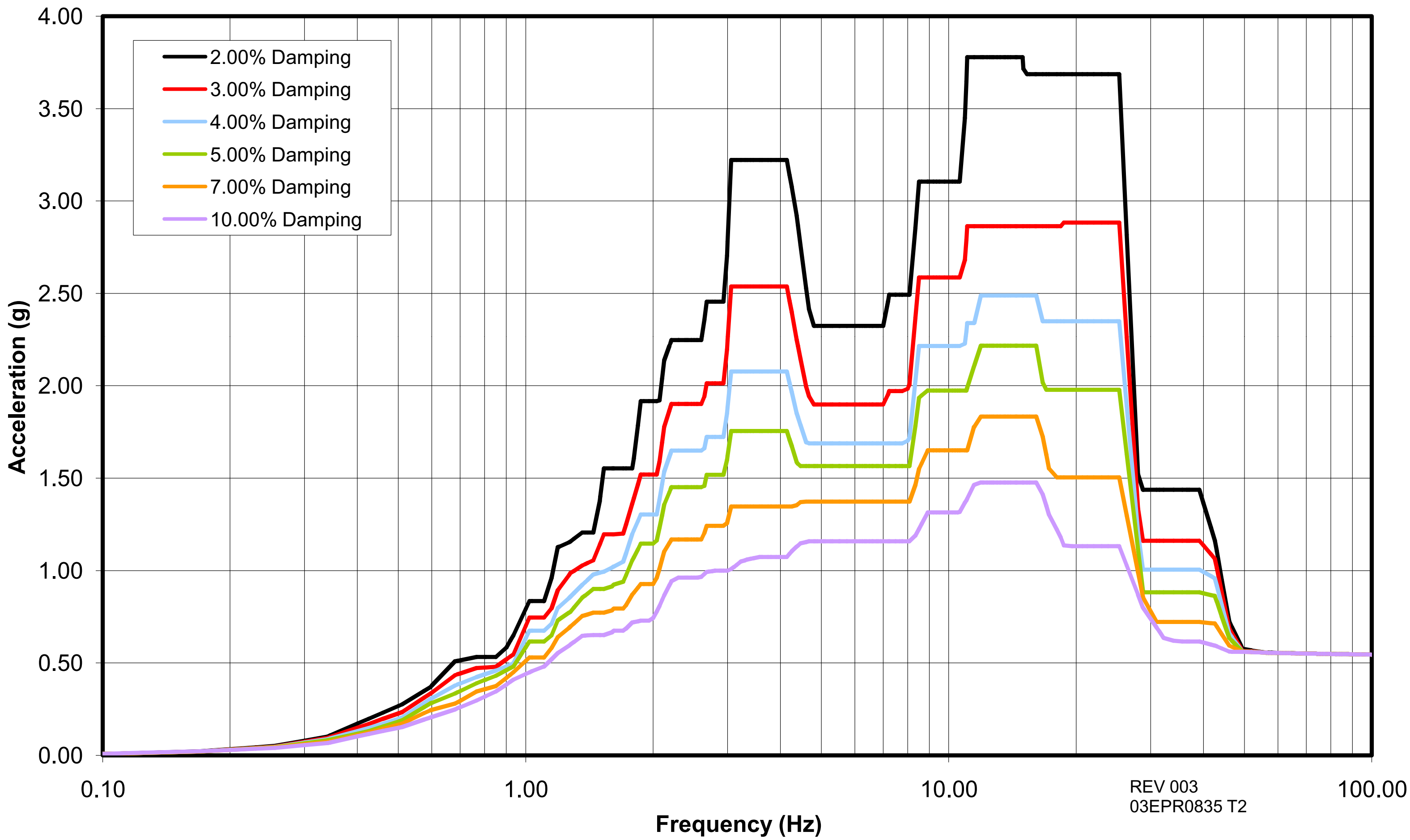
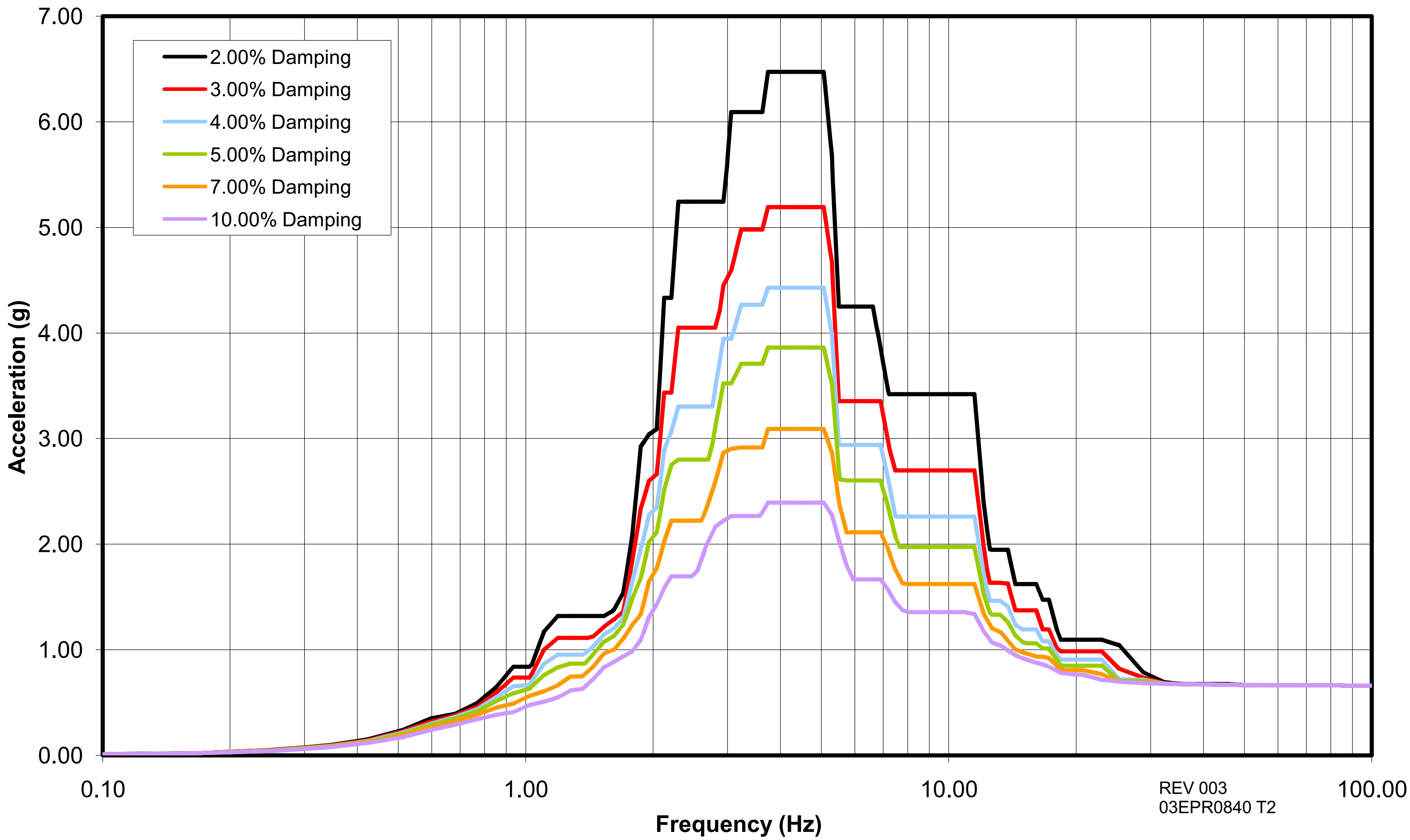


Figure 3.7.2-77—Spectrum Envelope of Reactor Building Internal Structure - Elev. +63 ft, 11-3/4 in (+19.50m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction



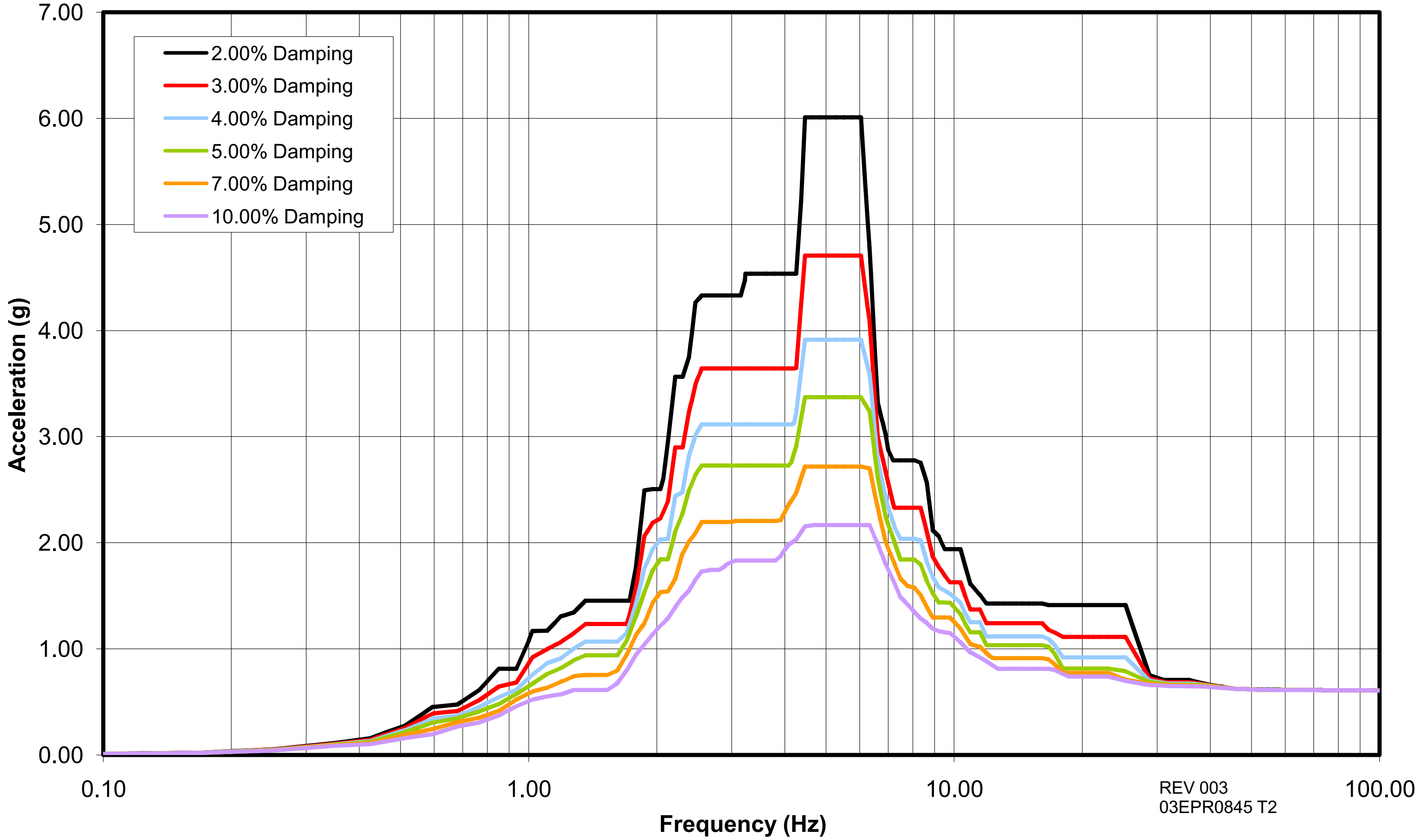


Figure 3.7.2-78—Spectrum Envelope of Reactor Building Internal Structure - Elev. +63 ft, 11-3/4 in (+19.50m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Y-Direction

Figure 3.7.2-79—Spectrum Envelope of Reactor Building Internal Structure - Elev. +63 ft, 11-3/4 in (+19.50m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction

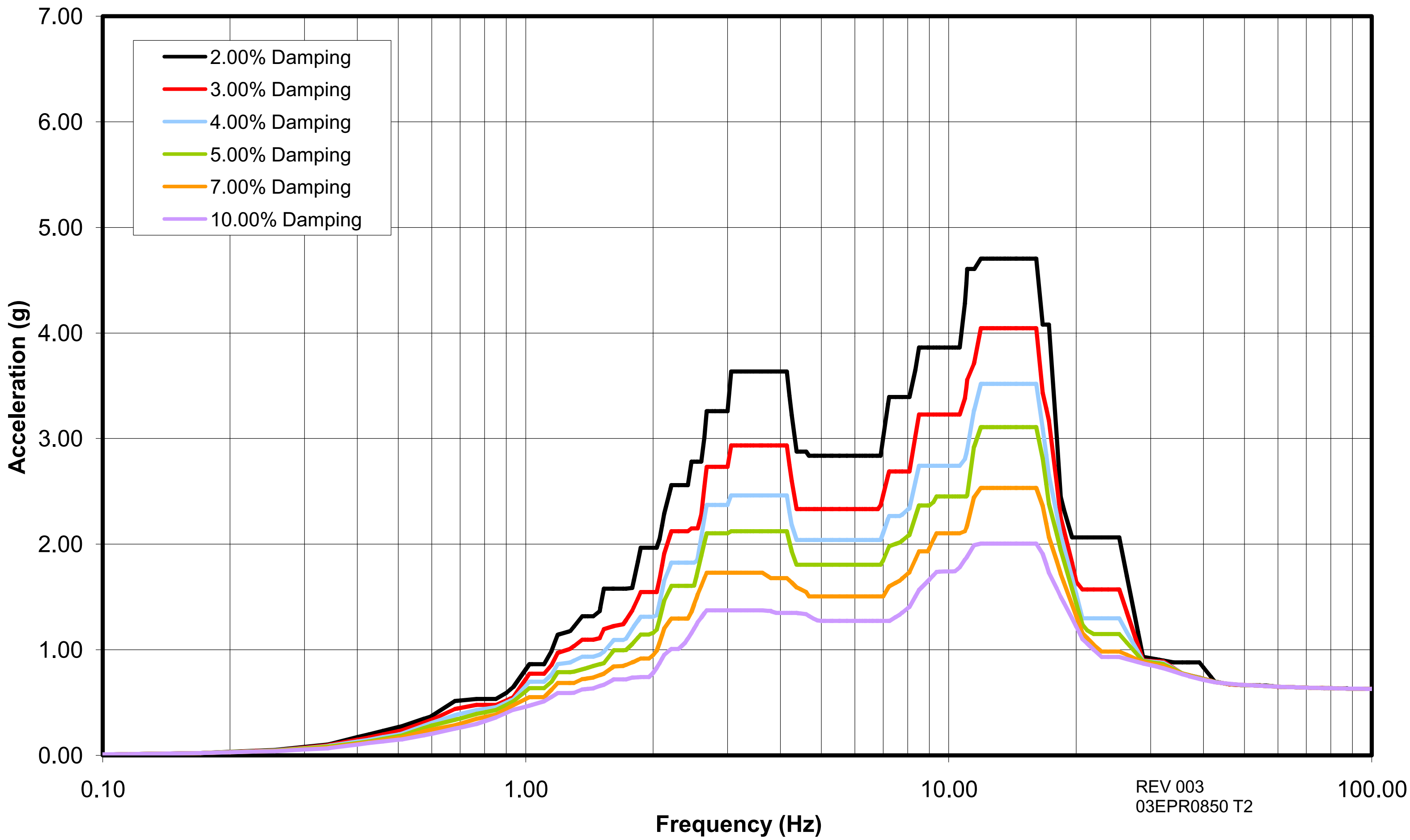


Figure 3.7.2-80—Spectrum Envelope of Safeguard Building 1 - Elev. +26 ft, 7 in (+8.10m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction

