3A Criteria for Distribution System Analysis and Support

This appendix provides the design criteria for the U.S. EPR distribution system analysis and supports. As noted in Section 3.7.3, this appendix describes criteria for design of supports for:

- Piping.
- Heating, ventilation, and air conditioning (HVAC) ducts.
- Cable trays.

3A.1 Piping and Supports

Information on piping, instrumentation, and supports is provided in AREVA NP Topical Report ANP-10264NP-A (Reference 1).

3A.2 Heating, Ventilation, and Air Conditioning Ducts and Supports

HVAC ductwork and its associated support structures are designed to withstand the loadings and load combinations presented in Section 3A.2.2 and Section 3A.2.3, based on the Codes and Standards provided in Section 3A.2.1. A typical HVAC duct system includes structural components (e.g., sheet metal ducts, duct stiffeners, duct supports) and inline components (e.g., heaters and dampers).

Safety-related, Seismic Category I HVAC ductwork, supports, and restraints meet the stress allowables provided in paragraph AA-4321 of ASME AG-1 (Reference 2). Seismic Category II HVAC ductwork, supports, and restraints are analyzed to make sure that a failure would not impair the safety function of safety-related equipment or components. Seismic Category II requirements are satisfied by meeting the criteria as established in Section 3.7.2.3.3.

Non-Seismic HVAC ductwork meets Sheet Metal and Air Conditioning Contractors National Association (SMACNA) standards (Reference 5). Non-Seismic HVAC ductwork support and restraint systems meet the analysis requirements of the American Institute of Steel Construction (AISC) Manual (Reference 3).

3A.2.1 Codes and Standards

HVAC ductwork, ductwork supports, and ductwork restraints conform to the following codes and standards:

- ASME AG-1, “Code on Nuclear Air and Gas Treatment” (Reference 2).
- AISC Manual of Steel Construction (Reference 3).

- American Iron and Steel Institute (AISI), North American Specification for the Design of Cold-Formed Steel Structural Members (Reference 4).
- SMACNA, HVAC Duct Construction Standards, Metal and Flexible (Reference 5).
- American Welding Society (AWS) D1.1/D1.1M, Structural Welding Code-Steel (Reference 6).
- AWS D1.3, Structural Welding Code – Sheet Steel (Reference 7).
- ANSI/AISC-N690, AISC "Specification for the Design, Fabrication, and Erection of Steel Safety-Related Structures for Nuclear Facilities" (Reference 8).

3A.2.2 HVAC Ductwork

3A.2.2.1 HVAC Ductwork Loads

The structural loads for the HVAC ductwork are listed below:

- Additional Dynamic Loads (ADL)—loads resulting from system excitations due to structural motion caused by safety relief valve actuation and other hydrodynamic loads due to the design basis accident (DBA), small pipe break accident (SBA), and intermediate pipe break accident (IBA); also, liquid slosh in tanks and vessels and mechanical shock loads.
- Constraint of Free End Displacement Loads (T)—loads caused by constraint of free end displacement that results from thermal or other movements.
- Dead Weight (DW)—weight of the equipment or ductwork including supports, stiffeners, insulation, any contained fluids, and internally and externally mounted components.
- Design Pressure Differential (DPD)—dynamic pressure loads resulting from a DBA, IBA, or SBA. Generally, HVAC is routed outside the local pipe break affected area. If HVAC is subjected to these loads, the design specification shall address the specific design requirements considering a Level D load combination.
- Design Wind Loads (W)—loads due to design hurricane, design tornado, or other abnormal meteorological conditions. See Section 3.3 for a discussion of design wind loads.
- External Loads (EL)—applied loads caused by attached piping, accessories, or other equipment.
- Fluid Momentum Loads (FML)—momentum and pressure forces because of fluid flow, as clarified in SA-4211 of ASME AG-1.
- Live Loads (L)—loads occurring during construction and maintenance and may also include loads due to snow, ice and ponded water. Live loads will not be less than a 250 lb construction or maintenance midspan man load over a 10 square inch area.

- Normal Operating Pressure Differential (NOPD)—maximum positive or negative differential pressure that may occur during normal plant operation including start-up and test conditions; this includes pressures resulting from normal airflow, and valve or damper closure.

  For ease of design, a duct system may be designed using one pressure value that envelops NOPD and SOPT. NOPD and SOPT may be positive or negative pressures. The worst case shall be considered in the design.

- Seismic Loads (SL)—Loads that are the result of the safe shutdown earthquake (SSE). Both orthogonal components of the horizontal seismic excitation are applied simultaneously with the vertical seismic loading. These seismic forces are applied in the directions that produce worst case stresses and deflections.

- System Operational Pressure Transient Loads (SOPT) – overpressure transient loads due to events such as rapid damper, plenum or housing door, and valve closure, or other normal loads that result in a short duration pressure differential.

  For ease of design, a duct system may be designed using one pressure value that envelops NOPD and SOPT. NOPD and SOPT may be positive or negative pressures. The worst case shall be considered in the design.

- Normal Loads (N) – loads consisting of normal operating pressure differential, system operating pressure transients, dead weight, external loads, and fluid momentum loads.

  N = NOPD + SOPT + DW + EL + FML

  As noted above for SOPT, if an enveloped pressure valve for NOPD and SOPT is utilized in the design, utilize the following load combination for Normal Loads:

  N = Envelop of (NOPD, SOPT) + DW + EL + FML

3A.2.2.2 HVAC Ductwork Load Combinations

Table 3A-1 lists the HVAC ductwork loading combinations for the design of HVAC ductwork.

