Appendix 3A HVAC Ducts and Duct Supports

This appendix provides the design criteria for seismic Category I and II HVAC ducts and their supports. These design criteria maintain structural integrity for seismic Category I and II ducts and functional capability for seismic Category I duct.

The structural components of a typical HVAC duct system include the sheet metal ducts, stiffeners for the ducts, duct supports, and other inline components such as duct heaters, dampers, etc.

3A.1 Codes and Standards

The design of the HVAC ducts and their supports conform to the following codes and standards:

- ASME N509-1989(R1996), Nuclear Power Plants Air Cleaning Units and Components
- ASME/ANSI AG-1-1997, Code on Nuclear Air and Gas Treatment
- American Institute of Steel Construction (AISC), Specification for the Design, Fabrication and Erection of Steel Safety Related Structures for Nuclear Facilities, AISC-N690-1994
- American Iron and Steel Institute (AISI), Specification for the Design of Cold Formed Steel Structural Members, 1996 Edition and Supplement No. 1, July 30, 1999
- SMACNA, HVAC Duct Construction Standards, Metal and Flexible, Second Edition 1995.

3A.2 Loads and Load Combinations

3A.2.1 Loads

3A.2.1.1 Dead Load (D)

Dead load includes the weight of the duct sheet, stiffeners and inline components such as duct heaters and dampers. It also includes permanently attached items such as insulation and fireproofing, where applicable, and the weight of the duct supports. Temporary items used during construction or maintenance are removed prior to operation.

3A.2.1.2 Construction Live Load (L)

Live load consists of a load of 250 pounds to be applied only during construction or maintenance on an area of 10 square inches on the duct at a critical location to maximize flexural and shear stresses. This load is not combined with seismic loads.

3A.2.1.3 Pressure (P)

The duct metal thickness and stiffener requirements are based on maximum system design pressures. SMACNA or ASME guidelines, as applicable, are used in the design of duct metal thickness and stiffener requirements.

The pressure loads occur during normal plant operation, including plant start up testing, damper closure and normal airflow. Occasionally, overpressure transient loads such as rapid damper closure may also produce short duration pressure differential.

3A.2.1.4 Safe Shutdown Earthquake (E_s)

Seismic response of the HVAC ductwork and its support system are produced due to seismic excitation of the supports.

3A.2.1.5 Wind Loads (W)

Ductwork within partially or fully vented buildings is subject to wind effects. Design wind loads are discussed in Section 3.3.

3A.2.1.6 Tornado Loads (W_t)

Ductwork within partially or fully vented buildings is subject to tornado differential pressure effects. Tornado loads are discussed in Section 3.3. Seismic Category I HVAC ductwork is protected from impact by tornado missiles.

3A.2.1.7 External Pressure Differential Loads (P_A)

Seismic Category I HVAC ductwork and its supports are designed to withstand dynamic external pressure differential loads resulting from postulated accident conditions. Usually HVAC ducts are routed outside the areas of potential pipe break.

3A.2.1.8 Thermal (T_O/T_A)

Stresses on the supports resulting from the ductwork expansion due to temperature changes are avoided by designing the system to take care of the expansion or by utilizing expansion joints. For ducts of gasketed companion angle construction, thermal loads are negligible. For ducts exposed to higher temperatures during a postulated accident condition, an evaluation is performed on a case by case basis for its effect.

3A.2.2 Load Combinations

The load combinations for various service levels are as follows:

Service Level		Load Combination
A	(Construction / maintenance)	$D + L + P + T_O$
A	(Normal Operating Condition)	$D + P + T_O$
B	(Severe Condition)	$D + W + P + T_O$
C	(Extreme Condition)	$D + E_s + P + T_O$
C	(Extreme Condition)	$D + W_t + P + T_O$
D	(Abnormal Condition)	$D + P + P_A + E_s + T_A$

3A.3 Analysis and Design

The HVAC duct support system is designed to maintain structural integrity of the duct. Function is not required for the seismic Category II ductwork. The stresses are maintained within the allowable limits specified in Subsection 3A.3.4. Section properties and masses are calculated in accordance with SMACNA standard.

The damping values for seismic analysis are as follows:

- Welded HVAC Ductwork 4 percent
- Bolted HVAC Ductwork 7 percent

The duct design due to pressure loads is based on ASME/ANSI AG-1 for seismic Category I ducts and SMACNA for seismic Category II ducts.

The global behavior of the duct is determined from the overall bending of the duct between the supports. It is similar to the beam type bending. The dead load is combined with the seismic inertial load to determine the maximum bending moment. For determining the section modulus, the corners of the duct are considered effective. The corner length in each direction equals 32 times the thickness of the duct (t) for this purpose.

3A.3.1 Response Due to Seismic Loads

The methodology for seismic analysis is provided in Subsection 3.7.3. Seismic loads are determined by either using the equivalent static load method of analysis or by performing dynamic analysis.

Stresses are determined for the seismic excitation in two horizontal and one vertical direction. The stresses in the three directions are combined using the square root of sum of the squares (SRSS) method or the 100-40-40 method as described in Subsection 3.7.3.6.

3A.3.2 Deflection Criteria

Deflections for panels and stiffeners conform to the limits stated in the “Code on Nuclear Air and Gas Treatment.”

3A.3.3 Relative Movement

Clearances are provided for allowing relative movement between equipment, other commodities, and HVAC system.

3A.3.4 Allowable Stresses

The basic stress allowables for the HVAC ducts are in accordance with paragraph SA-4220 of ASME/ANSI AG-1.

The basic stress allowables for duct supports utilizing rolled structural shapes are in accordance with ANSI/AISC N-690 and the supplemental requirements described in Subsection 3.8.4.5.2. The basic stress allowables for supports utilizing light gage cold rolled channel type sections are based on the manufacturer's published catalog values.

Service Level A and B	Basic Allowable
Service Level C and D	1.6 times basic allowable for tension and 1.4 times basic allowable for compression

3A.3.5 Connections

Connections are designed in accordance with the applicable codes and standards listed in Section 3A.1. For connections used with light gage cold rolled channel type sections, design is based on the manufacturer's published catalog values. Supports are attached to the building structure by bolted or welded connections. Fastening of the supports to concrete structures meets the supplemental requirements given in Subsection 3.8.4.5.1.