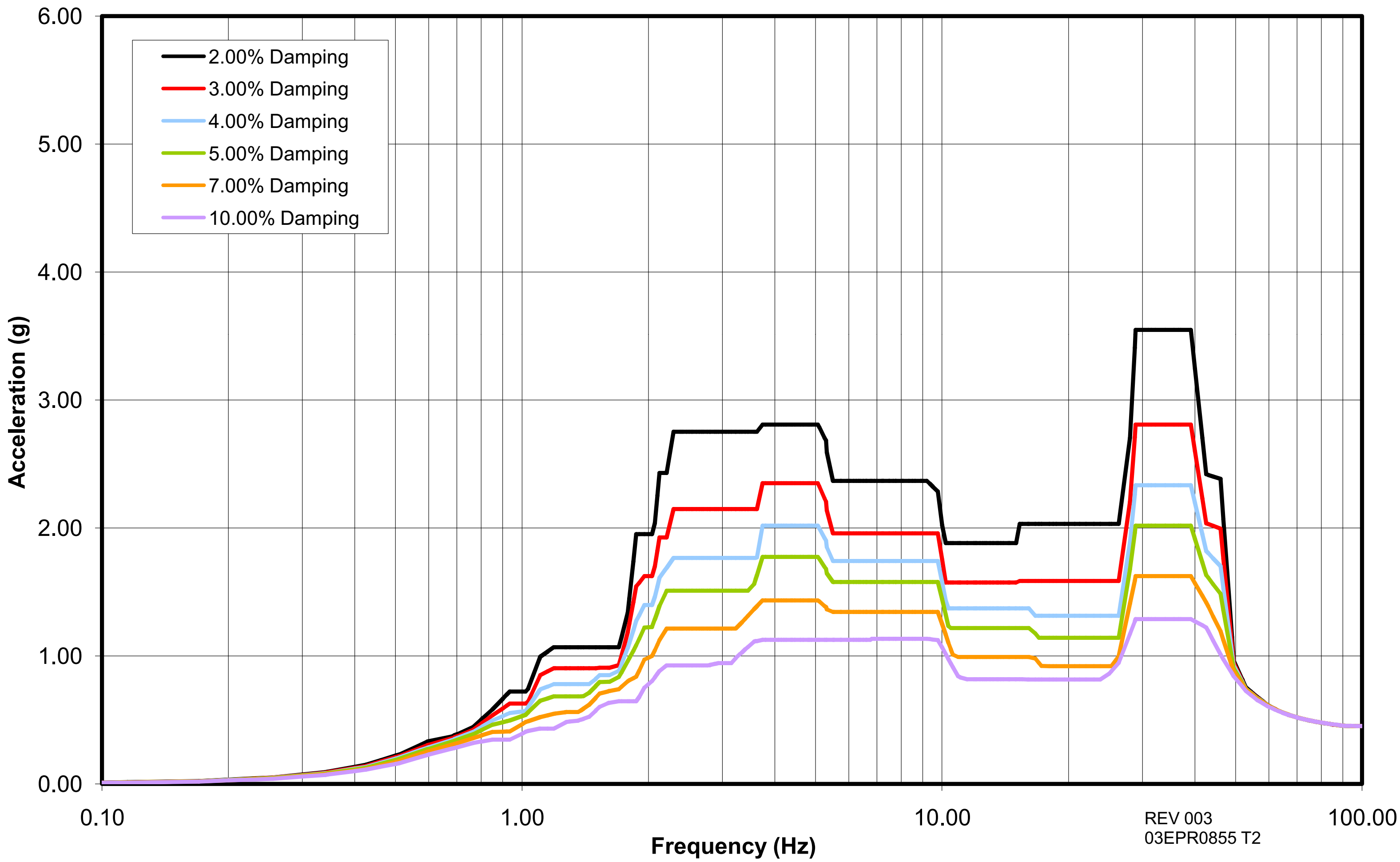


Figure 3.7.2-81—Spectrum Envelope of Safeguard Building 1 - Elev. +26 ft, 7 in (+8.10m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Y-Direction

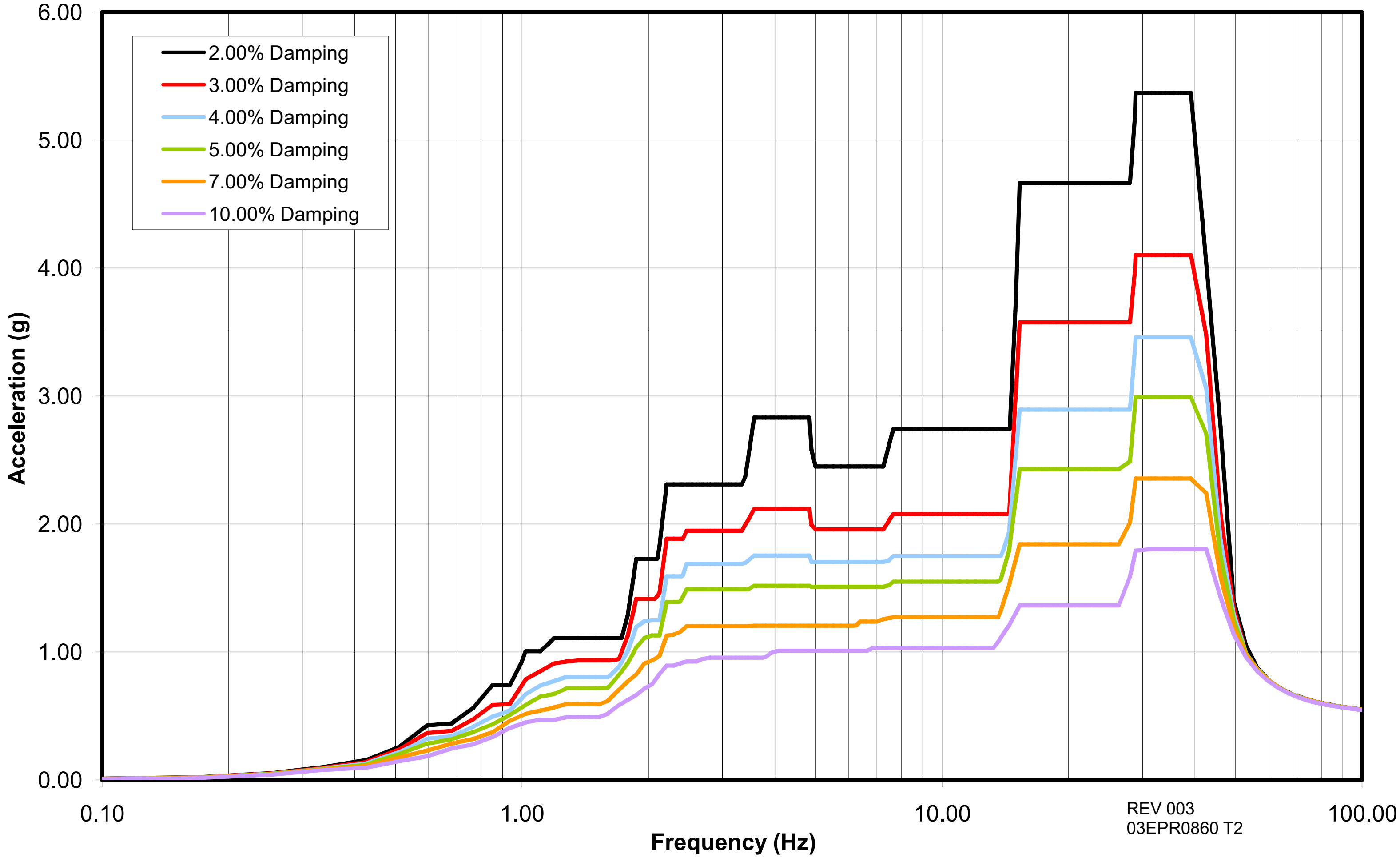


Figure 3.7.2-82—Spectrum Envelope of Safeguard Building 1 - Elev. +26 ft, 7 in (+8.10m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction

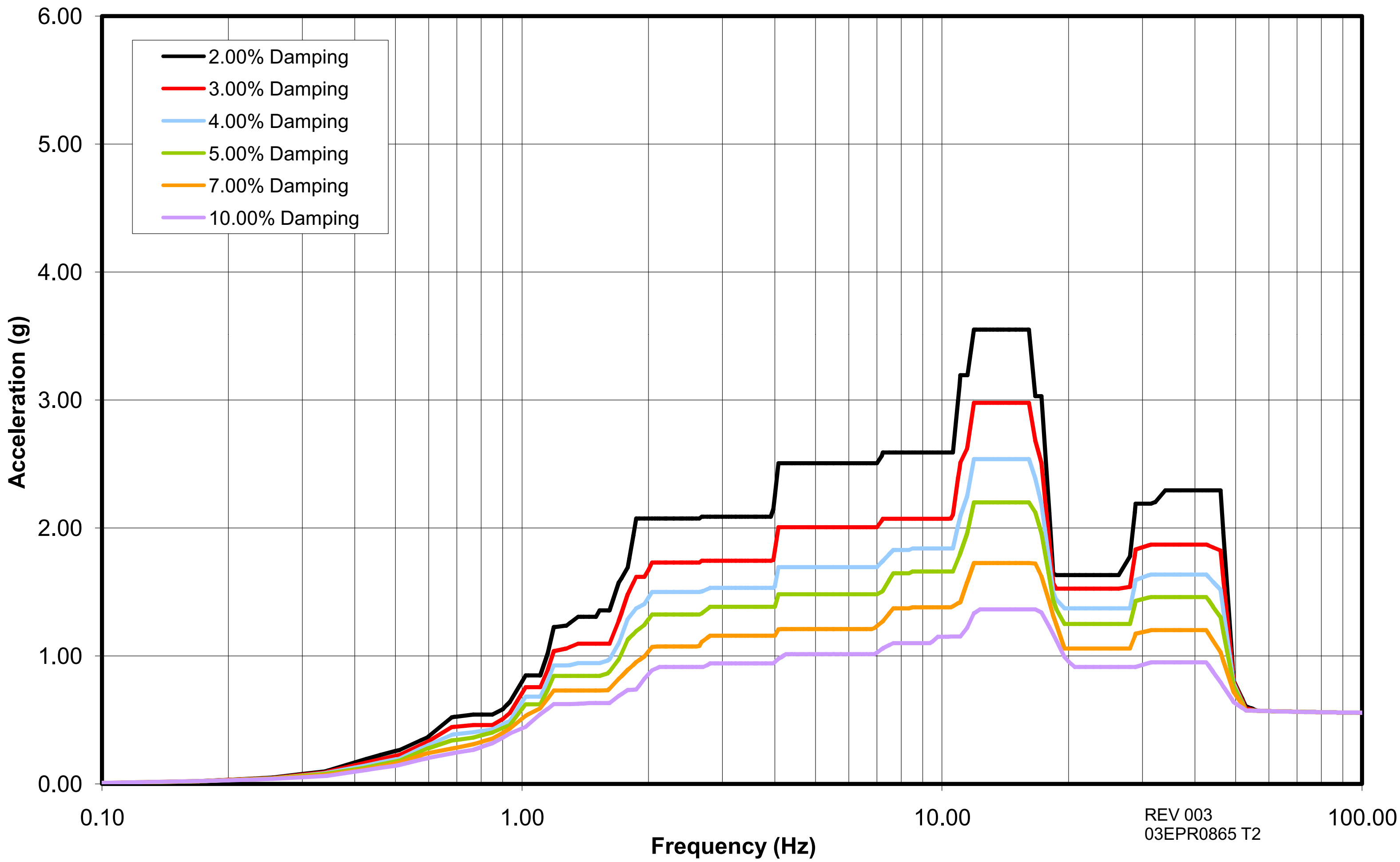


Figure 3.7.2-83—Spectrum Envelope of Safeguard Building 1 - Elev. +68 ft, 11 in (+21.00m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction

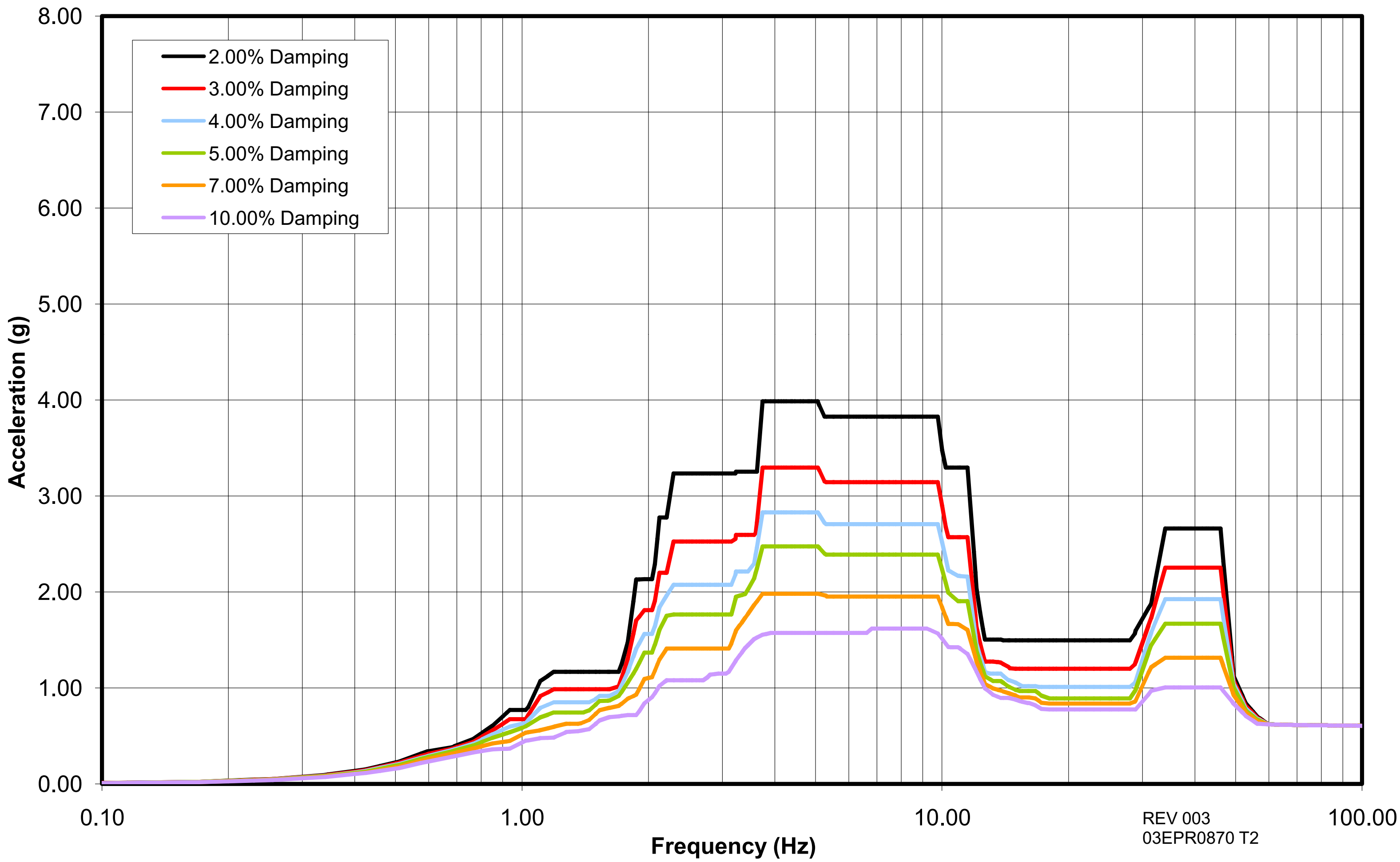


Figure 3.7.2-84—Spectrum Envelope of Safeguard Building 1 - Elev. +68 ft, 11 in (+21.00m) 2%, 3%, 4%, 5%, 7,% and 10% Damping, Y-Direction