3A.2.3 HVAC Duct Supports and Restraints

3A.2.3.1 HVAC Support and Restraint Loads

Loads ADL, DPD, DW, EL, FML, L, NOPD, SOPT, SL, T, and W (see Section 3A.2.2.1) apply to HVAC ductwork supports and restraints.

For HVAC ductwork supports and restraints, Normal Loads (N) = NOPD + SOPT + DW + EL + FM, or if an enveloped pressure value for NOPD and SOPT is utilized in the design, N = Envelop of (NOPD, SOPT) + DW + EL + FML.

3A.2.3.2 HVAC Support and Restraint Load Combinations

Table 3A-2 lists the HVAC support and restraint loading combinations for the design of HVAC supports and restraints.

3A.2.4 Design and Analysis

3A.2.4.1 Allowable Stress Criteria

Ductwork stresses are based on Reference 4. Ductwork support stresses are based on AISC "Specification for the Structural Steel Buildings - Allowable Stress Design and Plastic Design," contained in Reference 3.

The basic general membrane design stress for Service Level A condition does not exceed 0.6 S and is reduced as appropriate to account for lateral-torsional buckling of bending members and effective lengths of compression members. The combined membrane and bending stress for Service Level A does not exceed 1.5 x 0.6 S. The basic general membrane design stress allowable, and the combined membrane and bending stress allowable for Level B are the same as those for Level A. The basic general membrane stress for Service Level C condition does not exceed 1.2 x 0.6 S and is reduced as necessary to account for lateral-torsional buckling of bending members and effective lengths of compression members. The combined membrane and bending stress for Service Level C does not exceed 1.8 x 0.6 S. The basic general membrane design stress for Service Level D condition does not exceed the lesser of 1.5 x 0.6S or $0.4S_u$, where S_u is the ultimate stress. The combined membrane and bending stress for Service Level D does not exceed the lesser of 2.25 x 0.6S or $0.6S_u$.

3A.2.4.2 Deflection Limits

The allowable deflections for the load combinations described above are provided in Table 3A-3. Deflection criteria conform to Section SA-4230 of Reference 2.

3A.2.4.3 Damping

The damping values for the design of HVAC duct systems are discussed in Section 3.7.1.2 and are contained in Table 3.7.1-1.

3A.2.4.4 Seismic Analysis

This section describes the seismic analysis criteria for HVAC duct systems and their supports.

3A.2.4.4.1 Seismic Analysis Methods

Seismic analysis of HVAC duct system and associated supports is performed using dynamic analysis or the equivalent static load method. The dynamic analysis procedures include the response spectrum method and time history method as discussed in Section 3.7.3.1.1 and Section 3.7.3.1.2 respectively. The equivalent static load method, as described in Section 3.7.3.1.4, may be used for simple systems such as straight run ducts with uniformly spaced supports or subsystems that can be represented as simple frames.

3A.2.4.4.2 Determination of Number of Earthquake Cycles

Section 3.7.3.2 discusses the required number of earthquake cycles to be considered for seismic-induced fatigue. Rolled structural steel members for HVAC supports may be qualified for fatigue by evaluation in accordance with the provisions of ANSI/AISC N690 (Reference 8). Cold-formed members for HVAC supports may be qualified for fatigue by evaluation in accordance with the provisions of American Iron and Steel Institute (AISI), North American Specification for the Design of Cold-Formed Steel Structural Members (Reference 4). Connections for structural steel members are qualified by cyclic testing for the number of earthquake cycles specified in Section 3.7.3.2 Similarly, hardware components used to connect cold-formed members are also qualified by cyclic testing for the number of earthquake cycles specified in Section 3.7.3.2.

3A.2.4.4.3 Analytical Modeling Procedures

The modeling guidelines for accurate representation of duct systems and supports are presented in Section 3.7.3.3. The design of HVAC duct system is generally controlled by two failure modes: duct sheet failure by corner crippling and stiffener failure by buckling.

The response of the ductwork in the global bending mode is determined by modeling the duct section as an equivalent beam. The section modulus for rectangular HVAC ducts is reduced by determining an effective duct corner length; however, the entire section is considered effective for round HVAC ducts. The ductwork panels, including the stiffeners, may be modeled using shell elements to simulate the local yielding behavior, which occurs as sheet crippling or stiffener buckling. The local inelastic behavior is usually eliminated by proper selection of duct aspect ratio and stiffener spacing facilitating linear analysis of the subsystem.

3A.2.4.4.4 Basis for Selection of Frequencies

Refer to Section 3.7.3.4.

3A.2.4.4.5 Analysis Procedure for Damping

Refer to Section 3.7.3.5 for analysis procedure for damping. The damping criterion is further described in Section 3A.2.4.3.

3A.2.4.4.6 Three Components of Earthquake Motion

Refer to Section 3.7.3.6.

3A.2.4.4.7 Combination of Modal Responses

Refer to Section 3.7.3.7.

3A.2.4.4.8 Interaction of Other Systems with Seismic Category I Systems

Refer to Section 3.7.3.8.

3A.2.4.4.9 Multiply-Supported Equipment and Components with Distinct Inputs

Refer to Section 3.7.3.9.

3A.2.4.4.10 Use of Equivalent Vertical Static Factors

Refer to Section 3.7.3.10.

3A.2.4.4.11 Torsional Effects of Eccentric Masses

Refer to Section 3.7.3.11.