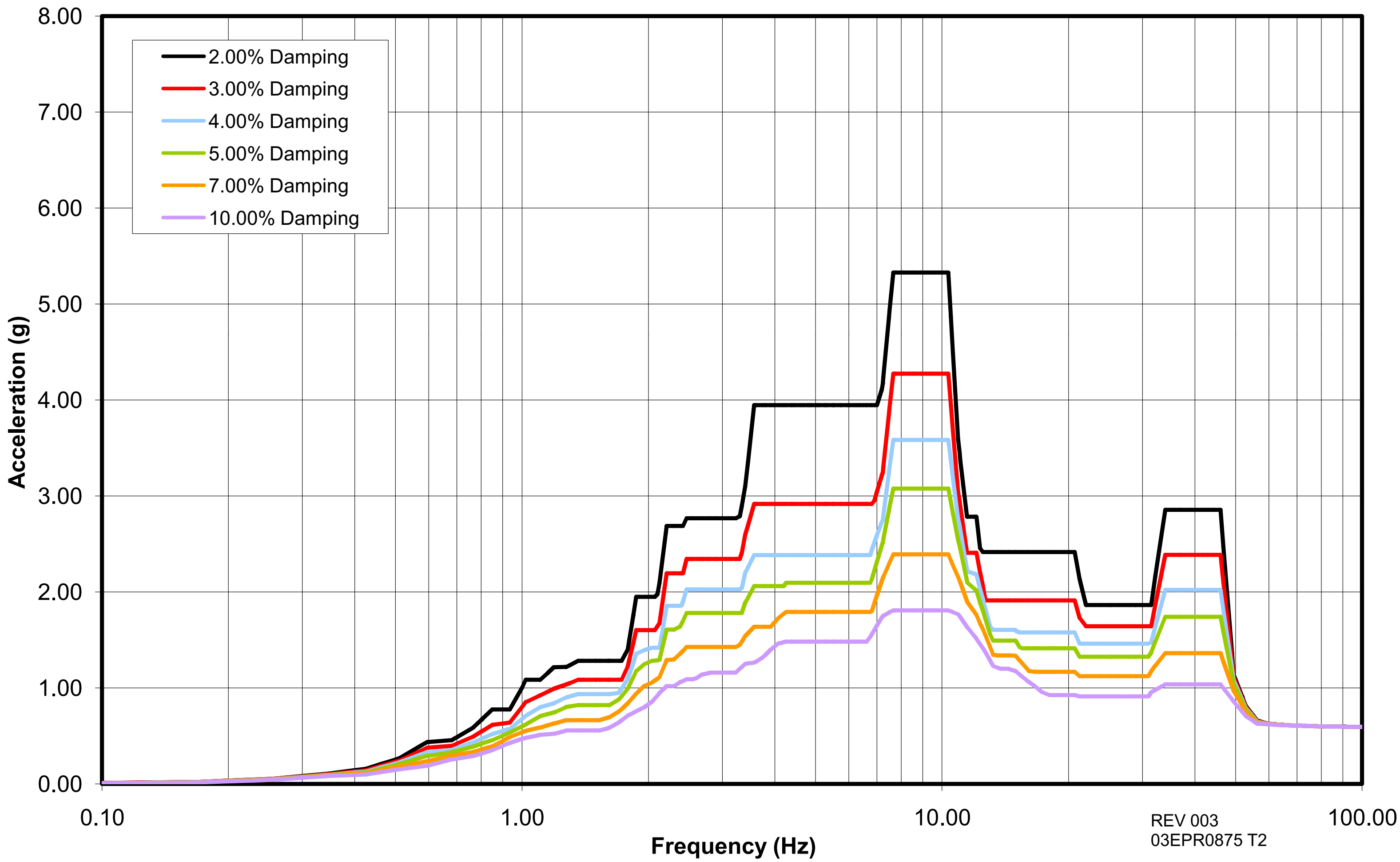


Figure 3.7.2-85—Spectrum Envelope of Safeguard Building 1 - Elev. +68 ft, 11 in (+21.00m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction

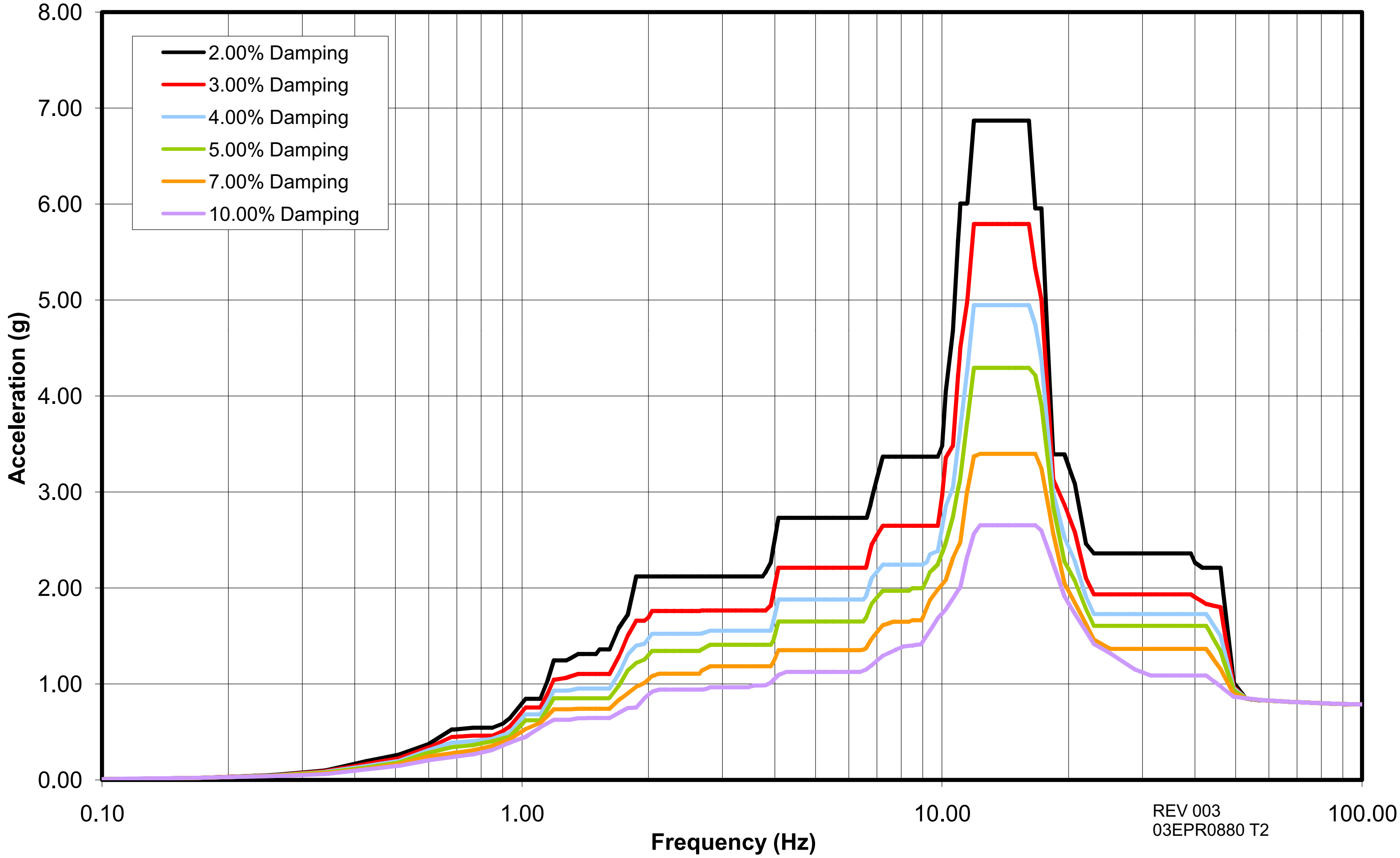


Figure 3.7.2-86—Spectrum Envelope of Safeguard Building 2&3 - Elev. +26 ft, 7 in (+8.10m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction

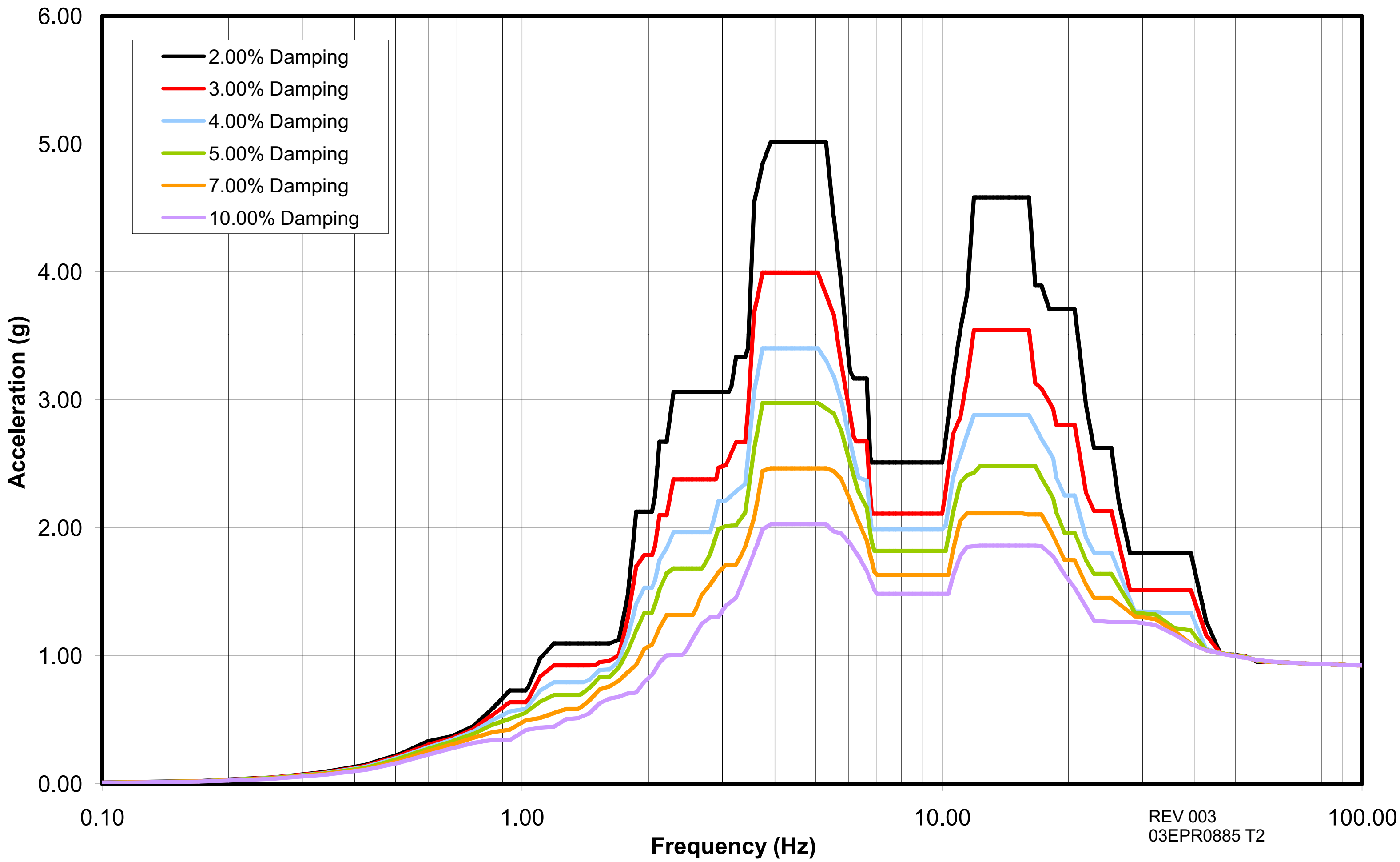


Figure 3.7.2-87—Spectrum Envelope of Safeguard Building 2&3 - Elev. +26 ft, 7 in (+8.10m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Y-Direction