3A.2.5 Other Criteria

3A.2.5.1 Vibration Isolation

The vibration isolation equipment restraints resist the loads generated by any service condition.

3A.2.5.2 Relative Movement

Clearances are provided that allow for relative movement between equipment, ductwork, and supports.

3A.2.5.3 Tolerances

Fabrication tolerances comply with Subarticle SA-6400, of Reference 2.

3A.2.5.4 Attachments

Attachments withstand the load combinations listed in Section 3A.2.2.2. The allowable types of welded joints are designed in accordance with the applicable requirements of AWS Structural Welding Code-Steel and Sheet Steel, D1.1 and D1.3 (References 6 and 7). Local stresses induced in the ductwork by integral attachments, as defined in Paragraph AA-4243 of Reference 2, are analyzed. The material selected for items used as part of an assembly for supporting or guiding the ductwork is compatible for welding. Consideration is given to the mechanical connection and local stresses induced in the ductwork by nonintegral attachments, as defined in Paragraph AA-4243 of Reference 2. The design of bolts for structural supports meets the requirements of Subarticle AA-4360 of Reference 2.

3A.3 Cable Tray, Conduit, and Supports

The following criteria apply to Seismic Category I and II cable trays, conduits, and the associated supports and restraints.

3A.3.1 Codes and Standards

Cable tray, conduit, and cable tray supports and restraints conform to the following codes and standards:

- *[ANSI/AISC-N690-1994, AISC "Specification for the Design, Fabrication, and Erection of Steel Safety-Related Structures for Nuclear Facilities," with Supplement 2 (10/06/2004),]** (Reference 8).
- American Iron and Steel Institute (AISI), North American Specification for the Design of Cold-Formed Steel Structural Members, 2001 Edition with 2003 Errata (Reference 4).
- AISC Manual of Steel Construction, Ninth Edition, (Reference 3).

3A.3.2 Loads

The following loads are considered for the design of cable trays, conduits, and their supporting structures:

- Dead Load (D)—weight of cable trays or conduits, supports, cable inside of the raceways, tray covers, and other permanently attached components and fittings.
- Live Loads (L)—loads occurring during construction and maintenance. Live loads will not be less than a 250 lb load applied to a tray span in a manner providing worst case stresses in the tray and/or maximizing support loads. This load is not combined with seismic loads and is not applicable for conduits.
- Seismic (S)—See Section 3A.2.2.1.
- Thermal (T)—Loads resulting from thermal expansion or contraction. These loads are avoided by placing expansion/contraction joints along raceway runs.

3A.3.3 Load Combinations

Table 3A-4 lists the raceway and support loading combinations for the design of cable trays, conduits and supports.

3A.3.4 Allowable Stress Criteria

The basic stress allowables for carbon steel cold formed sections are in accordance with the AISI cold-formed structural design specification (Reference 4). The basic stress allowables for support structural steel, welds, and bolts are in accordance with Reference 8.

3A.3.5 Damping

The damping values for the design of cable tray and conduit systems and their associated supports are addressed in Section 3.7.1.2, and are provided in Table 3.7.1-1.

Cable tray systems meeting the criteria in Table 3.7.1-7 for similarity to the Bechtel-ANCO test program may use damping values up to 15 percent in accordance with Figure 3.7.1-16 for the transverse direction (horizontal direction perpendicular to direction of tray run). Historic tests have demonstrated that a substantial amount of energy is dissipated by friction between cables and through movement and bouncing of cables within the tray. While damping values beyond 15 percent were identified in historic tests for loaded trays with higher input excitation, the maximum damping value in the transverse direction is limited to 15 percent for 50 percent to fully loaded tray (for input ground motion ZPA exceeding 0.25 g). For the other two directions, damping values are in accordance with RG 1.61 and is shown in Figure 3.7.1-16.

Cable tray systems not meeting the criteria in Table 3.7.1-7 for similarity to the Bechtel-ANCO test program are limited to damping values that are in accordance with RG 1.61 and as shown in Figure 3.7.1-16. The damping value is to be reduced to the values indicated in Table 3.7.1-1 for conduit, cable trays loaded to less than 50 percent of the cable tray rated capacity, cable trays loaded primarily with conduit, or when rigid fire proofing materials are used causing the cables to become effectively bundled together.

3A.3.6 Seismic Analysis

This section describes the seismic analysis criteria for cable trays, conduits and their supports.

3A.3.6.1 Seismic Analysis Methods

Refer to Section 3.7.3.1.

3A.3.6.2 Determination of Number of Earthquake Cycles

Section 3.7.3.2 discusses the required number of earthquake cycles to be considered for seismic-induced fatigue. Rolled structural steel members for cable tray and conduit supports may be qualified for fatigue by evaluation in accordance with the provisions of ANSI/AISC N690 (Reference 8). Cold-formed members for cable tray and conduit supports may be qualified for fatigue by evaluation in accordance with the provisions of American Iron and Steel Institute (AISI), North American Specification for the Design of Cold-Formed Steel Structural Members (Reference 4). Connections for structural steel members are qualified by cyclic testing for the number of earthquake cycles specified in Section 3.7.3.2. Similarly, hardware components used to connect cold-formed members are also qualified by cyclic testing for the number of earthquake cycles specified in Section 3.7.3.2.

3A.3.6.3 Analytical Modeling Procedures

Refer to Section 3.7.3.3.

For seismic analysis of cable tray systems using refined analysis methods (e.g., the Response Spectrum Method), and using damping values in excess of RG 1.61 in accordance with Figure 3.7.1-16, seismic models are constructed using the following criteria:

- The cable trays are modeled as continuous beam elements using the tray section properties provided by the vendor as input for the equivalent beam element properties. The beams are discretized into approximately one foot elements to accurately model the mass distribution and capture the response contribution of the higher modes.

- Vertical and horizontal support struts are modeled as continuous beam elements using strut section properties provided by the vendor. The beams are discretized into approximately one foot elements, with a minimum of three elements per beam, to accurately model the mass distribution and capture the response contribution of the higher modes.

- Transverse and longitudinal braces of the cable tray supports are modeled as single truss elements. Truss behavior is achieved by using beam elements and releasing end moments (releasing moments of the members transfer only axial and shear loads).

- Cable loading consistent with Section 3A.3.2 is considered by applying uniform loads to the beam element representing the tray.

- Strut support connections are modeled to reflect the flexural behavior of the strut-to-clip angle connections. In the transverse direction (horizontal direction perpendicular to direction of tray run), degraded rotational spring constants are used. The spring constants are obtained from moment versus rotation curves of strut connection load tests, and are defined as the slope of the line from the origin to the point on the strength curve corresponding to one-half the maximum tested rotation of the connection. In the longitudinal direction (horizontal direction parallel to direction of tray run), rotational spring constants are taken as one-half the value of the degraded rotational spring constants in the transverse direction. No reduction in stiffness is required in the vertical direction.

The Frequency Determination Approach to the equivalent static load method considers the response from an in-structure response spectra (ISRS) curve at the corresponding fundamental frequency of the cable tray system in each of the three orthogonal directions to determine the seismic loads. Because the seismic demands are calculated on a frequency dependent basis, softening effects of the support connections need to be addressed in determining the system fundamental frequency in the transverse direction (horizontal direction perpendicular to direction of tray run). If the system fundamental frequency in one seismic direction is determined to be equal to or less than the frequency associated with the peak spectral acceleration from the appropriate ISRS curve, the peak spectral acceleration is used in accordance with Section 3.7.3.1.4. The fundamental frequency for a given cable tray system can be calculated using analytical approaches or computational methods through eigen value analysis. Accounting for uncertainties in the calculation of system fundamental frequencies is conservatively mitigated by considering a frequency band extending from ±20 percent of the calculated fundamental frequencies in each of the three directions. Within the ±20 percent frequency band for each direction, the appropriate ISRS curve is inspected for maximum spectral acceleration, and corresponding equivalent static forces are evaluated.

A demonstration of how design basis ISRS are modified and ±20 percent frequency bands are implemented for the Frequency Determination Approach is illustrated in Figure 3A-1 and Figure 3A-2. Two possible scenarios are presented, with Figure 3A-1 showing the scenario of a design basis ISRS where the high frequency peak has the highest spectral acceleration and Figure 3A-2 showing the scenario of a design basis ISRS where the low frequency peak has the highest spectral acceleration. For both scenarios, three calculated system fundamental frequencies are plotted at different locations on the design basis ISRS to illustrate how design accelerations are picked within the corresponding ±20 percent frequency bands. The modified ISRS in Figure 3A-1 and Figure 3A-2 show the peak spectral acceleration extended left of the peak in accordance with Section 3.7.3.1.4. This extension of the peak spectral acceleration accounts for multimode effects and is applicable in each of the three orthogonal directions. Multimode response factors are derived based on a uniform acceleration spectrum. Implementation therefore requires that spectral accelerations at the frequencies of higher modes must be less than or equal to the acceleration at the fundamental frequency. In addition, for the manual determination of transverse system fundamental frequencies, selecting boundary conditions whose frequency approximation underestimates the actual system frequency as required by the seismic modeling procedures in 3A.3.6.3, together with extending the peak spectral acceleration to lower frequencies, verifies conservative acceleration values for the fundamental mode.

For the response spectrum method, a computational model is developed to perform eigen value analysis of the system. Softening effects of support connections in the transverse direction and characteristics of cable tray system computer models are addressed similar to the Frequency Determination Approach. However, accounting for uncertainties in calculation of system fundamental frequencies resulting from modeling is different. The appropriate ISRS for the transverse direction is smoothed and broadened consistent with Section 3.7.3.1.1, and is modified so that the peak is extended from a frequency of zero Hz to a frequency that extends 20 percent beyond the maximum frequency associated with the peak spectral acceleration. This approach is applied in the transverse direction to verify conservatism when using degraded rotational stiffness values for support connections. In the vertical and longitudinal directions, it is sufficient to broaden the peaks of the appropriate ISRS curves by ±20 percent. The ISRS curves are also smoothed and broadened in accordance with Section 3.7.3.1.1.

A demonstration of how design basis ISRS are modified when using the response spectrum method is illustrated in Figure 3A-3 and Figure 3A-4. Two possible scenarios are presented, with Figure 3A-3 showing the scenario of design basis ISRS where the high frequency peak has the highest spectral acceleration, and Figure 3A-4 showing the scenario of design basis ISRS where the low frequency peak has the highest spectral acceleration. In both scenarios, the peaks of the design basis ISRS are broadened by 20 percent for the vertical and longitudinal directions to account for uncertainties in fundamental frequency estimates resulting from modeling. For the transverse direction in both scenarios, the design basis ISRS is modified so that the peak spectral acceleration is extended left of the peak frequency to either the next modified ISRS peak or to a frequency of zero Hz as shown in Figure 3A-3 and Figure 3A-4. This extension of the peak spectral acceleration accounts for support connection softening effects in the transverse direction. For the transverse direction in both scenarios, the peak of the design basis ISRS is also extended to the right of the peak by 20 percent as shown in Figure 3A-3 and Figure 3A-4 to account for uncertainties in fundamental frequency estimates resulting from modeling.