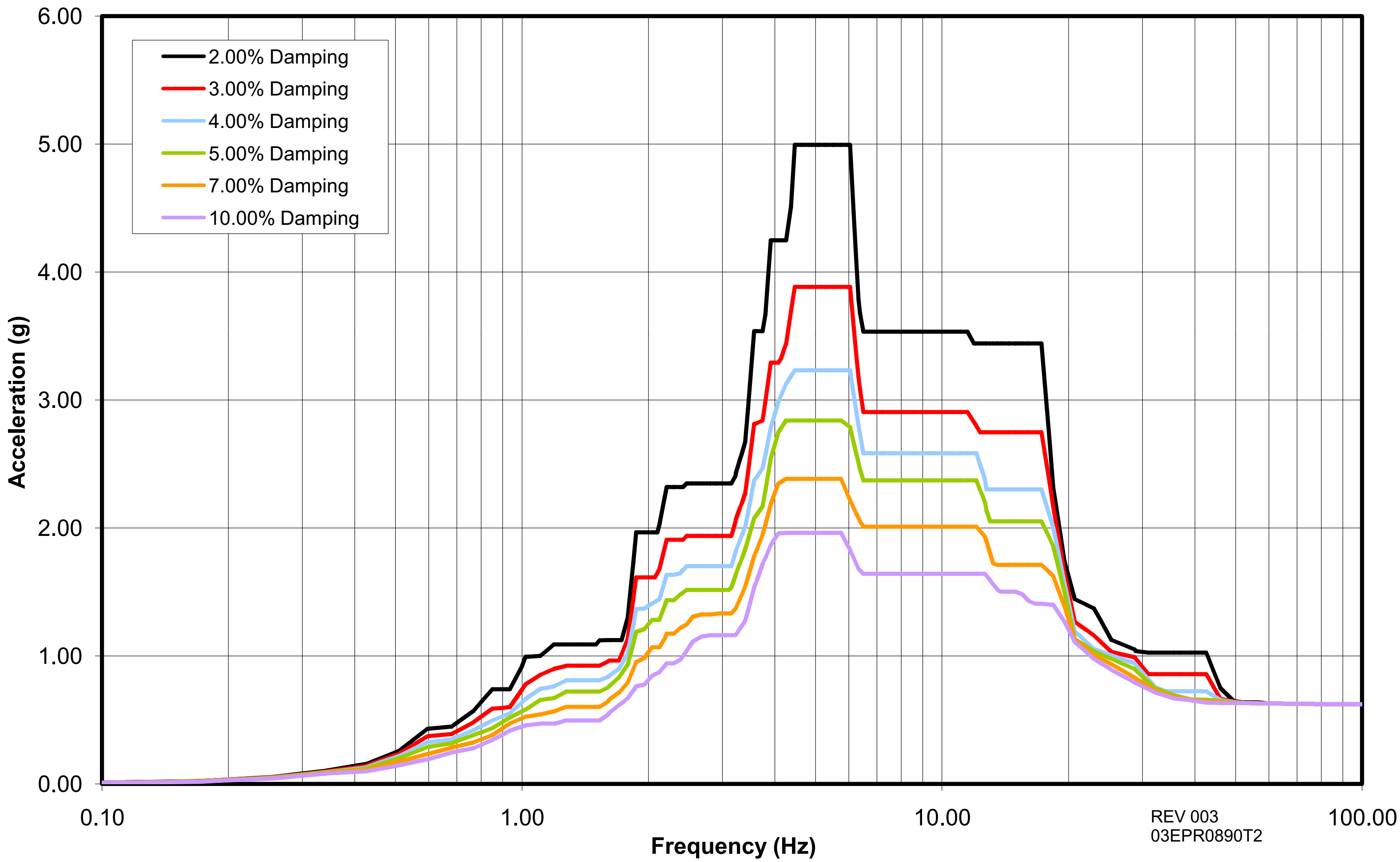


Figure 3.7.2-88—Spectrum Envelope of Safeguard Building 2&3 - Elev. +26 ft, 7 in (+8.10m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction

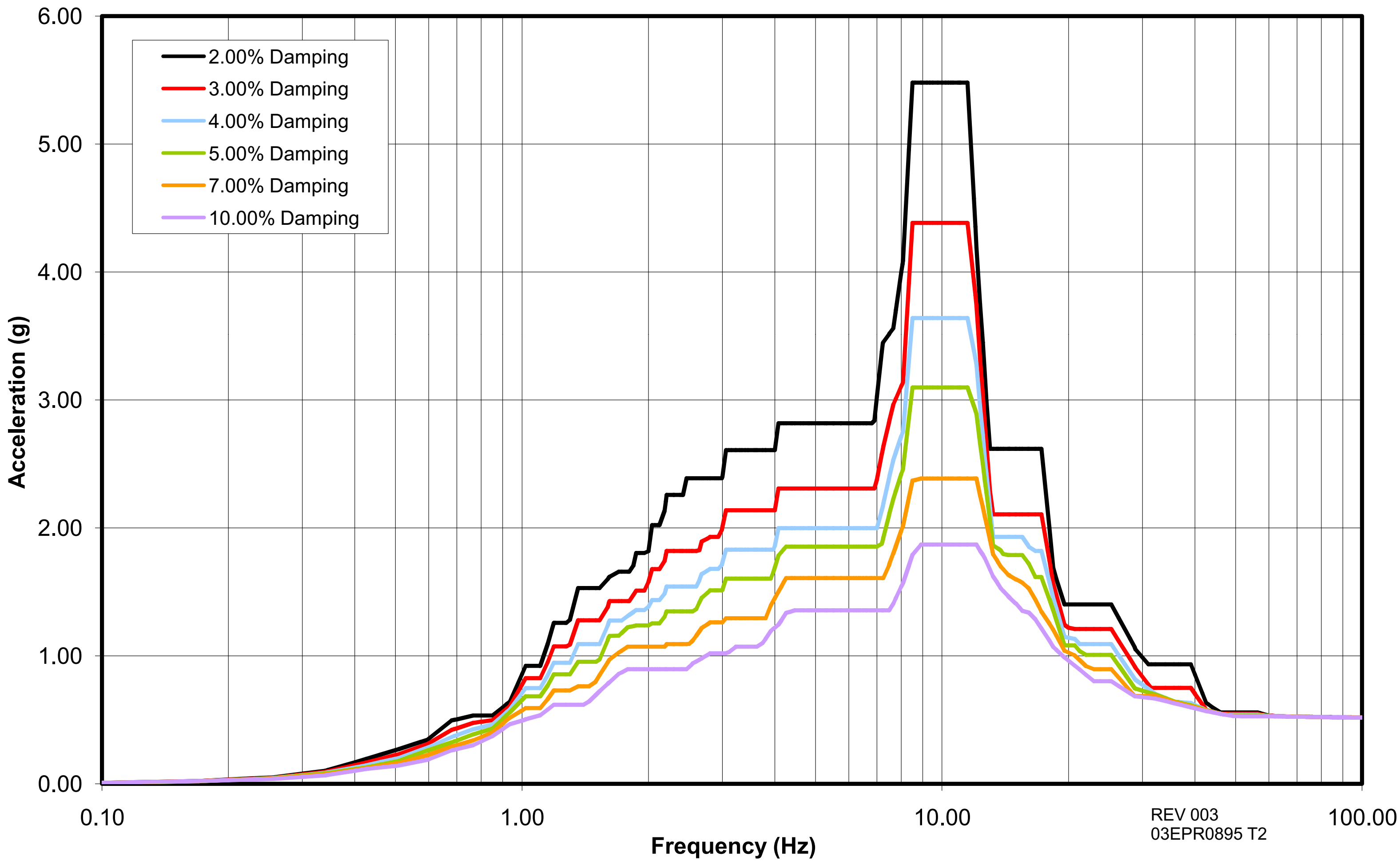


Figure 3.7.2-89—Spectrum Envelope of Safeguard Building 2&3 - Elev. +53 ft, 6 in (+16.30m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction

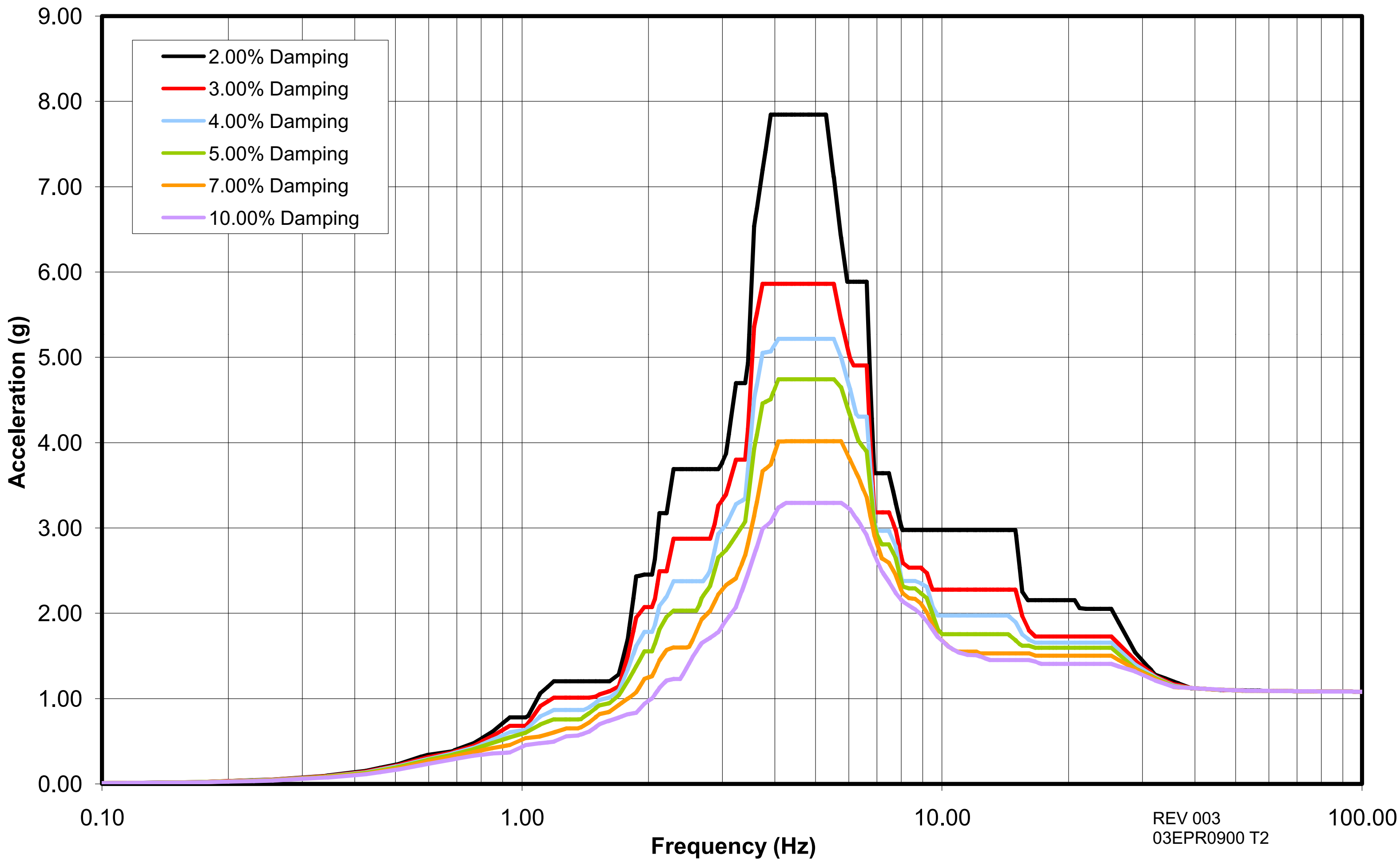


Figure 3.7.2-90—Spectrum Envelope of Safeguard Building 2&3 - Elev. +53 ft, 6 in (+16.30m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Y-Direction

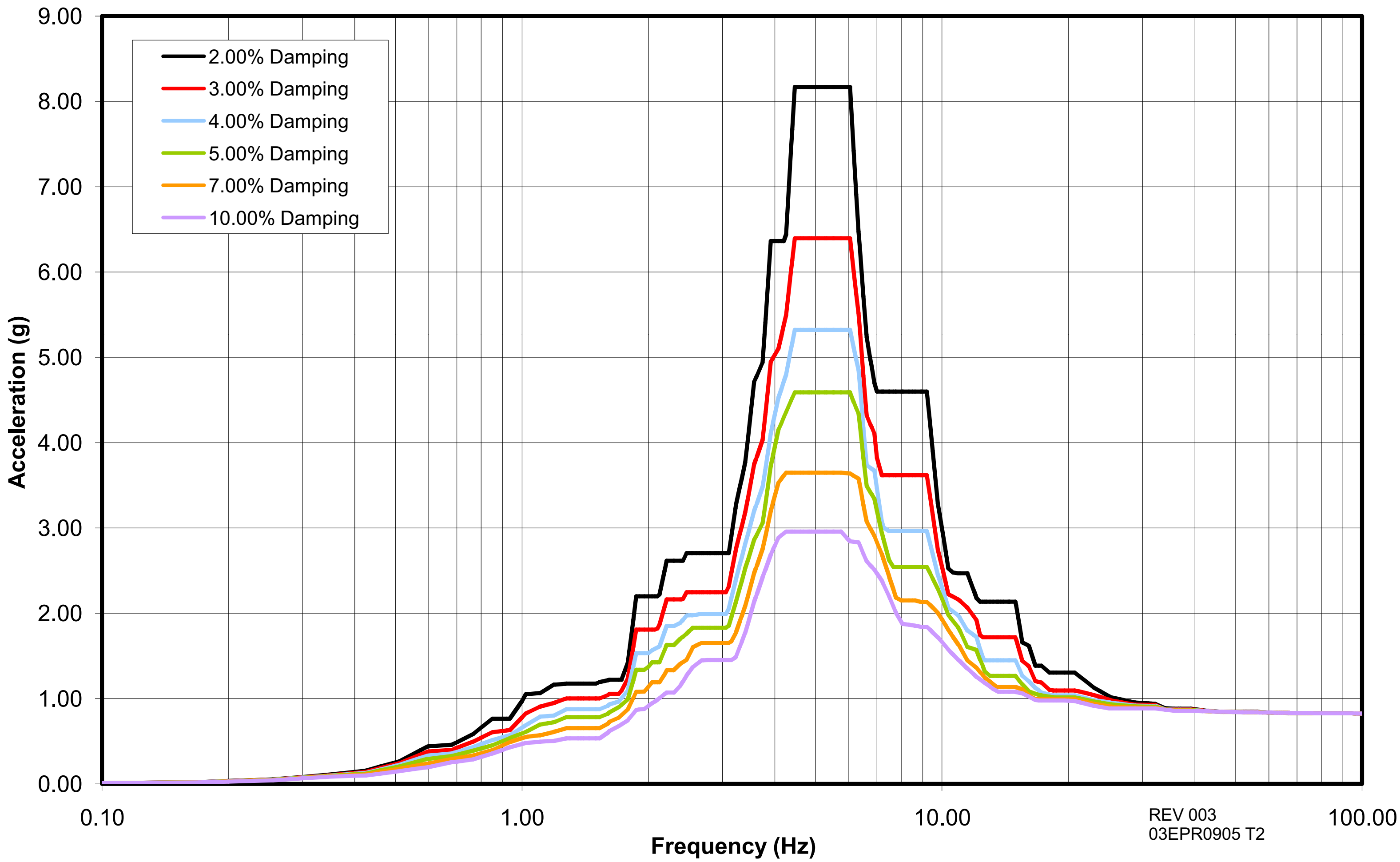


Figure 3.7.2-91—Spectrum Envelope of Safeguard Building 2&3 - Elev. +53 ft, 6 in (+16.30m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction

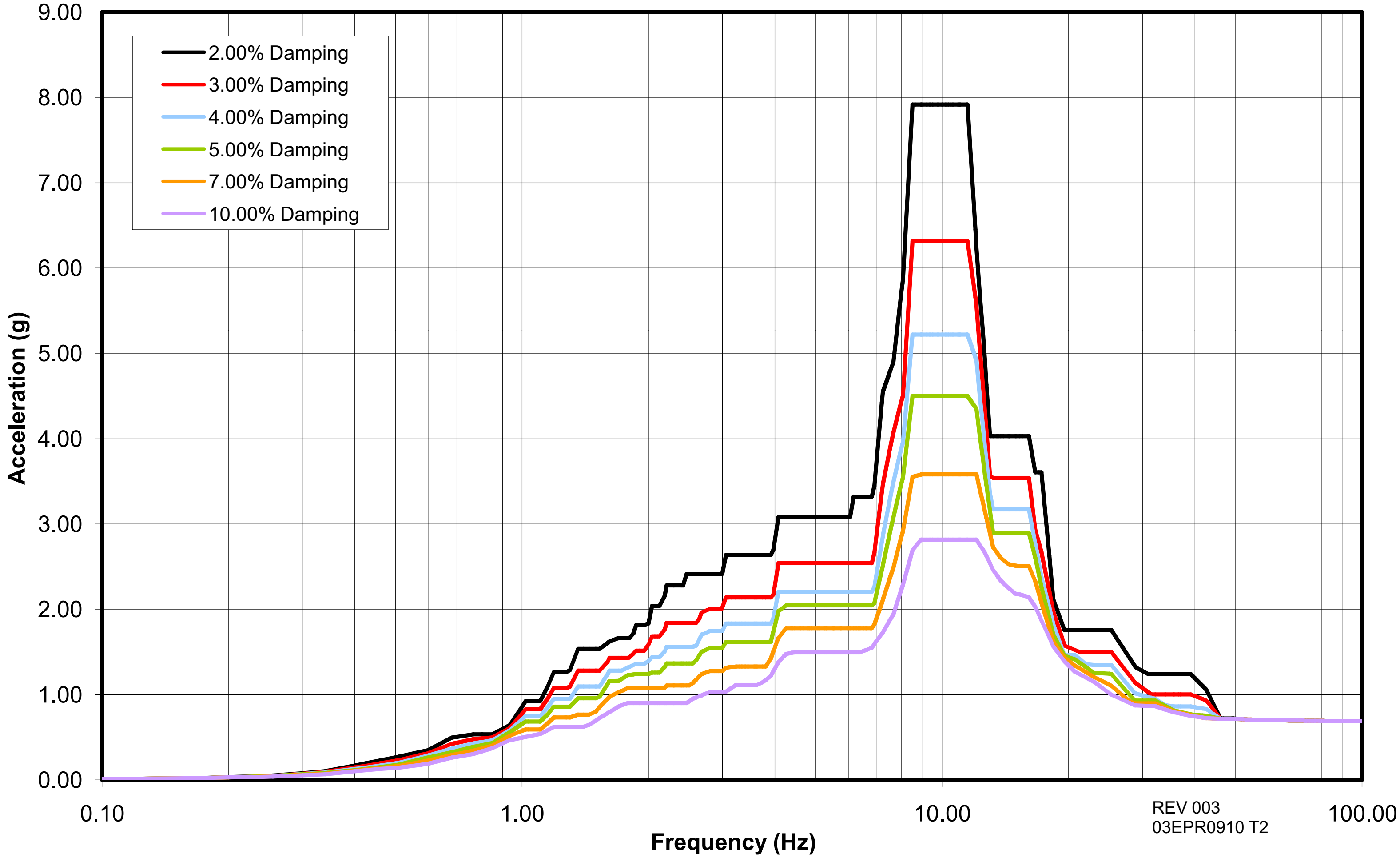


Figure 3.7.2-92—Spectrum Envelope of Safeguard Building 4 - Elev. +68 ft, 11 in (+21.00m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction

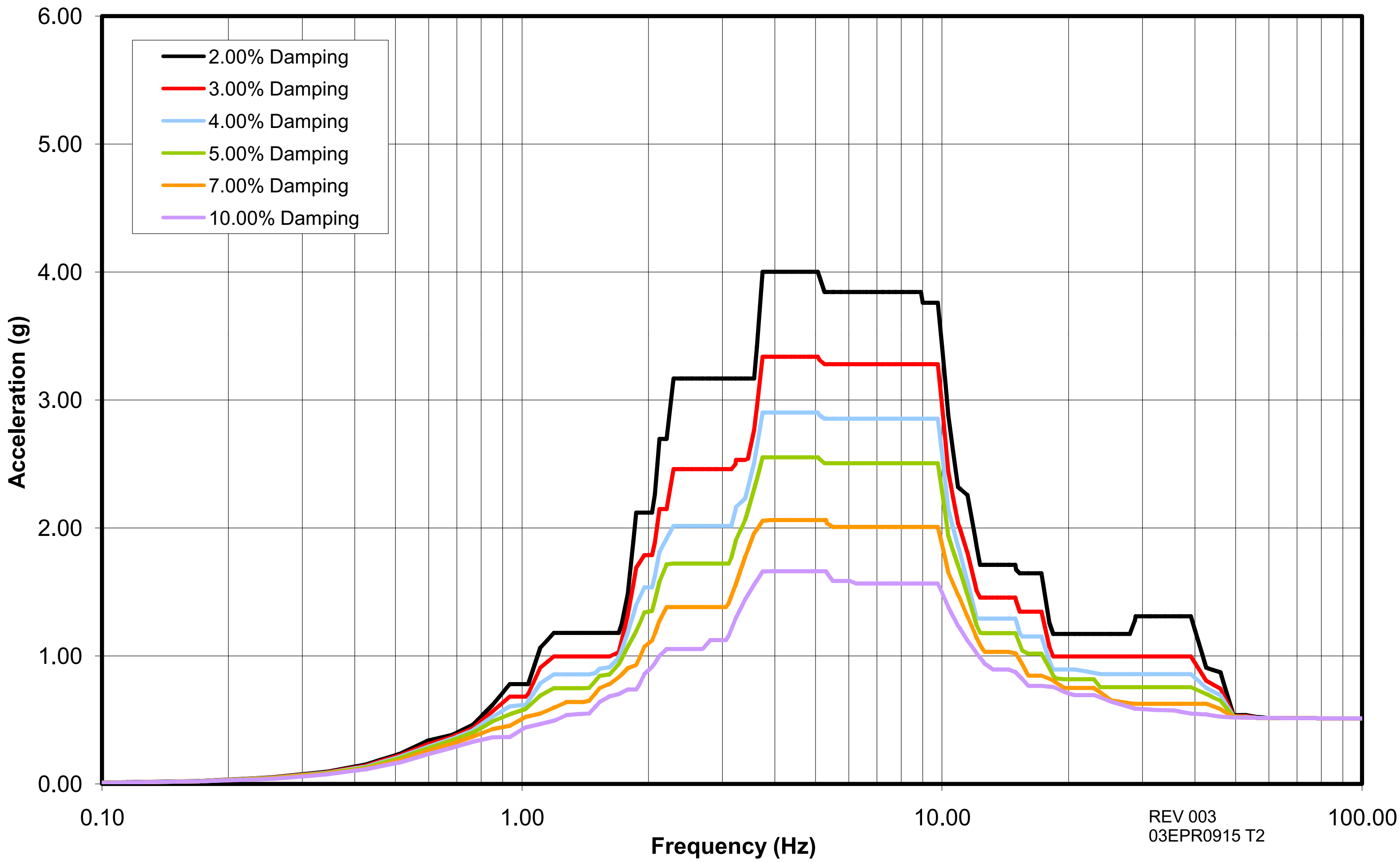


Figure 3.7.2-93—Spectrum Envelope of Safeguard Building 4 - Elev. +68 ft, 11 in (+21.00m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Y-Direction

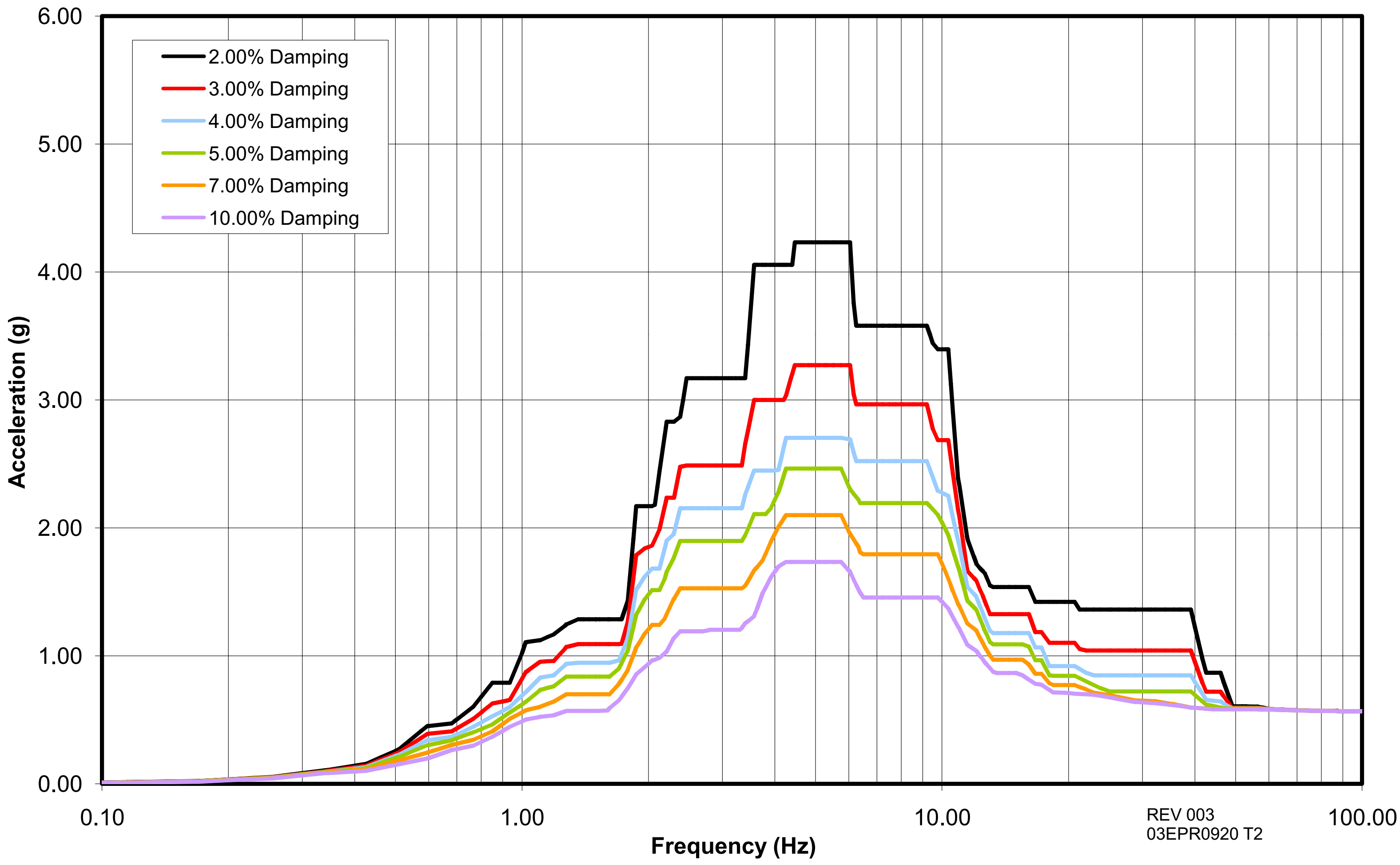


Figure 3.7.2-94—Spectrum Envelope of Safeguard Building 4 - Elev. +68 ft, 11 in (+21.00m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction

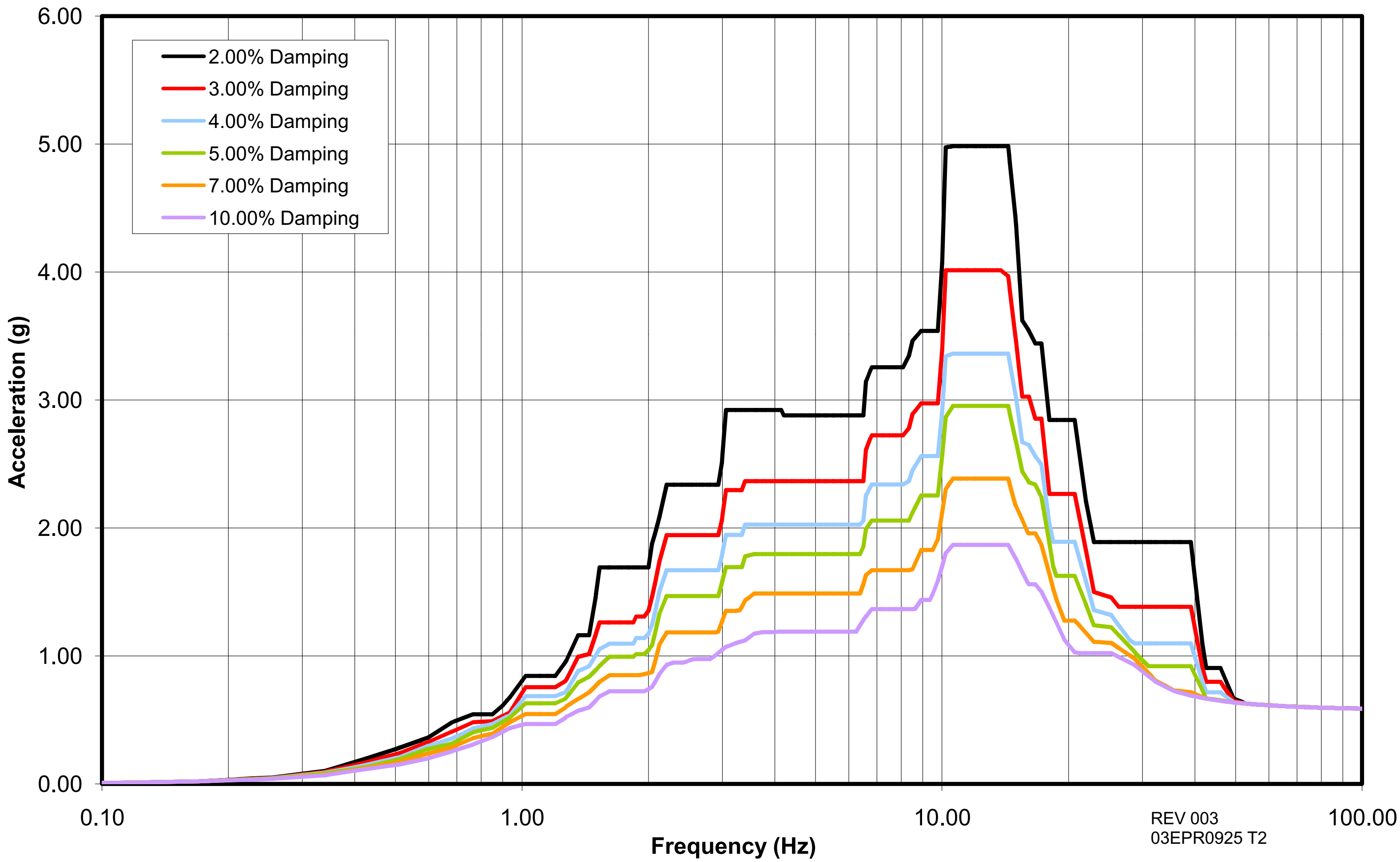


Figure 3.7.2-95—Spectrum Envelope of Containment Building - Elev. +123 ft, 4-1/4 in (+37.60m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction

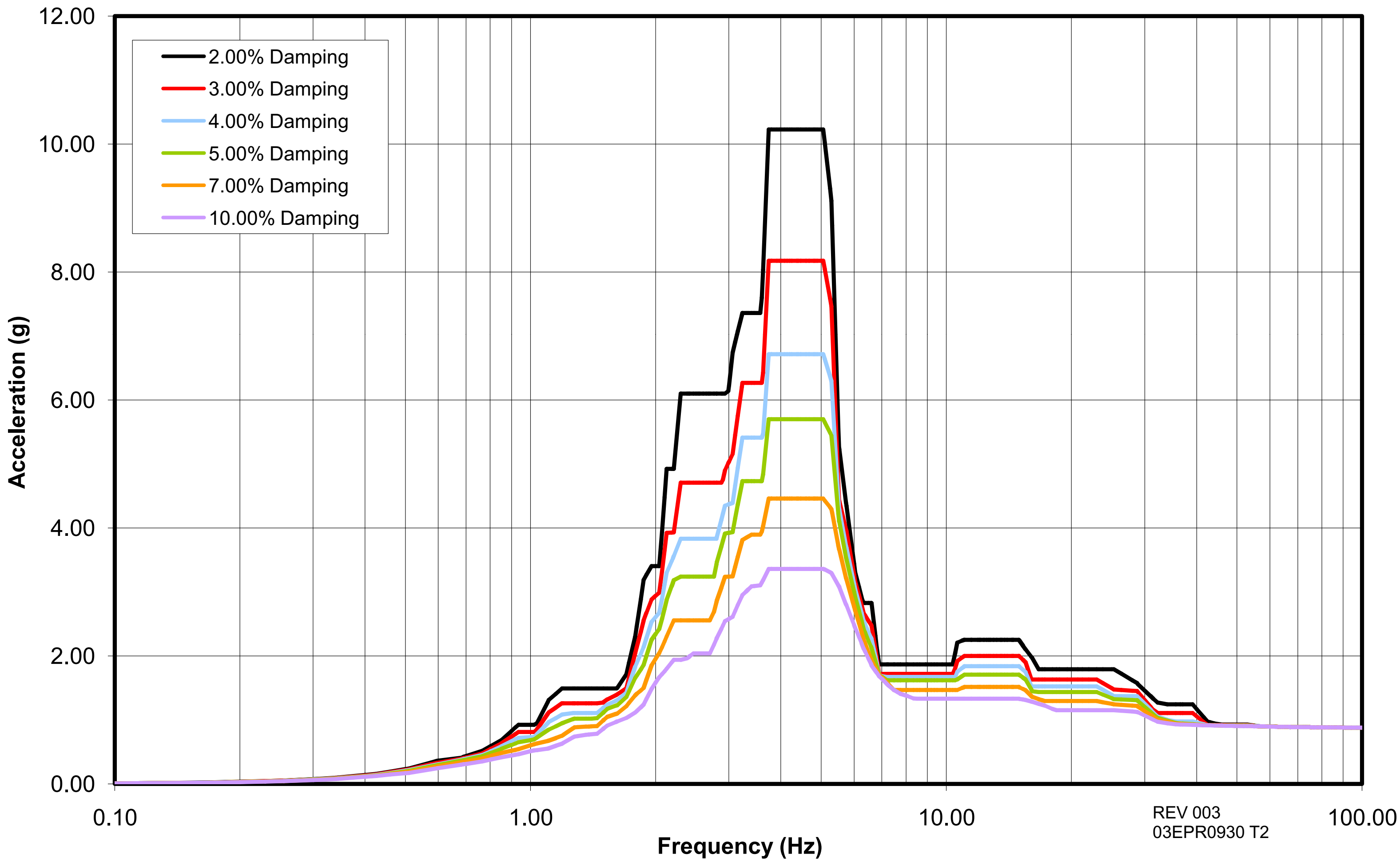


Figure 3.7.2-96—Spectrum Envelope of Containment Building - Elev. +123 ft, 4-1/4 in (+37.60m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Y-Direction

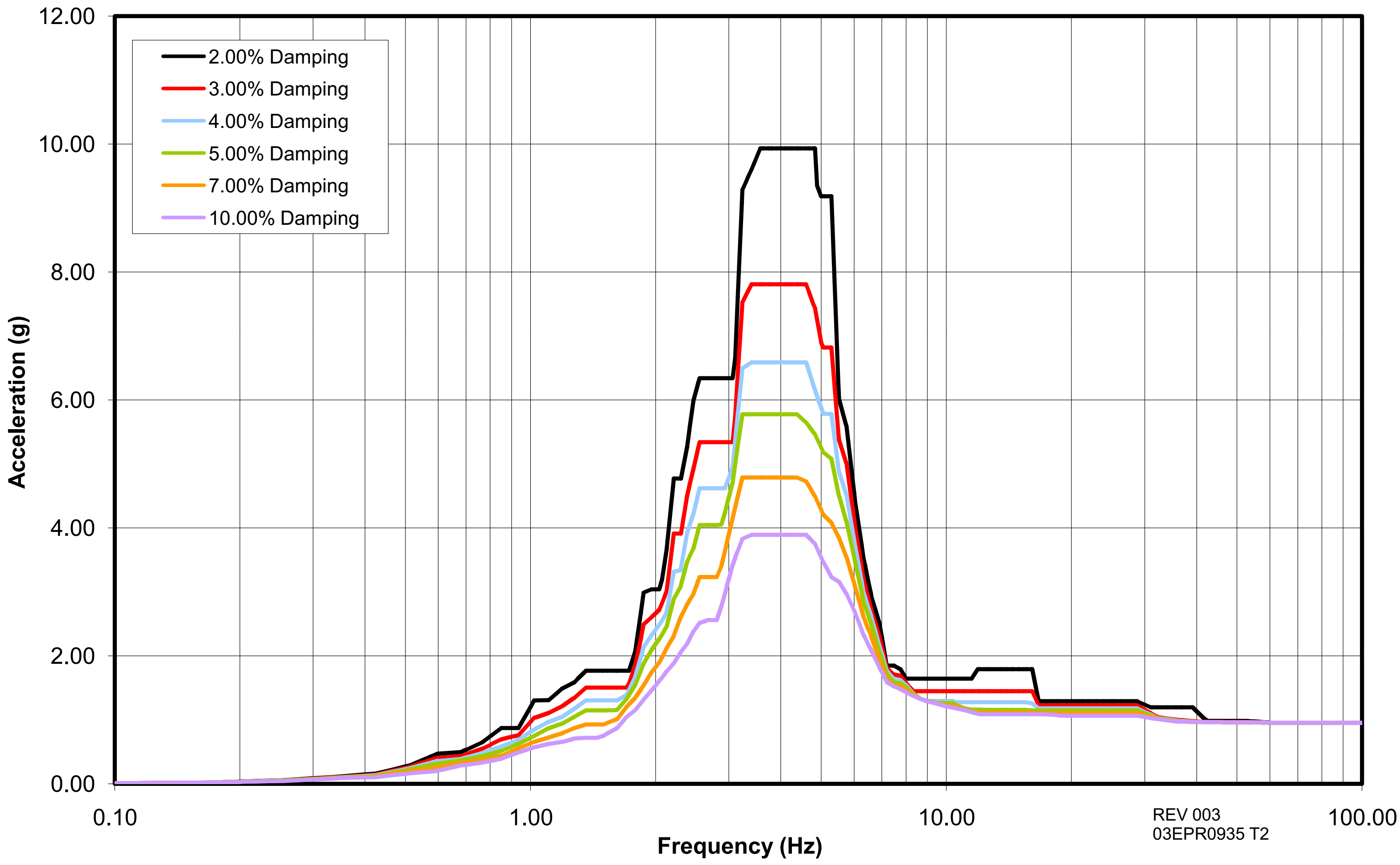


Figure 3.7.2-97—Spectrum Envelope of Containment Building - Elev. +123 ft, 4-1/4 in (+37.60m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction

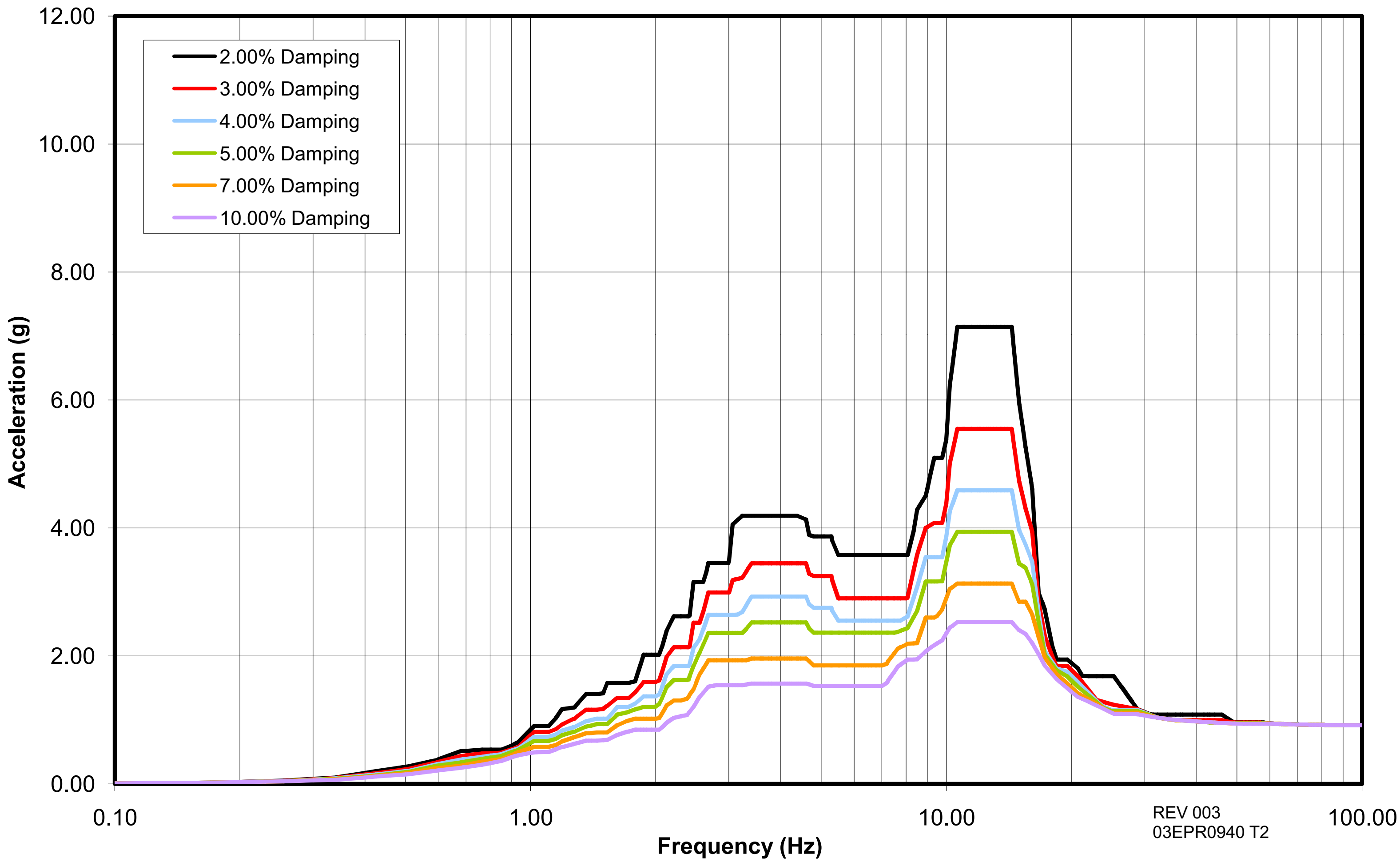


Figure 3.7.2-98—Spectrum Envelope of Containment Building - Elev. +190 ft, 3-1/2 in (+58.00m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction

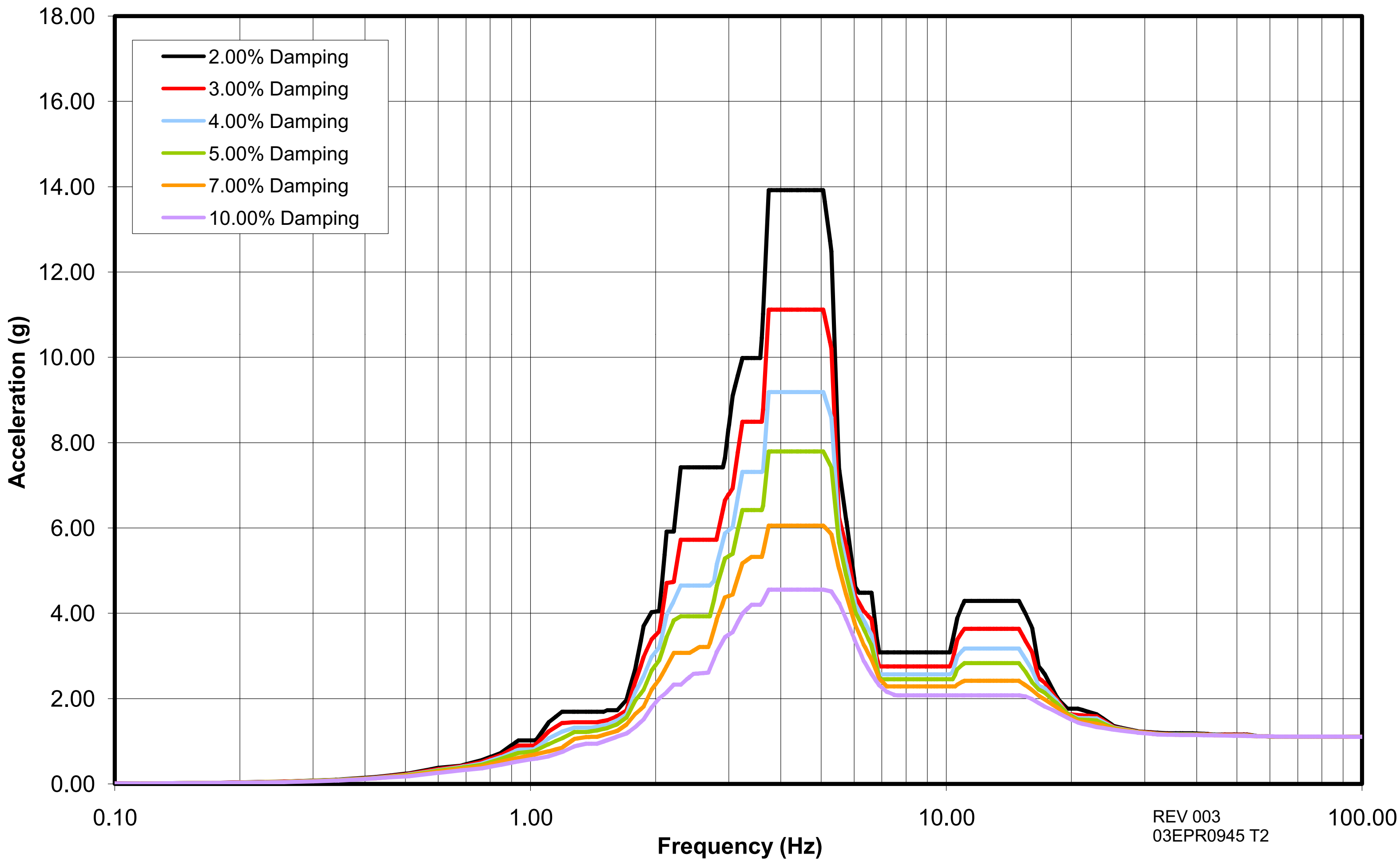


Figure 3.7.2-99—Spectrum Envelope of Containment Building - Elev. +190 ft, 3-1/2 in (+58.00m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Y-Direction