3A.3.6.4 Basis for Selection of Frequencies

Refer to Section 3.7.3.4.

3A.3.6.5 Analysis Procedure for Damping

Refer to Section 3.7.3.5 for analysis procedures for damping. The damping criteria is further described in Section 3A.3.5.

3A.3.6.6 Three Components of Earthquake Motion

Refer to Section 3.7.3.6.

3A.3.6.7 Combination of Modal Responses

Refer to Section 3.7.3.7.

3A.3.6.8 Interaction of Other Systems with Seismic Category I Systems

Refer to Section 3.7.3.8.

3A.3.6.9 Multiply-Supported Equipment and Components with Distinct Inputs

Refer to Section 3.7.3.9.

3A.3.6.10 Use of Constant Vertical Static Factors

Refer to Section 3.7.3.10.

3A.3.6.11 Torsional Effects of Eccentric Masses

Refer to Section 3.7.3.11.

3A.4 References

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

2. ASME AG-1, “Code on Nuclear Air and Gas Treatment,” The American Society of Mechanical Engineers, 1997 (including the AG-1a-2000, “Housings” Addenda).

3. AISC “Manual of Steel Construction,” Ninth Edition, American Institute of Steel Construction, April 2002.

4. AISI, “North American Specification for the Design of Cold-Formed Steel Structural Members,” American Iron and Steel Institute, 2001 Edition with 2003 Errata.

5. SMACNA, “HVAC Duct Construction Standards, Metal and Flexible,” Sheet Metal and Conditioning Contractors National Association, Third Edition, 2005.

6. AWS D1.1/D1.1M: 2004, “Structural Welding Code-Steel,” American Welding Society with errata through June 2005.

7. AWS D1.3-98, “Structural Welding Code – Sheet Steel,” American Welding Society, 1998.

8. ANSI/AISC-N690-1994, AISC “Specification for the Design, Fabrication, and Erection of Steel Safety-Related Structures for Nuclear Facilities,” American National Standards Institute/American Institute of Steel Construction, with Supplement 2, October 2004.

9. NUREG-0484, "Methodology for Combining Dynamic Responses," U.S. Nuclear Regulatory Commission, May 1980.

10. Report 1053-21.1-4, "Cable Tray and Conduit Raceway Seismic Test Program, Release 4," Bechtel-ANCO Engineers, Inc., December 15, 1978.

11. Koss, P., "Seismic Testing of Electric Cable Tray Systems," 48th Annual Convention of the Structural Engineers Association of California, October 4-6, 1979.

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

Table 3A-1—HVAC Ductwork Load Combinations[5]

Service Level	Load Combination (see Section 3A.2.2.1)	Stress Criteria
A	N + T N + L	See 3A.2.4.1
B	N + W + T N + T + ADL	See 3A.2.4.1
C	N + W + T N + SL + ADL	See 3A.2.4.1
D	N + DPD + SL + ADL	See 3A.2.4.1

Table 3A-2—HVAC Support and Restraint Load Combinations[5]

Service Level	Load Combination (see Section 3A.2.2.1 and 3A.2.3.1)	Stress Criteria
A	N + T N + L	See 3A.2.4.1
B	N + W + T N + T + ADL	See 3A.2.4.1
C	N + W + T N + SL + ADL	See 3A.2.4.1
D	N + DPD + SL + ADL	See 3A.2.4.1

Table 3A-3—Deflection Limits[1,2]

Service Level	Deflection Limit
A[3]	$d_{all} \le 0.6\ d_{max}$
B[3]	$d_{all} \le 0.6\ d_{max}$
C[4]	$d_{all} \le 0.9\ d_{max}$
D[4]	$d_{all} \le 0.9\ d_{max}$

Notes:

1. If particular equipment design criteria require more restrictive limits on deflections, those requirements will be stated in the applicable equipment section of Reference 2.
2. Deflections are limited to prevent transmission of excessive load to other components such as filter frames, coils, bearings, and access doors.
3. Deflections are limited to values that prevent buckling in primary load carrying elements.
4. Deflections are limited to values as described in AA-4323 of Reference 2.
5. Loads due to dynamic events are combined considering the time phasing of the events (i.e., whether the loads are consistent in time). When the time phasing relationship can be established, dynamic loads may be combined by the square-root-sum-of-the-squares (SRSS) method, provided it is demonstrated that the non-exceedance criteria given in NUREG-0484 (Reference 9) are met. When the time phasing relationship cannot be established or when the non-exceedance criteria in Reference 9 are not met, dynamic loads are combined by absolute sum. Safe shutdown earthquake (SSE) and high-energy line break loads—loss-of-coolant accident (LOCA) and secondary side rupture—are always combined using the SRSS method.

Table 3A-4—Load Combinations for Cable Trays, Conduits and Supports

Service Level	Category	Load Combination	Stress Limit[1]
A	Normal Condition	D+L	1.0 x S_a
C	Emergency Condition	D+S	1.6 x S_a (<0.9 F_y)

Notes:

1. S_a= The basic allowable stress.

Figure 3A-1—Demonstration of Modified ISRS for Frequency Determination Approach to Equivalent Static Load Method: High Frequency Peak Has Highest Spectral Acceleration

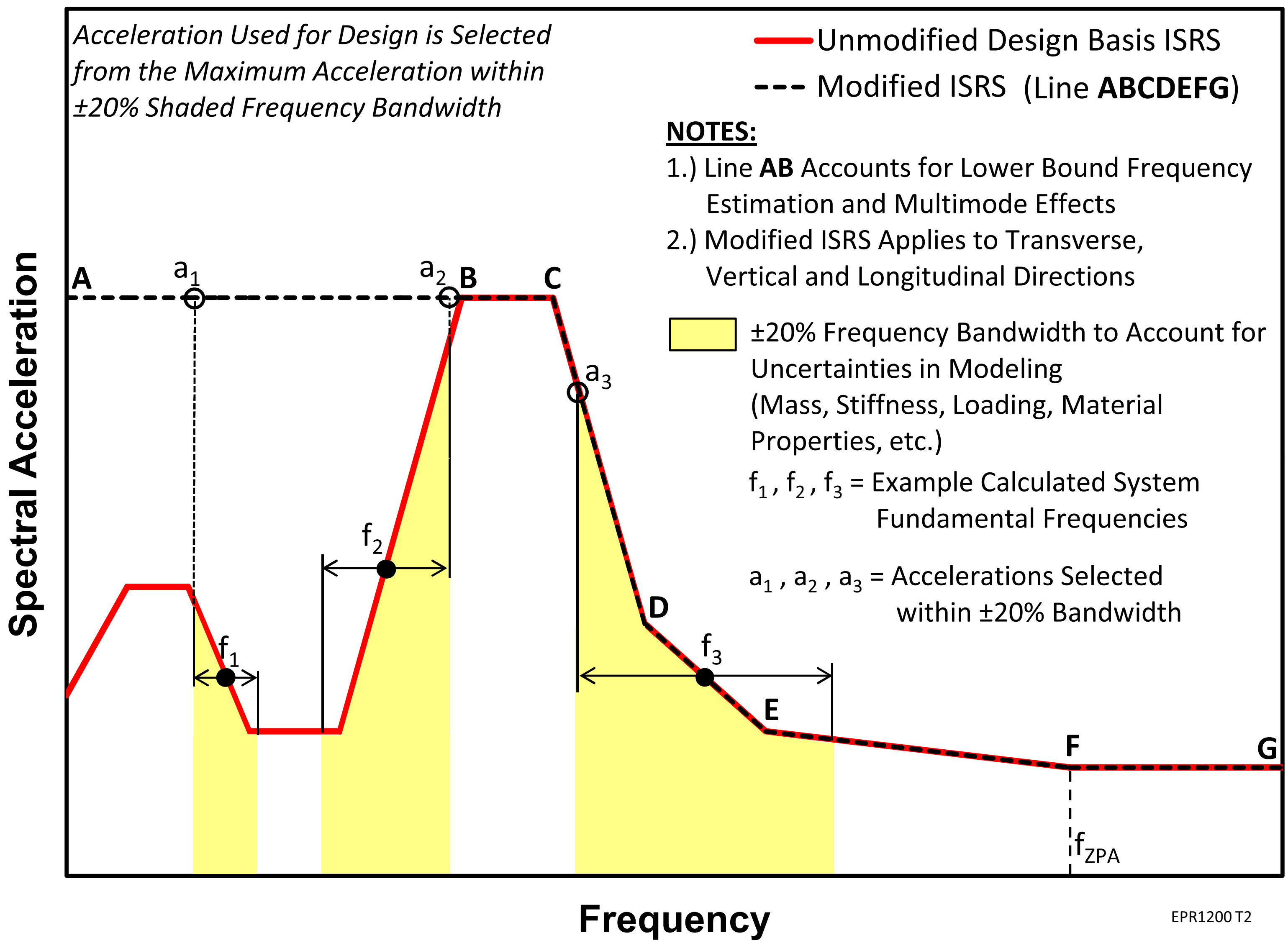


Figure 3A-2—Demonstration of Modified ISRS for Frequency Determination Approach to Equivalent Static Load Method: Low Frequency Peak Has Highest Spectral Acceleration