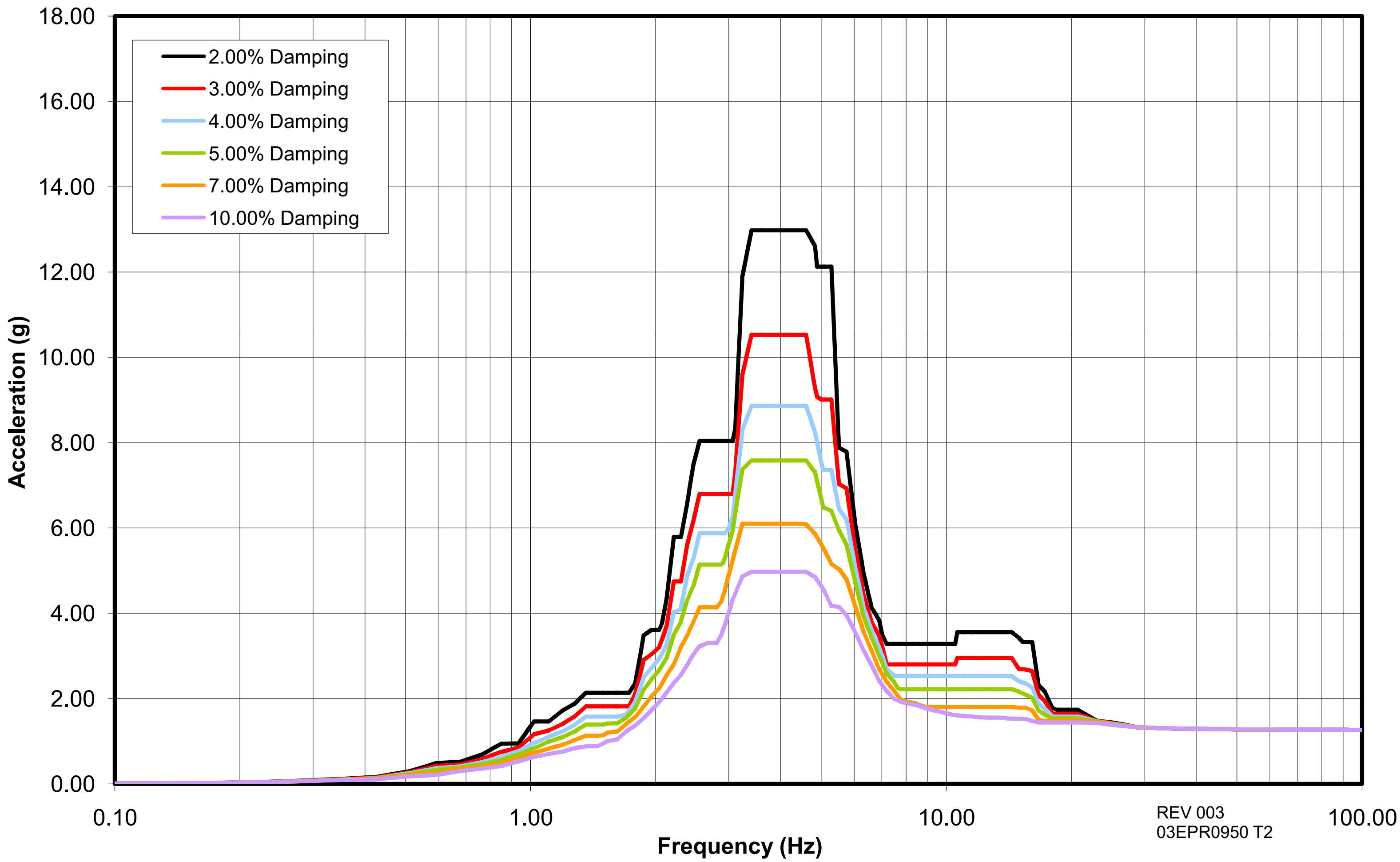


Figure 3.7.2-100—Spectrum Envelope of Containment Building - Elev. +190 ft, 3-1/2 in (+58.00m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction

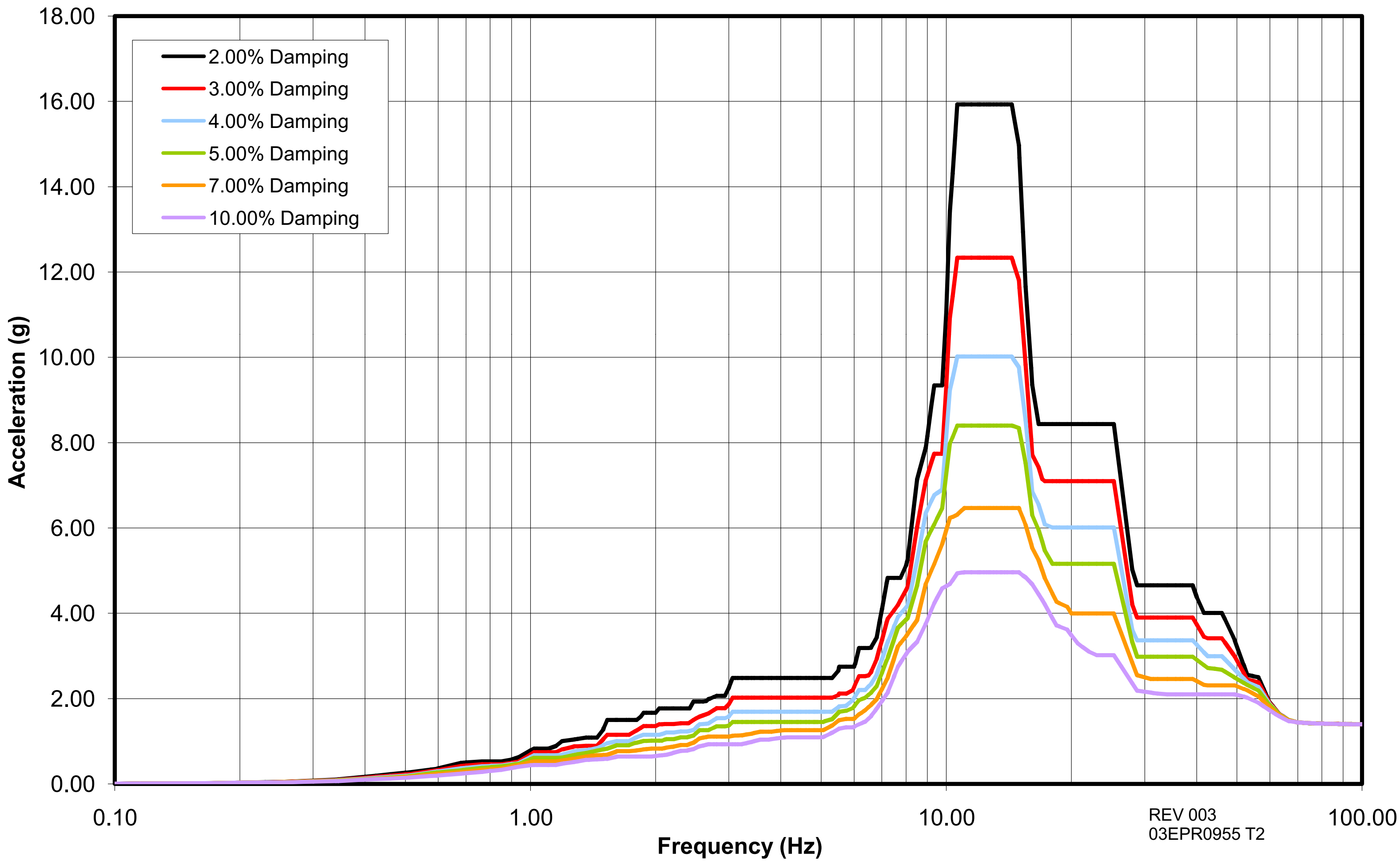


Figure 3.7.2-101—Spectrum Envelope of EPGB at the Center of Basemat - 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction

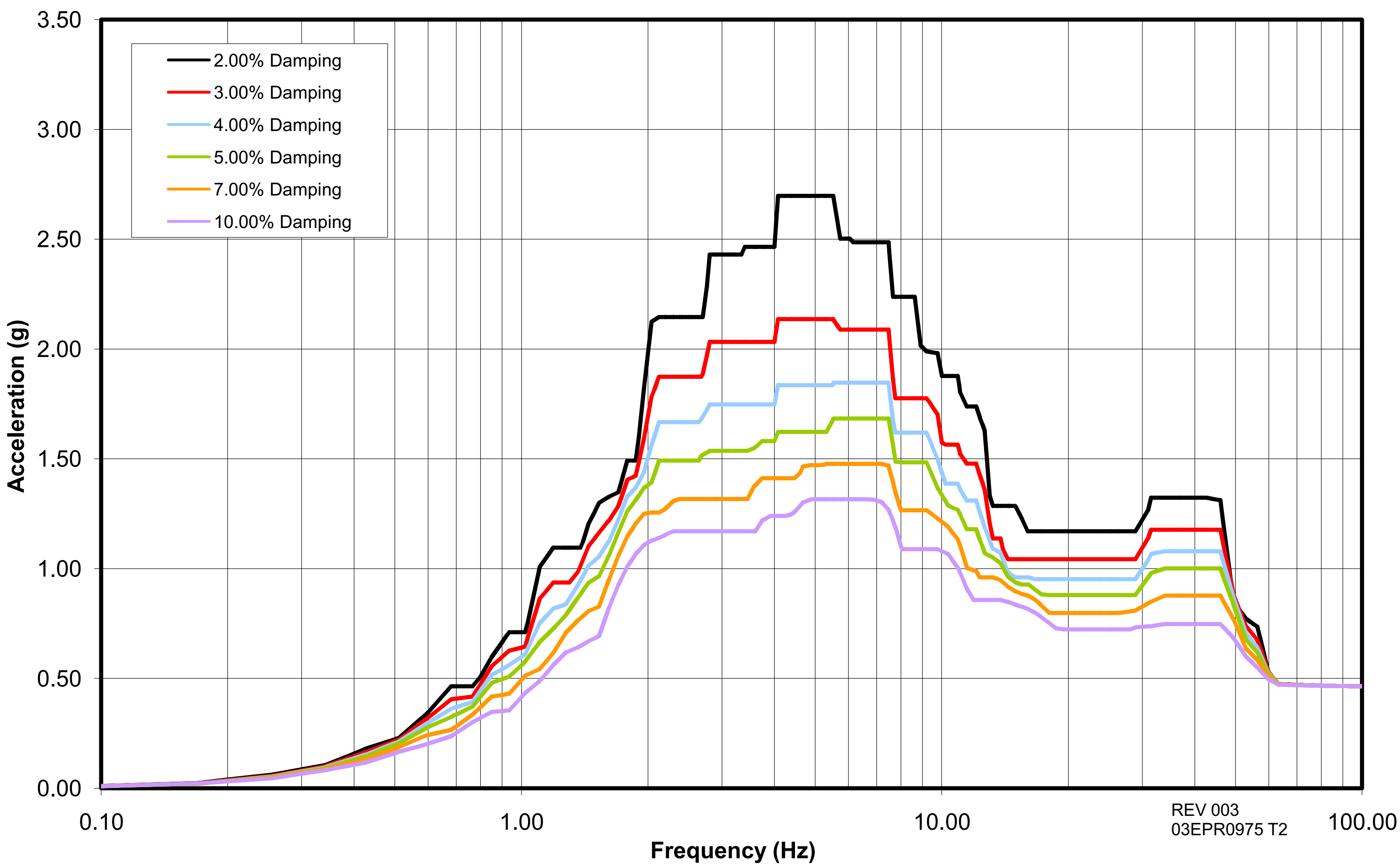


Figure 3.7.2-102—Spectrum Envelope of EPGB at the Center of Basemat - 2%, 3%, 4%, 5%, 7%, and 10% Damping, Y-Direction