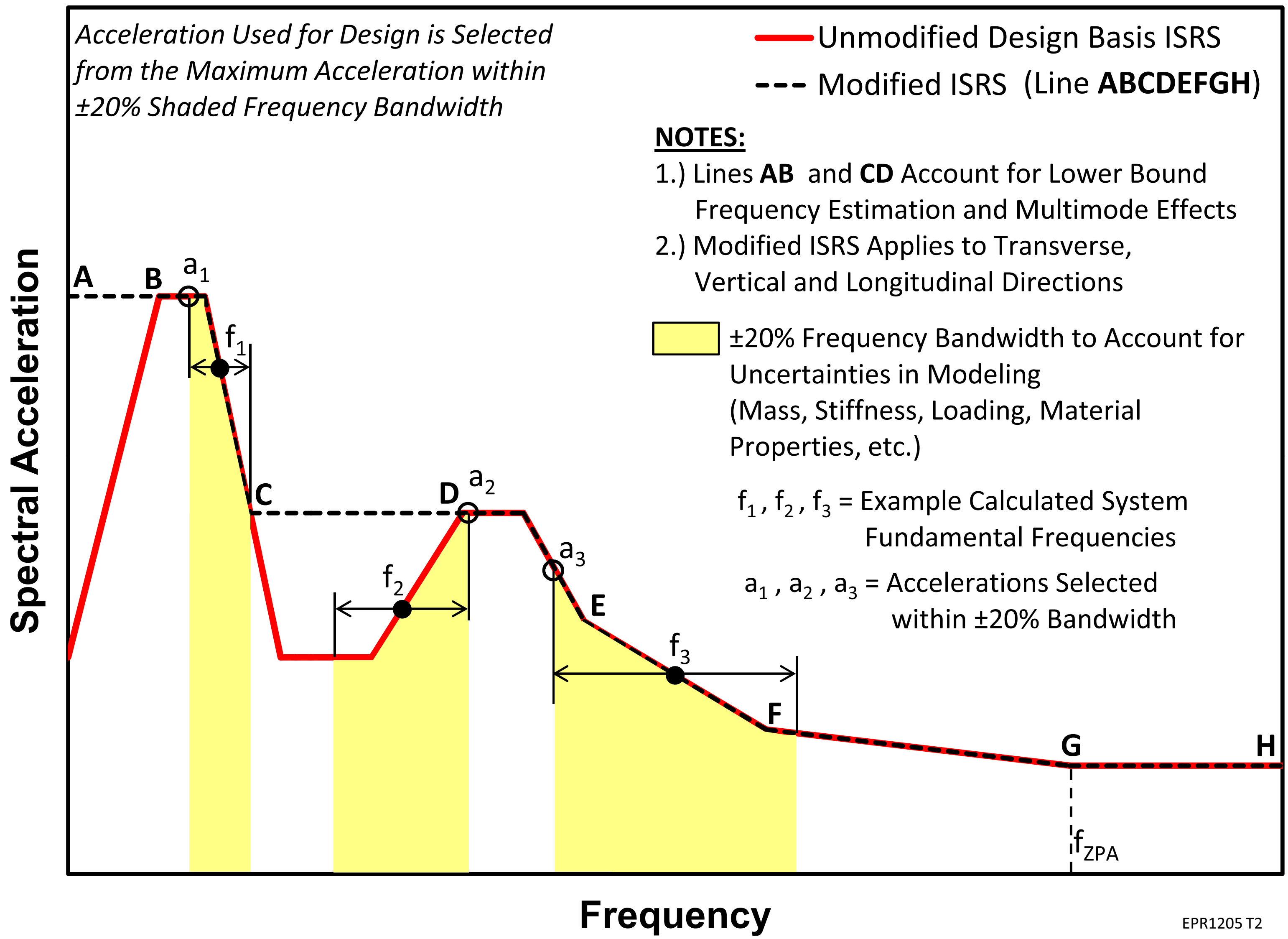


Figure 3A-3—Demonstration of Modified ISRS for Response Spectrum Method: High Frequency Peak Has Highest Spectral Acceleration