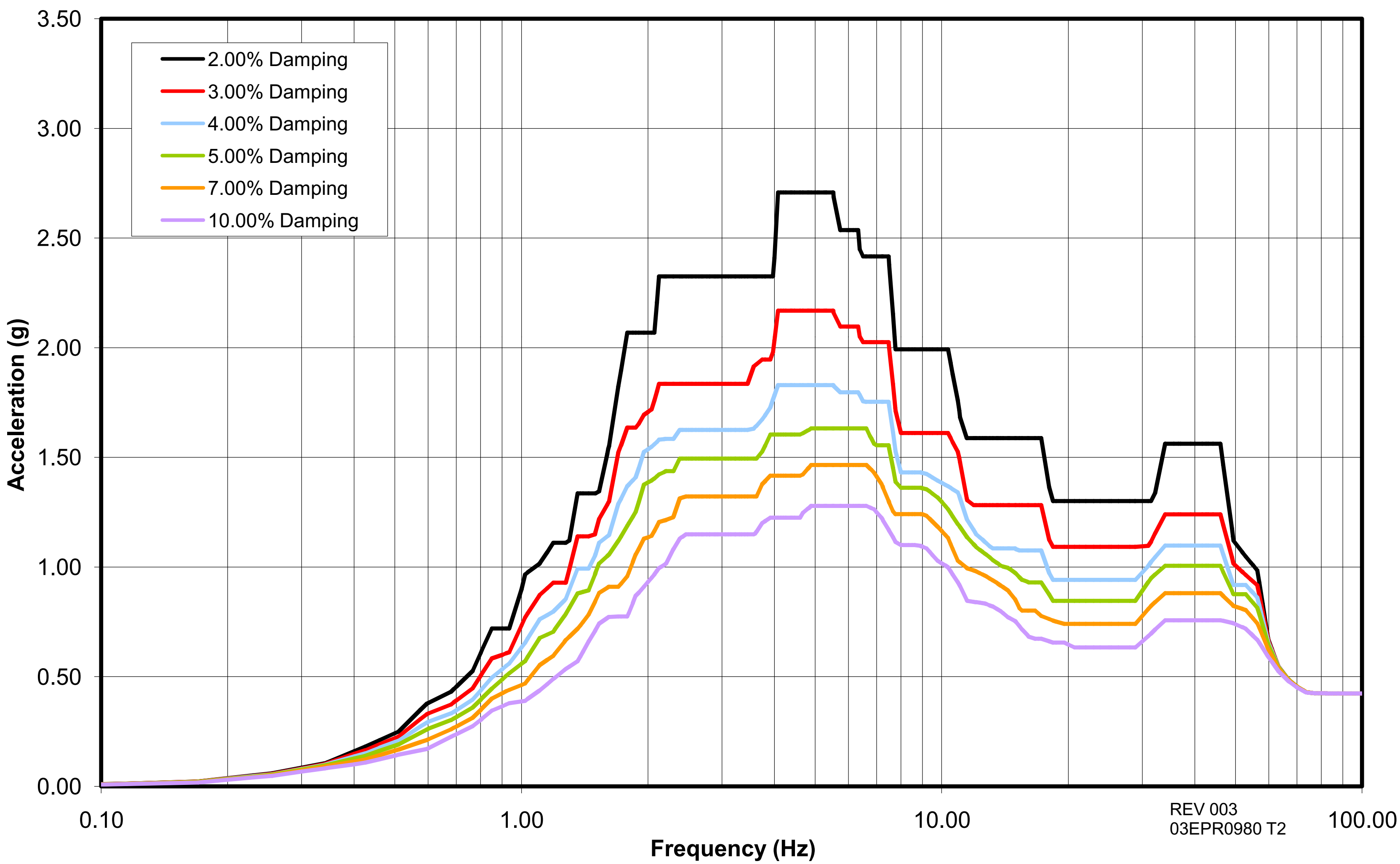


Figure 3.7.2-103—Spectrum Envelope of EPGB at the Center of Basemat - 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction

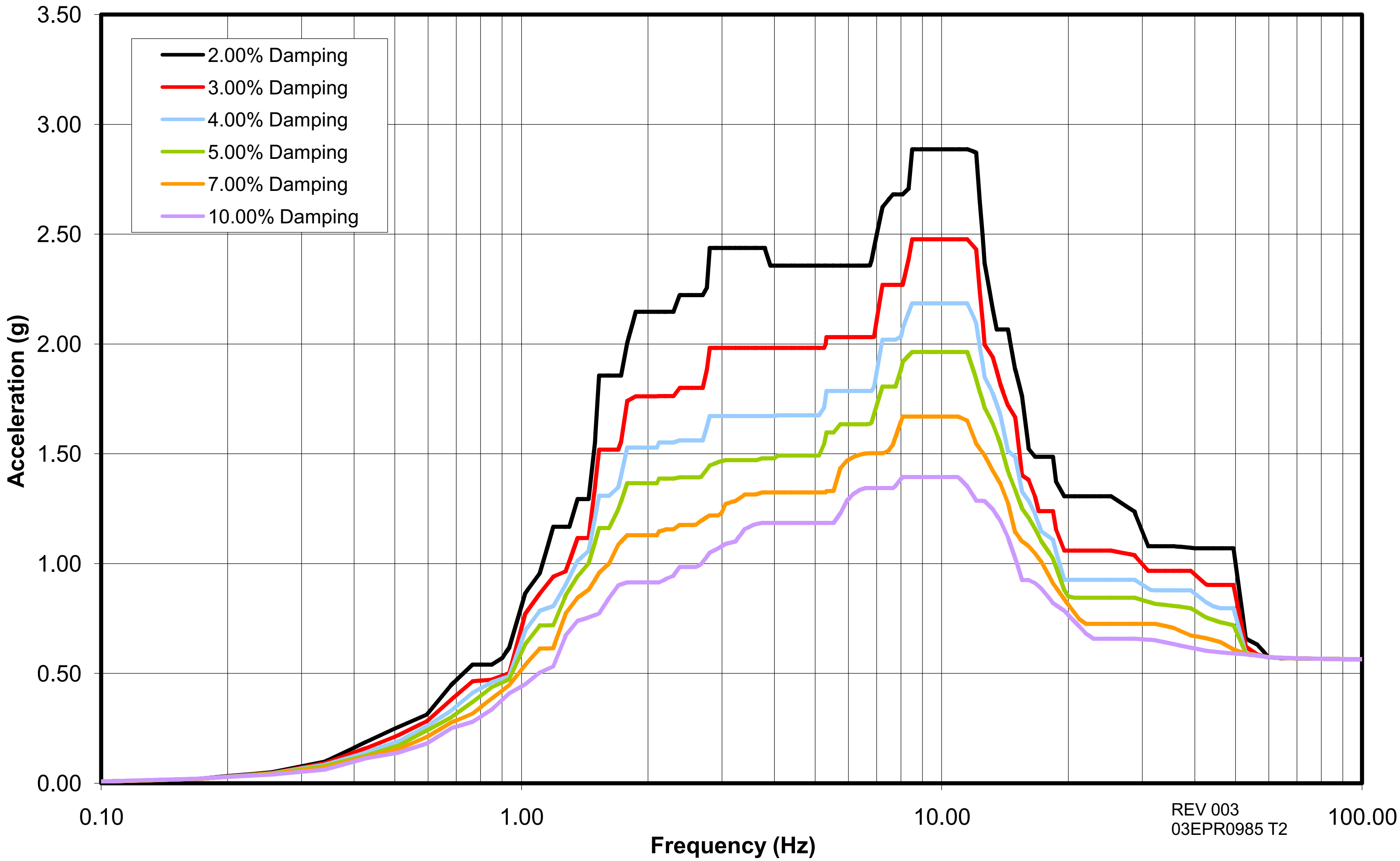


Figure 3.7.2-104—Spectrum Envelope of ESWB at Elev +63 ft, 0 in at Node 12733 - 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction

Will be provided later.

Figure 3.7.2-105—Spectrum Envelope of ESWB at Elev +63 ft, 0 in at Node 12733 - 2%, 3%, 4%, 5%, 7%, and 10% Damping, Y-Direction

Will be provided later.

Figure 3.7.2-106—Spectrum Envelope of ESWB at Elev +63 ft, 0 in at Node 12733 - 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction

Will be provided later.

Figure 3.7.2-107—Spectrum Envelope of ESWB at Elev +14 ft, 0 in at Node 10385 - 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction

Will be provided later.

Figure 3.7.2-108—Spectrum Envelope of ESWB at Elev +14 ft, 0 in at Node 10385 - 2%, 3%, 4%, 5%, 7%, and 10% Damping, Y-Direction

Will be provided later.

Figure 3.7.2-109—Spectrum Envelope of ESWB at Elev +14 ft, 0 in at Node 10385 - 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction

Will be provided later.

Figure 3.7.2-110—Spectrum Envelope of Fuel Building at Elev. +12 ft, 1-2/3 in (3.7 m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, X-Direction

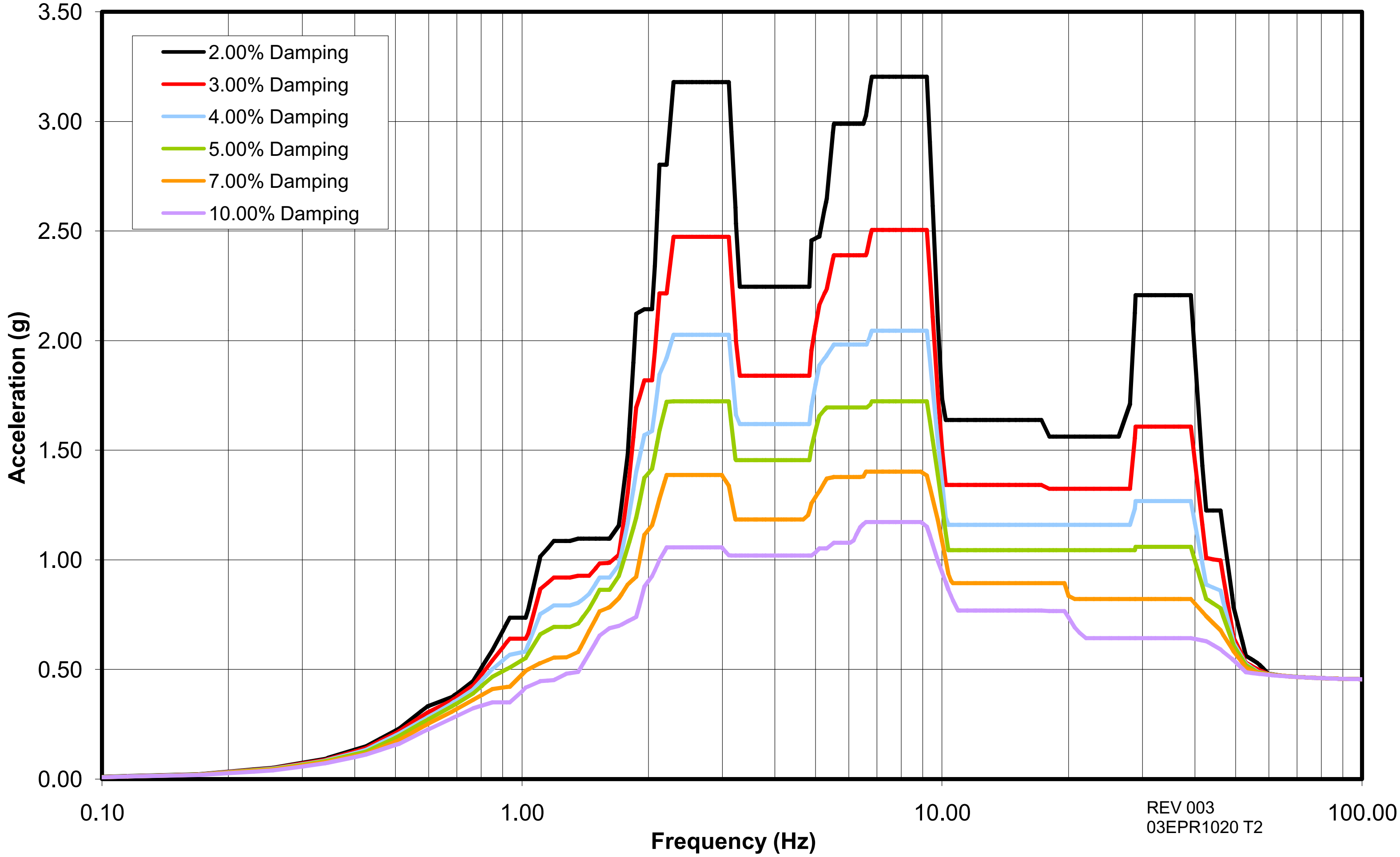


Figure 3.7.2-111—Spectrum Envelope of Fuel Building at Elev. +12 ft, 1-2/3 in (3.7 m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Y-Direction

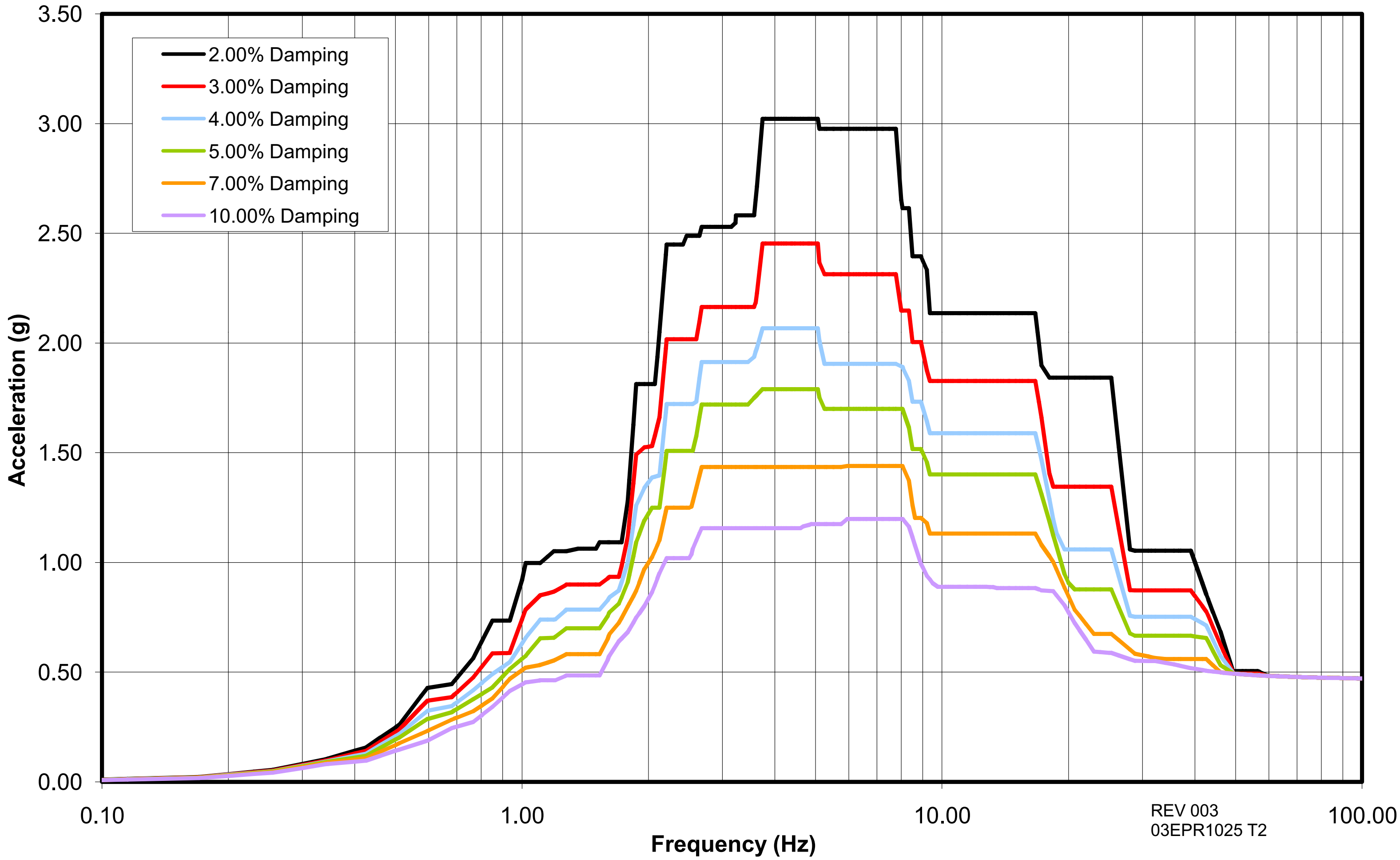


Figure 3.7.2-112—Spectrum Envelope of Fuel Building at Elev. +12 ft, 1-2/3 in (3.7 m) 2%, 3%, 4%, 5%, 7%, and 10% Damping, Z-Direction