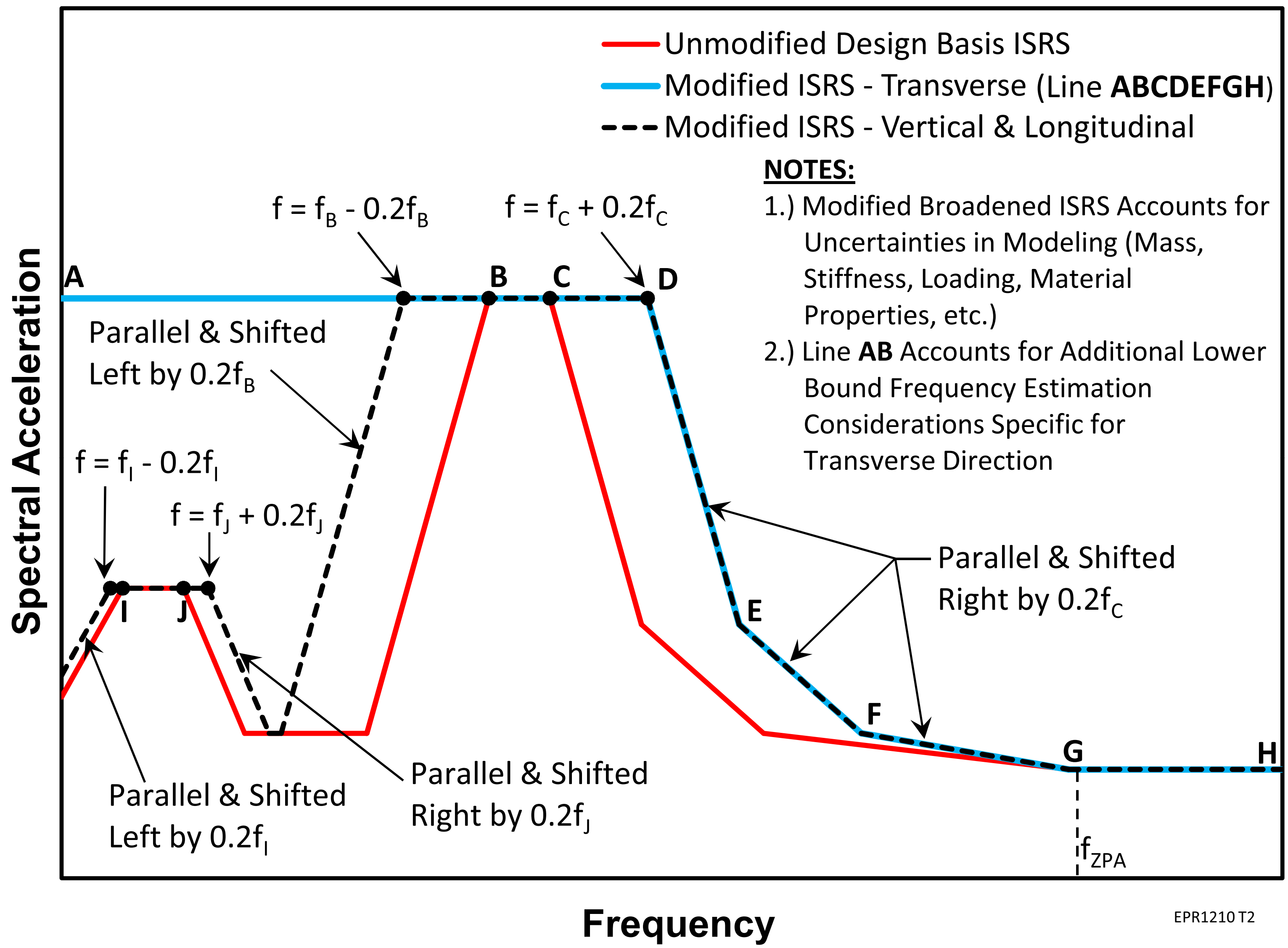
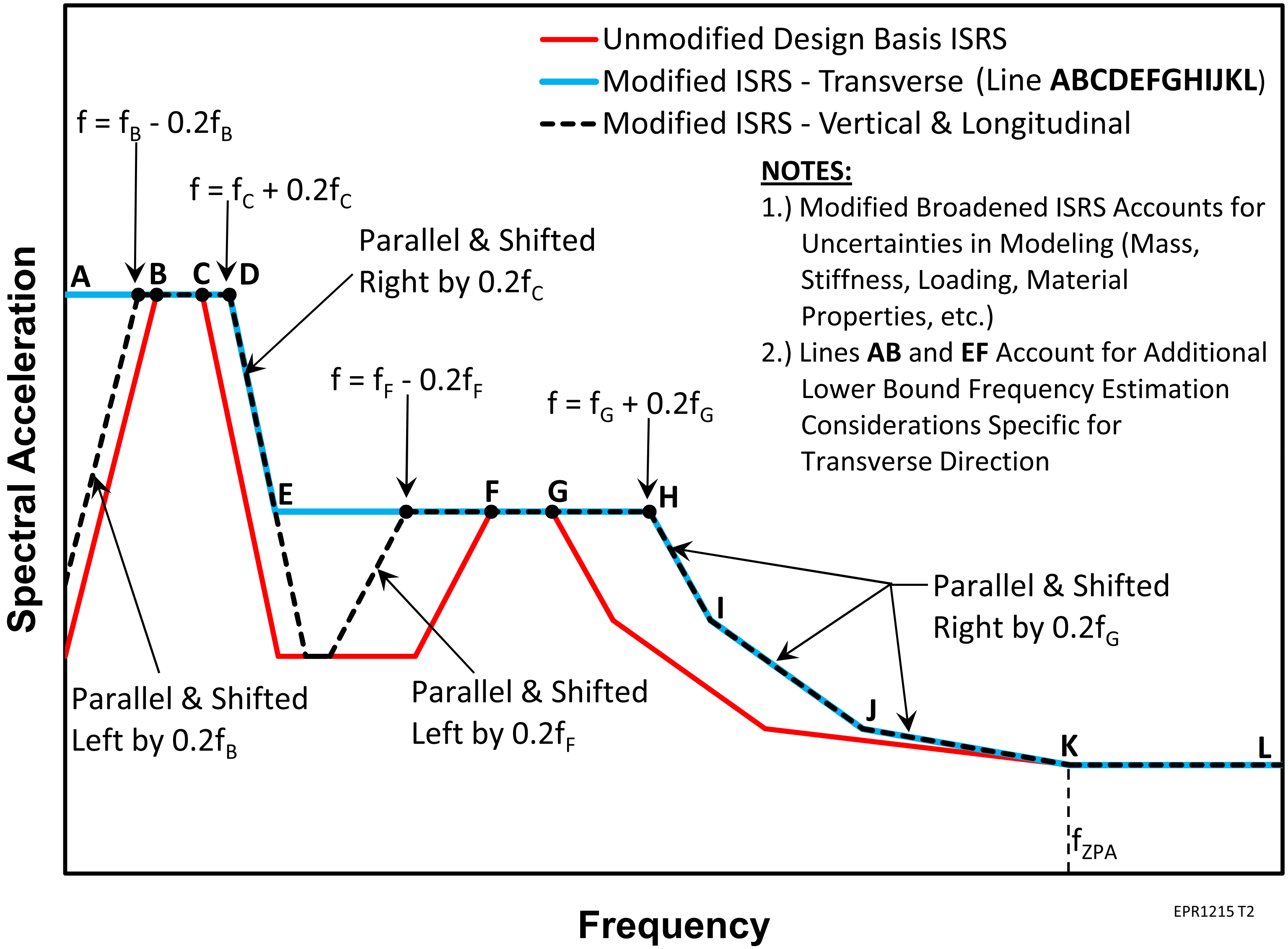


Figure 3A-4—Demonstration of Modified ISRS for Response Spectrum Method: Low Frequency Peak Has Highest Spectral Acceleration



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